Preface

The source of much copied reference material: Paul Vinkenoog
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https://github.com/FirebirdSQL/firebird-documentation/issues or submit a pull
request with the necessary changes.
# Table of Contents

1. About the Firebird 5.0 Language Reference .................................................. 18  
   1.1. Subject ........................................................................................................... 18  
   1.2. Authorship ................................................................................................. 18  
      1.2.1. Contributors ......................................................................................... 18  
   1.3. Reporting Errors or Missing Content ......................................................... 19  
   1.4. Acknowledgments ....................................................................................... 19  
   1.5. Contributing ............................................................................................... 19  
2. SQL Language Structure ................................................................................. 20  
   2.1. Background to Firebird’s SQL Language .................................................... 20  
      2.1.1. SQL Flavours ......................................................................................... 20  
      2.1.2. SQL Dialects ......................................................................................... 21  
      2.1.3. Error Conditions .................................................................................... 22  
   2.2. Basic Elements: Statements, Clauses, Keywords ......................................... 22  
   2.3. Identifiers .................................................................................................... 23  
      2.3.1. Rules for Regular Identifiers .................................................................. 23  
      2.3.2. Rules for Delimited Identifiers .............................................................. 24  
   2.4. Literals .......................................................................................................... 24  
   2.5. Operators and Special Characters ............................................................... 25  
   2.6. Comments .................................................................................................... 25  
3. Data Types and Subtypes ................................................................................. 27  
   3.1. Integer Data Types ...................................................................................... 30  
      3.1.1. SMALLINT ............................................................................................. 30  
      3.1.2. INTEGER ............................................................................................... 30  
      3.1.3. BIGINT ................................................................................................. 30  
      3.1.4. INT128 ................................................................................................. 30  
      3.1.5. Hexadecimal Format for Integer Numbers ........................................... 31  
   3.2. Floating-Point Data Types .......................................................................... 31  
      3.2.1. Approximate Floating-Point Data Types ............................................... 31  
      3.2.2. Decimal Floating-Point Types ............................................................... 33  
   3.3. Fixed-Point Data Types .............................................................................. 35  
      3.3.1. NUMERIC .............................................................................................. 36  
      3.3.2. DECIMAL .............................................................................................. 37  
   3.4. Data Types for Dates and Times ................................................................. 37  
      3.4.1. DATE .................................................................................................... 39  
      3.4.2. TIME .................................................................................................. 39  
      3.4.3. TIMESTAMP ......................................................................................... 40  
      3.4.4. Session Time Zone ................................................................................ 41  
      3.4.5. Time Zone Format ................................................................................. 41
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.6. Operations Using Date and Time Values</td>
<td>41</td>
</tr>
<tr>
<td>3.4.7. Supplemental Time Zone Features</td>
<td>43</td>
</tr>
<tr>
<td>3.5. Character Data Types</td>
<td>44</td>
</tr>
<tr>
<td>3.5.1. Unicode</td>
<td>44</td>
</tr>
<tr>
<td>3.5.2. Client Character Set</td>
<td>44</td>
</tr>
<tr>
<td>3.5.3. Special Character Sets</td>
<td>45</td>
</tr>
<tr>
<td>3.5.4. Collation</td>
<td>45</td>
</tr>
<tr>
<td>3.5.5. Character Indexes</td>
<td>46</td>
</tr>
<tr>
<td>3.5.6. Character Types in Detail</td>
<td>47</td>
</tr>
<tr>
<td>3.6. Boolean Data Type</td>
<td>50</td>
</tr>
<tr>
<td>3.6.1. BOOLEAN</td>
<td>50</td>
</tr>
<tr>
<td>3.7. Binary Data Types</td>
<td>52</td>
</tr>
<tr>
<td>3.7.1. BLOB Subtypes</td>
<td>53</td>
</tr>
<tr>
<td>3.7.2. BLOB Specifics</td>
<td>53</td>
</tr>
<tr>
<td>3.8. Array Types</td>
<td>54</td>
</tr>
<tr>
<td>3.8.1. Specifying Explicit Boundaries for Dimensions</td>
<td>55</td>
</tr>
<tr>
<td>3.8.2. Adding More Dimensions</td>
<td>55</td>
</tr>
<tr>
<td>3.8.3. PSQL Source for SHOW_LANSG, a procedure involving an array</td>
<td>55</td>
</tr>
<tr>
<td>3.9. Special Data Types</td>
<td>56</td>
</tr>
<tr>
<td>3.9.1. SQL_NULL Data Type</td>
<td>56</td>
</tr>
<tr>
<td>3.10. Conversion of Data Types</td>
<td>57</td>
</tr>
<tr>
<td>3.10.1. Explicit Data Type Conversion</td>
<td>57</td>
</tr>
<tr>
<td>3.10.2. Implicit Data Type Conversion</td>
<td>61</td>
</tr>
<tr>
<td>3.11. Custom Data Types — Domains</td>
<td>62</td>
</tr>
<tr>
<td>3.11.1. Domain Attributes</td>
<td>62</td>
</tr>
<tr>
<td>3.11.2. Domain Override</td>
<td>62</td>
</tr>
<tr>
<td>3.11.3. Creating and Administering Domains</td>
<td>63</td>
</tr>
<tr>
<td>3.12. Data Type Declaration Syntax</td>
<td>64</td>
</tr>
<tr>
<td>3.12.1. Scalar Data Types Syntax</td>
<td>65</td>
</tr>
<tr>
<td>3.12.2. BLOB Data Types Syntax</td>
<td>66</td>
</tr>
<tr>
<td>3.12.3. Array Data Types Syntax</td>
<td>67</td>
</tr>
<tr>
<td>4. Common Language Elements</td>
<td>69</td>
</tr>
<tr>
<td>4.1. Expressions</td>
<td>69</td>
</tr>
<tr>
<td>4.1.1. Literals (Constants)</td>
<td>71</td>
</tr>
<tr>
<td>4.1.2. SQL Operators</td>
<td>78</td>
</tr>
<tr>
<td>4.1.3. Conditional Expressions</td>
<td>81</td>
</tr>
<tr>
<td>4.1.4. NULL in Expressions</td>
<td>83</td>
</tr>
<tr>
<td>4.1.5. Subqueries</td>
<td>84</td>
</tr>
<tr>
<td>4.2. Predicates</td>
<td>86</td>
</tr>
<tr>
<td>4.2.1. Conditions</td>
<td>86</td>
</tr>
<tr>
<td>4.2.2. Comparison Predicates</td>
<td>86</td>
</tr>
</tbody>
</table>
4.2.3. Existential Predicates ................................................................. 98
4.2.4. Quantified Subquery Predicates ............................................... 102
5. Data Definition (DDL) Statements .................................................. 104
  5.1. DATABASE .................................................................................. 104
    5.1.1. CREATE DATABASE ................................................................. 104
    5.1.2. ALT\(\text{ER} \) DATABASE .......................................................... 110
    5.1.3. DRO\(\text{P} \) DATABASE .............................................................. 116
  5.2. SHADOW ................................................................................. 116
    5.2.1. CREATE SHADOW ................................................................. 116
    5.2.2. DROP SHADOW ................................................................. 118
  5.3. DOMAIN .................................................................................. 119
    5.3.1. CREATE DOMAIN ................................................................. 119
    5.3.2. ALT\(\text{ER} \) DOMAIN .............................................................. 124
    5.3.3. DRO\(\text{P} \) DOMAIN .............................................................. 127
  5.4. TABLE ..................................................................................... 128
    5.4.1. CREATE TABLE ................................................................. 128
    5.4.2. ALT\(\text{ER} \) TABLE ................................................................. 146
    5.4.3. DRO\(\text{P} \) TABLE ................................................................. 153
    5.4.4. RECRA\(\text{TE} \) TABLE .............................................................. 154
  5.5. INDEX ..................................................................................... 155
    5.5.1. CREATE INDEX ................................................................. 155
    5.5.2. ALT\(\text{ER} \) INDEX ................................................................. 160
    5.5.3. DRO\(\text{P} \) INDEX ................................................................. 161
    5.5.4. SET STATISTICS ................................................................. 162
  5.6. VIEW ..................................................................................... 163
    5.6.1. CREATE VIEW ................................................................. 164
    5.6.2. ALT\(\text{ER} \) VIEW ................................................................. 168
    5.6.3. CREATE OR ALT\(\text{ER} \) VIEW .............................................. 169
    5.6.4. DRO\(\text{P} \) VIEW ................................................................. 170
    5.6.5. RECRA\(\text{TE} \) VIEW .............................................................. 171
  5.7. TRIGGER ............................................................................... 172
    5.7.1. CREATE TRIGGER ................................................................. 172
    5.7.2. ALT\(\text{ER} \) TRIGGER .............................................................. 184
    5.7.3. CREATE OR ALT\(\text{ER} \) TRIGGER ........................................... 186
    5.7.4. DRO\(\text{P} \) TRIGGER .............................................................. 187
    5.7.5. RECRA\(\text{TE} \) TRIGGER .............................................................. 188
  5.8. PROCEDURE ............................................................................. 189
    5.8.1. CREATE PROCEDURE .............................................................. 189
    5.8.2. ALT\(\text{ER} \) PROCEDURE ........................................................ 194
    5.8.3. CREATE OR ALT\(\text{ER} \) PROCEDURE .................................... 195
    5.8.4. DRO\(\text{P} \) PROCEDURE .............................................................. 196
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8.5.</td>
<td>RECREATE PROCEDURE</td>
<td>197</td>
</tr>
<tr>
<td>5.9.</td>
<td>FUNCTION</td>
<td>198</td>
</tr>
<tr>
<td>5.9.1.</td>
<td>CREATE FUNCTION</td>
<td>198</td>
</tr>
<tr>
<td>5.9.2.</td>
<td>ALTER FUNCTION</td>
<td>205</td>
</tr>
<tr>
<td>5.9.3.</td>
<td>CREATE OR ALTER FUNCTION</td>
<td>206</td>
</tr>
<tr>
<td>5.9.4.</td>
<td>DROP FUNCTION</td>
<td>207</td>
</tr>
<tr>
<td>5.9.5.</td>
<td>RECREATE FUNCTION</td>
<td>208</td>
</tr>
<tr>
<td>5.10.</td>
<td>EXTERNAL FUNCTION</td>
<td>208</td>
</tr>
<tr>
<td>5.10.1.</td>
<td>DECLARE EXTERNAL FUNCTION</td>
<td>209</td>
</tr>
<tr>
<td>5.10.2.</td>
<td>ALTER EXTERNAL FUNCTION</td>
<td>213</td>
</tr>
<tr>
<td>5.10.3.</td>
<td>DROP EXTERNAL FUNCTION</td>
<td>214</td>
</tr>
<tr>
<td>5.11.</td>
<td>PACKAGE</td>
<td>215</td>
</tr>
<tr>
<td>5.11.1.</td>
<td>CREATE PACKAGE</td>
<td>215</td>
</tr>
<tr>
<td>5.11.2.</td>
<td>ALTER PACKAGE</td>
<td>218</td>
</tr>
<tr>
<td>5.11.3.</td>
<td>CREATE OR ALTER PACKAGE</td>
<td>220</td>
</tr>
<tr>
<td>5.11.4.</td>
<td>DROP PACKAGE</td>
<td>220</td>
</tr>
<tr>
<td>5.11.5.</td>
<td>RECREATE PACKAGE</td>
<td>221</td>
</tr>
<tr>
<td>5.12.</td>
<td>PACKAGE BODY</td>
<td>222</td>
</tr>
<tr>
<td>5.12.1.</td>
<td>CREATE PACKAGE BODY</td>
<td>222</td>
</tr>
<tr>
<td>5.12.2.</td>
<td>DROP PACKAGE BODY</td>
<td>225</td>
</tr>
<tr>
<td>5.12.3.</td>
<td>RECREATE PACKAGE BODY</td>
<td>226</td>
</tr>
<tr>
<td>5.13.</td>
<td>FILTER</td>
<td>227</td>
</tr>
<tr>
<td>5.13.1.</td>
<td>DECLARE FILTER</td>
<td>227</td>
</tr>
<tr>
<td>5.13.2.</td>
<td>DROP FILTER</td>
<td>229</td>
</tr>
<tr>
<td>5.14.</td>
<td>SEQUENCE (GENERATOR)</td>
<td>230</td>
</tr>
<tr>
<td>5.14.1.</td>
<td>CREATE SEQUENCE</td>
<td>231</td>
</tr>
<tr>
<td>5.14.2.</td>
<td>ALTER SEQUENCE</td>
<td>232</td>
</tr>
<tr>
<td>5.14.3.</td>
<td>CREATE OR ALTER SEQUENCE</td>
<td>234</td>
</tr>
<tr>
<td>5.14.4.</td>
<td>DROP SEQUENCE</td>
<td>235</td>
</tr>
<tr>
<td>5.14.5.</td>
<td>RECREATE SEQUENCE</td>
<td>236</td>
</tr>
<tr>
<td>5.14.6.</td>
<td>SET GENERATOR</td>
<td>237</td>
</tr>
<tr>
<td>5.15.</td>
<td>EXCEPTION</td>
<td>238</td>
</tr>
<tr>
<td>5.15.1.</td>
<td>CREATE EXCEPTION</td>
<td>238</td>
</tr>
<tr>
<td>5.15.2.</td>
<td>ALTER EXCEPTION</td>
<td>239</td>
</tr>
<tr>
<td>5.15.3.</td>
<td>CREATE OR ALTER EXCEPTION</td>
<td>240</td>
</tr>
<tr>
<td>5.15.4.</td>
<td>DROP EXCEPTION</td>
<td>240</td>
</tr>
<tr>
<td>5.15.5.</td>
<td>RECREATE EXCEPTION</td>
<td>241</td>
</tr>
<tr>
<td>5.16.</td>
<td>COLLATION</td>
<td>242</td>
</tr>
<tr>
<td>5.16.1.</td>
<td>CREATE COLLATION</td>
<td>242</td>
</tr>
<tr>
<td>5.16.2.</td>
<td>DROP COLLATION</td>
<td>246</td>
</tr>
<tr>
<td>5.17.</td>
<td>CHARACTER SET</td>
<td>247</td>
</tr>
</tbody>
</table>
6. Data Manipulation (DML) Statements

6.1. SELECT

6.1.1. FIRST, SKIP
6.1.2. The SELECT Columns List
6.1.3. The FROM clause
6.1.4. Joins
6.1.5. The WHERE clause
6.1.6. The GROUP BY clause
6.1.7. The WINDOW Clause
6.1.8. The PLAN Clause
6.1.9. UNION
6.1.10. ORDER BY
6.1.11. ROWS
6.1.12. OFFSET, FETCH
6.1.13. FOR UPDATE [OF]
6.1.14. WITH LOCK
6.1.15. OPTIMIZE FOR
6.1.16. INTO
6.1.17. Common Table Expressions ("WITH ... AS ... SELECT")
6.1.18. Full SELECT Syntax

6.2. INSERT

6.2.1. INSERT ... VALUES
6.2.2. INSERT ... SELECT
6.2.3. INSERT ... DEFAULT VALUES
6.2.4. OVERRIDING
6.2.5. The RETURNING Clause
6.2.6. Inserting into BLOB columns

6.3. UPDATE

6.3.1. Using an alias
6.3.2. The SET Clause
6.3.3. The WHERE Clause
6.3.4. The ORDER BY and ROWS Clauses
6.3.5. The SKIP LOCKED Clause
6.3.6. The RETURNING Clause
6.3.7. Updating BLOB columns

6.4. UPDATE OR INSERT

6.4.1. The ORDER BY and ROWS Clauses
6.4.2. The RETURNING Clause
8. Built-in Scalar Functions

8.1. Context Functions

8.1.1. RDB$GET_CONTEXT() .............................................. 411
8.1.2. RDB$SET_CONTEXT() ............................................. 415

8.2. Mathematical Functions ........................................... 416
Table of Contents

8.3. String and Binary Functions .......................................................... 430
  8.3.1. ASCII_CHAR() ................................................................. 430
  8.3.2. ASCII_VAL() ................................................................. 431
  8.3.3. BASE64_DECODE() ......................................................... 431
  8.3.4. BASE64_ENCODE() ......................................................... 432
  8.3.5. BIT_LENGTH() ............................................................... 433
  8.3.6. BLOB_APPEND() ........................................................... 434
  8.3.7. CHAR_LENGTH(), CHARACTER_LENGTH() ......................... 436
  8.3.8. CRYPT_HASH() ............................................................ 437
  8.3.9. HASH() .......................................................... 438
  8.3.10. HEX_DECODE() ..................................................... 439
  8.3.11. HEX_ENCODE() ..................................................... 440
Table of Contents

15.3.1. SET ROLE .................................................. 630
15.3.2. SET TRUSTED ROLE .......................................... 631
15.4. Session Timeouts .............................................. 632
  15.4.1. SET SESSION IDLE TIMEOUT .................................. 632
  15.4.2. SET STATEMENT TIMEOUT .................................... 634
15.5. Time Zone Management ........................................ 637
  15.5.1. SET TIME ZONE ................................................ 637
15.6. Optimizer Configuration ....................................... 638
  15.6.1. SET OPTIMIZE ................................................ 638
15.7. Reset Session State ........................................... 638
  15.7.1. ALTER SESSION RESET ...................................... 638
15.8. Debugging ..................................................... 640
  15.8.1. SET DEBUG OPTION .......................................... 640
Appendix A: Supplementary Information ............................. 641
  The RDB$VALID_BLR Field ........................................... 641
  How Invalidation Works ............................................. 641
  A Note on Equality ................................................ 643
Appendix B: Exception Codes and Messages .......................... 644
  SQLSTATE Error Codes and Descriptions ................................ 644
  SQLCODE and GDSCODE Error Codes and Descriptions .................. 651
Appendix C: Reserved Words and Keywords .......................... 708
  Reserved words ................................................... 708
  Keywords ........................................................ 710
Appendix D: System Tables ............................................ 715
  RDB$AUTH_MAPPING ................................................. 717
  RDB$BACKUP_HISTORY .............................................. 718
  RDB$CHARACTER_SETS ............................................... 718
  RDB$CHECK_CONSTRAINTS ............................................ 719
  RDB$COLLATIONS .................................................... 719
  RDB$CONFIG ........................................................ 720
  RDB$DATABASE ...................................................... 721
  RDB$DB_CREATORS .................................................. 722
  RDB$DEPENDENCIES ............................................... 722
  RDB$EXCEPTIONS .................................................... 723
  RDB$FIELDS ........................................................ 724
  RDB$FIELD_DIMENSIONS ............................................. 729
  RDB$FILES ........................................................ 729
  RDB$FILTERS ........................................................ 730
  RDB$FORMATS ........................................................ 730
  RDB$FUNCTIONS ..................................................... 731
  RDB$FUNCTION_ARGUMENTS ......................................... 733
<table>
<thead>
<tr>
<th>Table of Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$GENERATORS</td>
</tr>
<tr>
<td>RDB$INDEX_SEGMENTS</td>
</tr>
<tr>
<td>RDB$INDICES</td>
</tr>
<tr>
<td>RDB$KEYWORDS</td>
</tr>
<tr>
<td>RDB$LOG_FILES</td>
</tr>
<tr>
<td>RDB$PACKAGES</td>
</tr>
<tr>
<td>RDB$PAGES</td>
</tr>
<tr>
<td>RDB$PROCEDURES</td>
</tr>
<tr>
<td>RDB$PROCEDURE_PARAMETERS</td>
</tr>
<tr>
<td>RDB$PUBLICATIONS</td>
</tr>
<tr>
<td>RDB$PUBLICATION_TABLES</td>
</tr>
<tr>
<td>RDB$REF_CONSTRAINTS</td>
</tr>
<tr>
<td>RDB$RELATIONS</td>
</tr>
<tr>
<td>RDB$RELATION_CONSTRAINTS</td>
</tr>
<tr>
<td>RDB$RELATION_FIELDS</td>
</tr>
<tr>
<td>RDB$ROLES</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASSES</td>
</tr>
<tr>
<td>RDB$TIME_ZONES</td>
</tr>
<tr>
<td>RDB$TRANSACTIONS</td>
</tr>
<tr>
<td>RDB$TRIGGERS</td>
</tr>
<tr>
<td>RDB$TRIGGER_TYPE Value</td>
</tr>
<tr>
<td>RDB$TRIGGER_MESSAGES</td>
</tr>
<tr>
<td>RDB$TYPES</td>
</tr>
<tr>
<td>RDB$USER_PRIVILEGES</td>
</tr>
<tr>
<td>RDB$VIEW_RELATIONS</td>
</tr>
<tr>
<td>Appendix E: Monitoring Tables</td>
</tr>
<tr>
<td>MON$ATTACHMENTS</td>
</tr>
<tr>
<td>Using MON$ATTACHMENTS to Kill a Connection</td>
</tr>
<tr>
<td>MON$COMPiled_STATEMENTS</td>
</tr>
<tr>
<td>MON$CALL_STACK</td>
</tr>
<tr>
<td>MON$CONTEXT_VARIABLES</td>
</tr>
<tr>
<td>MON$DATABASE</td>
</tr>
<tr>
<td>MON$IO_STATS</td>
</tr>
<tr>
<td>MON$MEMORY_USAGE</td>
</tr>
<tr>
<td>MON$RECORD_STATS</td>
</tr>
<tr>
<td>MON$STATEMENTS</td>
</tr>
<tr>
<td>Using MON$STATEMENTS to Cancel a Query</td>
</tr>
<tr>
<td>MON$TABLE_STATS</td>
</tr>
<tr>
<td>MON$TRANSACTIONS</td>
</tr>
<tr>
<td>Appendix F: Security tables</td>
</tr>
<tr>
<td>SEC$DB_CREATORS</td>
</tr>
<tr>
<td>Table of Contents</td>
</tr>
<tr>
<td>-------------------</td>
</tr>
<tr>
<td>SEC$GLOBAL_AUTH_MAPPING</td>
</tr>
<tr>
<td>SEC$USERS</td>
</tr>
<tr>
<td>SEC$USER_ATTRIBUTES</td>
</tr>
<tr>
<td>Appendix G: Plugin tables</td>
</tr>
<tr>
<td>PLG$PROF_CURSORS</td>
</tr>
<tr>
<td>PLG$PROF_PSQL_STATS</td>
</tr>
<tr>
<td>PLG$PROF_PSQL_STATS_VIEW</td>
</tr>
<tr>
<td>PLG$PROF_RECORD_SOURCES</td>
</tr>
<tr>
<td>PLG$PROF_RECORD_SOURCE_STATS</td>
</tr>
<tr>
<td>PLG$PROF_RECORD_SOURCE_STATS_VIEW</td>
</tr>
<tr>
<td>PLG$PROF_REQUESTS</td>
</tr>
<tr>
<td>PLG$PROF_SESSIONS</td>
</tr>
<tr>
<td>PLG$PROF_STATEMENTS</td>
</tr>
<tr>
<td>PLG$PROF_STATEMENT_STATS VIEW</td>
</tr>
<tr>
<td>PLG$SRP</td>
</tr>
<tr>
<td>PLG$USERS</td>
</tr>
<tr>
<td>Appendix H: Character Sets and Collations</td>
</tr>
<tr>
<td>Appendix I: License notice</td>
</tr>
<tr>
<td>Appendix J: Document History</td>
</tr>
</tbody>
</table>
Chapter 1. About the Firebird 5.0 Language Reference

This Language Reference describes the SQL language supported by Firebird 5.0.

This Firebird 5.0 Language Reference is the fourth comprehensive manual to cover all aspects of the query language used by developers to communicate, through their applications, with the Firebird relational database management system.

1.1. Subject

The subject of this volume is Firebird’s implementation of the SQL (“Structured Query Language”) relational database language. Firebird conforms closely with international standards for SQL, from data type support, data storage structures, referential integrity mechanisms, to data manipulation capabilities and access privileges. Firebird also implements a robust procedural language—procedural SQL (PSQL)—for stored procedures, stored functions, triggers, and dynamically-executable code blocks. These areas are addressed in this volume.

This document does not cover configuration of Firebird, Firebird command-line tools, nor its programming APIs. See Firebird RDBMS, and specifically Reference Manuals for more Firebird documentation.

1.2. Authorship

For the Firebird 5.0 version, the Firebird 4.0 Language Reference was taken as the base, and Firebird 5.0 information was added based on the Firebird 5.0 Release Notes and feature documentation.

1.2.1. Contributors

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1.3. Reporting Errors or Missing Content

If you find errors, missing content or other problems in this document, please report this in our issue tracker of the firebird-documentation GitHub repository.

Pull requests with changes and fixes are also much appreciated.

1.4. Acknowledgments

Sponsors and Other Donors

See also the Acknowledgements in the Firebird 2.5 Language Reference for the sponsors of the initial Russian version and its translation.


Moscow Exchange (Russia)

*Moscow Exchange is the largest exchange holding in Russia and Eastern Europe, founded on December 19, 2011, through the consolidation of the MICEX (founded in 1992) and RTS (founded in 1995) exchange groups. Moscow Exchange ranks among the world's top 20 exchanges by trading in bonds and by the total capitalization of shares traded, as well as among the 10 largest exchange platforms for trading derivatives.*

IBSurgeon (ibase.ru) (Russia)

*Technical support and developer of administrator tools for the Firebird DBMS.*

1.5. Contributing

There are several ways you can contribute to the documentation of Firebird, or Firebird in general:

- Participate on the mailing lists
- Report bugs or submit pull requests on the FirebirdSQL GitHub Project
- Become a developer (contact us on firebird-devel)
- Donate to the Firebird Foundation
- Become a paying member or sponsor of the Firebird Foundation
Chapter 2. SQL Language Structure

This reference describes the SQL language supported by Firebird.

2.1. Background to Firebird’s SQL Language

To begin, a few points about some characteristics of Firebird’s SQL implementation.

2.1.1. SQL Flavours

Distinct subsets of SQL apply to different areas of activity. The SQL subsets in Firebird’s language implementation are:

- **DSQL** Dynamic SQL
- **PSQL** Procedural SQL
- **ESQL** Embedded SQL
- **ISQL** Interactive SQL

*Dynamic SQL* is the major part of the language which corresponds to Part 2 (SQL/Foundation) of the SQL specification. DSQL represents statements passed by client applications through the public Firebird API and processed by the database engine.

*Procedural SQL* augments Dynamic SQL to allow compound statements containing local variables, assignments, conditions, loops and other procedural constructs. PSQL corresponds to Part 4 (SQL/PSM) of the SQL specifications. PSQL extensions are available in persistent stored modules (procedures, functions and triggers), and in Dynamic SQL as well (see **EXECUTE BLOCK**).

*Embedded SQL* is the SQL subset supported by Firebird *gpre*, the application which allows you to embed SQL constructs into your host programming language (C, C++, Pascal, Cobol, etc.) and preprocess those embedded constructs into the proper Firebird API calls.

Only a subset of the statements and expressions implemented in DSQL are supported in ESQL.

*Interactive ISQL* refers to the language that can be executed using Firebird *isql*, the command-line application for accessing databases interactively. As a regular client application, its native language is DSQL. It also offers a few additional commands that are not available outside its specific environment.

Both DSQL and PSQL subsets are completely presented in this reference. Neither ESQL nor ISQL flavours are described here unless mentioned explicitly.

For ISQL, consult the manual *Firebird Interactive SQL Utility*. 
2.1.2. SQL Dialects

SQL dialect is a term that defines the specific features of the SQL language that are available when accessing a database. SQL dialects can be defined at the database level and specified at the connection level. Three dialects are available:

- **Dialect 1** is intended solely to allow backward compatibility with legacy databases from old InterBase versions, version 5 and below. A “Dialect 1” database retains certain language features that differ from Dialect 3, the default for Firebird databases.
  
  ◦ Date and time information are stored in a DATE data type. A TIMESTAMP data type is also available, that is identical to this DATE implementation.
  
  ◦ Double quotes may be used as an alternative to apostrophes for delimiting string data. This is contrary to the SQL standard—double quotes are reserved for a distinct syntactic purpose both in standard SQL and in Dialect 3. Double-quoting strings is therefore to be avoided.
  
  ◦ The precision for NUMERIC and DECIMAL data types is smaller than in Dialect 3 and, if the precision of a fixed decimal number is greater than 9, Firebird stores it internally as a double-precision floating point value.
  
  ◦ The BIGINT (64-bit integer) data type is not supported.
  
  ◦ Identifiers are case-insensitive and must always comply with the rules for regular identifiers — see the section Identifiers below.
  
  ◦ Although generator values are stored as 64-bit integers, a Dialect 1 client request, SELECT GEN_ID (MyGen, 1), for example, will return the generator value truncated to 32 bits.

- **Dialect 2** is available only on a Firebird client connection and cannot be set in a database. It is intended to assist debugging of possible problems with legacy data when migrating a database from dialect 1 to 3.

- **In Dialect 3 databases,**
  
  ◦ numbers (DECIMAL and NUMERIC data types) are stored as fixed-point values (scaled integers) for all precisions; depending on the type and precision, they are stored as a SMALLINT, INTEGER, BIGINT or INT128.
  
  ◦ The TIME data type is available for storing time-of-day data.
  
  ◦ The DATE data type stores only date information.
  
  ◦ The TIMESTAMP data type stores date and time information.
  
  ◦ The 64-bit integer data type BIGINT is available.
  
  ◦ Double quotes are reserved for delimiting non-regular identifiers, enabling object names that are case-sensitive or that do not meet the requirements for regular identifiers in other ways.
  
  ◦ Strings must be delimited with single quotes (apostrophes) or using Q-strings.
  
  ◦ Generator values are stored as 64-bit integers.

Use of Dialect 3 is strongly recommended for newly developed databases and applications. Both database and connection dialects should match, except under
migration conditions with Dialect 2.

This reference describes the semantics of SQL Dialect 3 unless specified otherwise.

### 2.1.3. Error Conditions

Processing of every SQL statement either completes successfully or fails due to a specific error condition. Error handling can be done both client-side in the application, or server-side using PSQL.

### 2.2. Basic Elements: Statements, Clauses, Keywords

The primary construct in SQL is the *statement*. A statement defines what the database management system should do with a particular data or metadata object. More complex statements contain simpler constructs — *clauses* and *options*.

#### Clauses

A clause defines a certain type of directive in a statement. For instance, the *WHERE* clause in a *SELECT* statement and in other data manipulation statements (e.g. *UPDATE*, *DELETE*) specifies criteria for searching one or more tables for the rows that are to be selected, updated or deleted. The *ORDER BY* clause specifies how the output data — result set — should be sorted.

#### Options

Options, being the simplest constructs, are specified in association with specific keywords to provide qualification for clause elements. Where alternative options are available, it is usual for one of them to be the default, used if nothing is specified for that option. For instance, the *SELECT* statement will return all rows that match the search criteria unless the *DISTINCT* option restricts the output to non-duplicated rows.

#### Keywords

All words that are included in the SQL lexicon are keywords. Some keywords are *reserved*, meaning their usage as identifiers for database objects, parameter names or variables is prohibited in some or all contexts. Non-reserved keywords can be used as identifiers, although this is not recommended. From time to time, non-reserved keywords may become reserved, or new (reserved or non-reserved) keywords may be added when new language feature are introduced. Although unlikely, reserved words may also change to non-reserved keywords, or keywords may be removed entirely, for example when parser rules change.

For example, the following statement will be executed without errors because, although *ABS* is a keyword, it is not a reserved word.

```sql
CREATE TABLE T (ABS INT NOT NULL);
```

On the contrary, the following statement will return an error because *ADD* is both a keyword and a reserved word.

```sql
CREATE TABLE T (ADD INT NOT NULL);
```
2.3. Identifiers

All database objects have names, often called identifiers. The maximum identifier length is 63 characters character set UTF8 (252 bytes).

It is possible to restrict the actual maximum identifier length through configuration. Consult the Firebird 4.0 Release Notes for details. In this language reference we assume the default configuration of 63 characters (252 bytes).

Two types of names are valid as identifiers: regular identifiers, similar to variable names in regular programming languages, and delimited identifiers that are specific to SQL. To be valid, each type of identifier must conform to a set of rules, as follows:

2.3.1. Rules for Regular Identifiers

- Length cannot exceed 63 characters
- The name must start with an unaccented, 7-bit ASCII alphabetic character. It may be followed by other 7-bit ASCII letters, digits, underscores or dollar signs. No other characters, including spaces, are valid. The name is case-insensitive, meaning it can be declared and used in either upper or lower case. Thus, from the system's point of view, the following names are the same:

  ```
  fullname
  FULLNAME
  FuLlNaMe
  FullName
  ```

- Regular identifiers are stored in uppercase

**Regular name syntax**

```plaintext
<name> ::= <letter> | <name><letter> | <name><digit> | <name>_ | <name>$

<letter> ::= <upper letter> | <lower letter>

<upper letter> ::= A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

<lower letter> ::= a | b | c | d | e | f | g | h | i | j | k | l | m | n | o | p | q | r | s | t | u | v | w | x | y | z

<digit> ::= 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9
```
2.3.2. Rules for Delimited Identifiers

- Length cannot exceed 63 characters in character set UTF8 (252 bytes). Identifiers are stored in character set UTF8, which means characters outside the ASCII range are stored using 2 to 4 bytes.
- The entire string must be enclosed in double-quotes, e.g. "anIdentifier"
- A double-quote in an identifier can be escaped by doubling it, e.g. "with""doublequote"; we recommend avoiding double-quotes in delimited identifiers.
- It may contain any character from the UTF8 character set, including accented characters, spaces and special characters
- An identifier can be a reserved word
- Delimited identifiers are stored as-is and are case-sensitive in all contexts
- Trailing spaces in delimited identifiers are removed, as with any string constant
- Delimited identifiers are available in Dialect 3 only. For more details on dialects, see SQL Dialects

Delimited identifier syntax

\[
<\text{delimited identifier}> ::= \"<\text{permitted character}>[<\text{permitted character}> ...]\"
\]

A delimited identifier such as "FULLNAME" is the same as the regular identifiers FULLNAME, fullname, FullName, and so on. The reason is that Firebird stores regular identifiers in upper case, regardless of how they were defined or declared. Delimited identifiers are always stored according to the exact case of their definition or declaration. Thus, "FullName" (quoted, or delimited) is different from FullName (unquoted, or regular) which is stored as FULLNAME in the metadata.

2.4. Literals

Literals are used to directly represent values in a statement. Examples of standard types of literals are:

- integer        - 0, -34, 45, 0X080000000;
- fixed-point    - 0, 0.0, -3.14
- floating-point - 3.23e-23;
- string         - 'text', 'don''t!', Q'{don't!}';
- binary string  - x'48656C6C6F20776F726C64'
- date           - DATE '2018-01-19';
- time           - TIME '15:12:56';
- timestamp      - TIMESTAMP '2018-01-19 13:32:02';
- boolean        - true, false, unknown
- null state     - null

Details about literals for each data type are discussed in section Literals (Constants) of chapter Common Language Elements.
2.5. Operators and Special Characters

A set of special characters is reserved for use as operators or separators.

<special char> ::= any of <space> or "%'(*+,.-;/:<=>?>|^{|}

Some of these characters, alone or in combination, may be used as operators (arithmetical, string, logical), as SQL command separators, to quote identifiers, or to mark the limits of string literals or comments.

Operator Syntax

<operator> ::= <string concatenation operator> | <arithmetic operator> | <comparison operator> | <logical operator>

<string concatenation operator> ::= '||'

<arithmetic operator> ::= * / + -

<comparison operator> ::= = <> != ~= ^= > < >= <= !> ~> ^> !< ~< ^<

<logical operator> ::= NOT | AND | OR

For more details on operators, see Expressions.

2.6. Comments

Comments may be present in SQL scripts, SQL statements and PSQL modules. A comment can be any text, usually used to document how particular parts of the code work. The parser ignores the text of comments.

Firebird supports two types of comments: block (or bracketed) and in-line (or simple).

Syntax

<comment> ::= <block comment> | <single-line comment>

<block comment> ::= /* <character>[<character> ...] */

<single-line comment> ::=
Block comments start with the /* character pair and end with the */ character pair. Text in block comments may be of any length and can occupy multiple lines.

In-line comments start with a pair of hyphen characters, -- and continue until the first linebreak (end of line).

Example

```sql
CREATE PROCEDURE P(APARAM INT)
  RETURNS (B INT)
AS
BEGIN
  /* This text will be ignored during the execution of the statement
     since it is a comment */
  B = A + 1; -- In-line comment
  SUSPEND;
END
```
Chapter 3. Data Types and Subtypes

Data of various types are used to:

- Define columns in a database table in the `CREATE TABLE` statement or change columns using `ALTER TABLE`.
- Declare or change a domain using the `CREATE DOMAIN` or `ALTER DOMAIN` statements.
- Declare local variables, return values and parameters in PSQL modules and UDFs—user-defined functions.
- Provide arguments for the `CAST()` function when explicitly converting data from one type to another.

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Precision &amp; Limits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIGINT</td>
<td>64 bits</td>
<td>From $-2^{63}$ to $(2^{63} - 1)$</td>
<td>Signed 64-bit integer. This data type is available in Dialect 3 only.</td>
</tr>
<tr>
<td>BINARY($n$)</td>
<td>$n$ bytes</td>
<td>from 1 to 32,767 bytes</td>
<td>A fixed-length binary data type; synonym for <code>CHAR($n$) CHARACTER SET OCTETS</code> Values shorter than the declared length are padded with NUL (0x00) up to the declared length. If the number of characters is not specified, 1 is used by default.</td>
</tr>
<tr>
<td>BLOB</td>
<td>Varying</td>
<td>The size of a BLOB segment is limited to 64K. The maximum size of a BLOB field is 4 GB.</td>
<td>A data type of variable size for storing large amounts of data, such as images, text, digital sounds. The blob subtype defines its content. Depending on the page size, BLOBs can exceed 4 GB, but some built-in functions and features may not be able to access data beyond 4 GB.</td>
</tr>
<tr>
<td>BOOLEAN</td>
<td>1 byte</td>
<td>false, true, unknown</td>
<td>Boolean data type</td>
</tr>
<tr>
<td>CHAR($n$), CHARACTER($n$)</td>
<td>$n$ characters. Size in bytes depends on the encoding, the number of bytes in a character</td>
<td>from 1 to 32,767 bytes</td>
<td>A fixed-length character data type. Values shorter than the declared length are padded with spaces (0x20) — or NUL (0x00) for character set OCTETS — up to the declared length. If the number of characters is not specified, 1 is used by default.</td>
</tr>
<tr>
<td>Name</td>
<td>Size</td>
<td>Precision &amp; Limits</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>DATE</td>
<td>4 bytes</td>
<td>From 0001-01-01 AD to 9999-12-31 AD</td>
<td>Date only, no time element</td>
</tr>
<tr>
<td>DECFLOAT((\text{dec_prec}))</td>
<td>64 or 128 bits</td>
<td>\text{dec_prec} = 16 or 34, defines the number of decimal digits</td>
<td>Decimal floating-point type, IEEE-754 \textit{decimal64} or \textit{decimal128}. If the precision is not specified, 34 is used by default.</td>
</tr>
<tr>
<td>DECIMAL((\text{precision, scale}))</td>
<td>Varying (16, 32, 64 or 128 bits)</td>
<td>\text{precision} = from 1 to 38, defines the minimum number of digits to store; \text{scale} = from 0 to 38, defines the number of digits after the decimal point</td>
<td>A number with a decimal point that has \text{scale} digits after the point. \text{scale} must be less than or equal to \text{precision}. Example: \text{DECIMAL}(10,3) contains a number in exactly the following format: ppppppp.sss</td>
</tr>
<tr>
<td>DOUBLE PRECISION</td>
<td>64 bits</td>
<td>2.225 * 10^{-308} to 1.797 * 10^{308}</td>
<td>Double-precision, IEEE-754 \textit{binary64}, ~15 digits, reliable size depends on the platform</td>
</tr>
<tr>
<td>FLOAT</td>
<td>32 bits</td>
<td>1.175 * 10^{-38} to 3.402 * 10^{38}</td>
<td>Single-precision, IEEE-754 \textit{binary32}, ~7 digits</td>
</tr>
<tr>
<td>FLOAT((\text{bin_prec}))</td>
<td>32 or 64 bits</td>
<td>\text{bin_prec} = from 1 to 53, binary precision</td>
<td>Binary precision 1 - 24: synonym for \text{FLOAT} (32-bit single precision) 25 - 53: synonym for \text{DOUBLE PRECISION} (64-bit double precision)</td>
</tr>
<tr>
<td>INTEGER, INT</td>
<td>32 bits</td>
<td>-2,147,483,648 up to 2,147,483,647</td>
<td>Signed 32-bit integer</td>
</tr>
<tr>
<td>INT128</td>
<td>128 bits</td>
<td>From (-2^{127}) to (2^{127}) minus 1</td>
<td>Signed 128-bit integer</td>
</tr>
<tr>
<td>NUMERIC((\text{precision, scale}))</td>
<td>Varying (16, 32, 64 or 128 bits)</td>
<td>\text{precision} = from 1 to 38, defines the minimum number of digits to store; \text{scale} = from 0 to 38, defines the number of digits after the decimal point</td>
<td>A number with a decimal point that has \text{scale} digits after the point. \text{scale} must be less than or equal to \text{precision}. Example: \text{NUMERIC}(10,3) contains a number in exactly the following format: ppppppp.sss</td>
</tr>
<tr>
<td>REAL</td>
<td>32 bits</td>
<td>-32,768 to 32,767</td>
<td>Synonym for \text{FLOAT}</td>
</tr>
<tr>
<td>SMALLINT</td>
<td>16 bits</td>
<td></td>
<td>Signed short (word)</td>
</tr>
</tbody>
</table>
### Name

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Precision &amp; Limits</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIME [WITHOUT TIME ZONE]</td>
<td>4 bytes</td>
<td>0:00 to 23:59:59.9999</td>
<td>Time of day. It cannot be used to store an interval of time.</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>6 bytes</td>
<td>0:00 to 23:59:59.9999</td>
<td>Time of day with either a time zone offset or named zone. It cannot be used to store an interval of time.</td>
</tr>
<tr>
<td>TIMESTAMP [WITHOUT TIME ZONE]</td>
<td>8 bytes</td>
<td>From start of day 0001-01-01 AD to end of day 9999-12-31 AD</td>
<td>Date and time of day</td>
</tr>
<tr>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>10 bytes</td>
<td>From start of day 0001-01-01 AD to end of day 9999-12-31 AD</td>
<td>Date and time of day with either a time zone offset or named zone.</td>
</tr>
<tr>
<td>VARBINARY(n), BINARY VARYING(n)</td>
<td>n bytes</td>
<td>from 1 to 32,765 bytes</td>
<td>Variable length string type; synonym for VARCHAR(n) CHARACTER SET OCTETS. The total size cannot be larger than (32KB-3). The two leading bytes store the declared length. There is no default size: the n argument is mandatory. Leading and trailing NUL characters are stored, and they are not trimmed, except for those trailing characters that are past the declared length.</td>
</tr>
<tr>
<td>VARCHAR(n), CHARACTER VARYING(n)</td>
<td>n characters. Size in bytes depends on the encoding, the number of bytes in a character</td>
<td>from 1 to 32,765 bytes</td>
<td>Variable length string type. The total size of characters in bytes cannot be larger than (32KB-3), taking into account their encoding. The two leading bytes store the declared length. There is no default size: the n argument is mandatory. Leading and trailing spaces are stored, and they are not trimmed, except for those trailing characters that are past the declared length.</td>
</tr>
</tbody>
</table>

---

**Note About Dates**

Bear in mind that a time series consisting of dates in past centuries is processed without taking into account the actual historical facts, as though the Gregorian calendar were applicable throughout the entire series.
3.1. Integer Data Types

The SMALLINT, INTEGER, BIGINT and INT128 data types are used for integers of various precision in Dialect 3. Firebird does not support an unsigned integer data type.

3.1.1. SMALLINT

The 16-bit SMALLINT data type is for compact data storage of integer data for which only a narrow range of possible values is required. Numbers of the SMALLINT type are within the range from $-2^{16}$ to $2^{16} - 1$, that is, from -32,768 to 32,767.

**SMALLINT Examples**

```sql
CREATE DOMAIN DFLAG AS SMALLINT DEFAULT 0 NOT NULL CHECK (VALUE=-1 OR VALUE=0 OR VALUE=1);
CREATE DOMAIN RGB_VALUE AS SMALLINT;
```

3.1.2. INTEGER

The INTEGER — or INT — data type is a 32-bit integer. Numbers of the INTEGER type are within the range from $-2^{32}$ to $2^{32} - 1$, that is, from -2,147,483,648 to 2,147,483,647.

**INTEGER Example**

```sql
CREATE TABLE CUSTOMER (
    CUST_NO INTEGER NOT NULL,
    CUSTOMER VARCHAR(25) NOT NULL,
    CONTACT_FIRST VARCHAR(15),
    CONTACT_LAST VARCHAR(20),
    ...
    PRIMARY KEY (CUST_NO) )
```

3.1.3. BIGINT

BIGINT is a 64-bit integer data type, available only in Dialect 3.

Numbers of the BIGINT type are within the range from $-2^{63}$ to $2^{63} - 1$, or from -9,223,372,036,854,775,808 to 9,223,372,036,854,775,807.

3.1.4. INT128

INT128 is a 128-bit integer data type. This type is not defined in the SQL standard.

Numbers of the INT128 type are within the range from $-2^{127}$ to $2^{127} - 1$. 
3.1.5. Hexadecimal Format for Integer Numbers

Constants of integer types can be specified in a hexadecimal format by means of 1 to 8 digits for INTEGER, 9 to 16 hexadecimal digits for BIGINT, and 10 to 32 hexadecimal digits for INT128. Hex representation for writing to SMALLINT is not explicitly supported, but Firebird will transparently convert a hex number to SMALLINT if necessary, provided it falls within the ranges of negative and positive SMALLINT.

The usage and numerical value ranges of hexadecimal notation are described in more detail in the discussion of number constants in the chapter entitled Common Language Elements.

Examples Using Integer Types

```sql
CREATE TABLE WHOLELOTTARECORDS (  
    ID BIGINT NOT NULL PRIMARY KEY,  
    DESCRIPTION VARCHAR(32)  
);  
INSERT INTO MYBIGINTS VALUES (  
    -236453287458723,  
    328832607832,  
    22,  
    -56786237632476,  
    0X6F55A09D42, -- 478177959234  
    0X7FFFFFFFFFFFFFF, -- 9223372036854775807  
    0XFFFFFFFFFFFFFFFF, -- -1  
    0X80000000, -- -2147483648, an INTEGER  
    0X0800000000, -- 2147483648, a BIGINT  
    0XFFFFFFFF, -- -1, an INTEGER  
    0X0FFFFFFFF -- 4294967295, a BIGINT  
);  
```

The hexadecimal INTEGERS in the above example are automatically cast to BIGINT before being inserted into the table. However, this happens after the numerical value is determined, so 0x80000000 (8 digits) and 0x0800000000 (9 digits) will be stored as different BIGINT values.

3.2. Floating-Point Data Types

Firebird supports two types of floating-point data types: approximate or binary floating-point data types (FLOAT and DOUBLE PRECISION), and decimal floating-point types (DECFLOAT).

3.2.1. Approximate Floating-Point Data Types

Approximate floating-point values are stored in an IEEE 754 binary format that comprises sign, exponent and mantissa. Precision is dynamic, corresponding to the physical storage format of the value, which is exactly 4 bytes for the FLOAT type and 8 bytes for DOUBLE PRECISION.

Considering the peculiarities of storing floating-point numbers in a database, these data types are not recommended for storing monetary data. For the same reasons, columns with floating-point
data are not recommended for use as keys or to have uniqueness constraints applied to them.

For testing data in columns with floating-point data types, expressions should check using a range, for instance, BETWEEN, rather than searching for exact matches.

When using these data types in expressions, extreme care is advised regarding the rounding of evaluation results.

FLOAT

_Data Type Declaration Format_

```
FLOAT [(bin_prec)]
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bin_prec</td>
<td>Precision in binary digits, default is 24</td>
</tr>
</tbody>
</table>

The FLOAT data type defaults to a 32-bit single precision floating-point type with an approximate precision of 7 decimal digits after the decimal point (24 binary digits). To ensure the safety of storage, rely on 6 decimal digits of precision.

The syntax `FLOAT(bin_prec)` behaves as follows:

- 1 <= _bin_prec <= 23: 32-bit single precision (synonym for FLOAT)
- 25 <= _bin_prec <= 53: 64-bit double precision (synonym for DOUBLE PRECISION)

The behaviour of FLOAT (without explicit precision) behaves as the SQL standard type REAL.

_REAL_

_Data Type Declaration Format_

```
REAL
```
The data type REAL is a synonym for FLOAT, and is provided for syntax compatibility. When used to define a column or parameter, it's indistinguishable from using FLOAT or FLOAT(1) — FLOAT(24).

**Compatibility Note**

- REAL has been available as a synonym for FLOAT since Firebird 1.0 and even earlier, but was never documented.
- Most Firebird tools will report FLOAT instead of REAL.

**DOUBLE PRECISION**

*Data Type Declaration Format*

```
DOUBLE PRECISION
```

The DOUBLE PRECISION data type is stored with an approximate precision of 15 digits.

**Compatibility Notes**

- Firebird also has the — previously undocumented — synonyms for DOUBLE PRECISION: LONG FLOAT and LONG FLOAT(bin_prec), with 1 <= bin_prec <= 53.

These non-standard type names are deprecated and may be removed in a future Firebird version.

- Firebird 3.0 and earlier supported LONG FLOAT(dec_prec) where dec_prec was the approximate precision in decimal digits, where any value for dec_prec mapped to 64-bit double precision.

### 3.2.2. Decimal Floating-Point Types

Decimal floating-point values are stored in an IEEE 754 decimal format that comprises sign, exponent and coefficient. Contrary to the approximate floating-point data types, precision is either 16 or 34 decimal digits.

**DECFLOAT**

*Data Type Declaration Format*

```
DECFLOAT [(dec_prec)]
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dec_prec</td>
<td>Precision in decimal digits, either 16 or 34. Default is 34.</td>
</tr>
</tbody>
</table>

DECFLOAT is a SQL standard-compliant numeric type that stores floating-point number precisely (decimal floating-point type), unlike FLOAT or DOUBLE PRECISION that provide a binary approximation of the purported precision.
The type is stored and transmitted as IEEE 754 standard types `Decimal64` (DECFLOAT(16)) or `Decimal128` (DECFLOAT(34)).

All intermediate calculations are performed with 34-digit values.

16-digit and 34-digit

The “16” and “34” refer to the maximum precision in Base-10 digits. See [https://en.wikipedia.org/wiki/iEEE_754#Basic_and_interchange_formats](https://en.wikipedia.org/wiki/iEEE_754#Basic_and_interchange_formats) for a comprehensive table.

<table>
<thead>
<tr>
<th>Type</th>
<th>Maximum precision</th>
<th>Minimum Exponent</th>
<th>Maximum Exponent</th>
<th>Smallest value</th>
<th>Largest value</th>
</tr>
</thead>
<tbody>
<tr>
<td>DECFLOAT(16)</td>
<td>16</td>
<td>-383</td>
<td>+384</td>
<td>1E-398</td>
<td>9.9..9E+384</td>
</tr>
<tr>
<td>DECFLOAT(34)</td>
<td>34</td>
<td>-6143</td>
<td>+6144</td>
<td>1E-6176</td>
<td>9.9..9E+6144</td>
</tr>
</tbody>
</table>

Observe that although the smallest exponent for DECFLOAT(16) is -383, the smallest value has an exponent of -398, but 15 fewer digits. And similar for DECFLOAT(34), smallest exponent is -6143, but the smallest value has an exponent of -6176, but 33 fewer digits. The reason is that precision was “sacrificed” to be able to store a smaller value.

This is a result of how the value is stored: as a decimal value of 16 or 34 digits and an exponent. For example, \(1.234567890123456 \times 10^{-383}\) is stored as coefficient 1234567890123456 and exponent -398, while \(1 \times 10^{-398}\) is stored as coefficient 1, exponent -398.

Behaviour of DECFLOAT Operations

The behaviour of DECFLOAT operations in a session, specifically rounding and error behaviour, can be configured using the `SET DECFLOAT` management statement, and the `isc_dpb_decfloat_round` and `isc_dpb_decfloat_traps` DPB items.

Length of DECFLOAT Literals

It is possible to express DECFLOAT(34) values in approximate numeric literals, but only for values with a mantissa of 20 or more digits, or an absolute exponent larger than 308. Scientific notation literals with fewer digits or a smaller absolute exponent are DOUBLE PRECISION literals. Exact numeric literals with 40 or more digits — actually 39 digits, when larger than the maximum INT128 value — are also handled as DECFLOAT(34).

Alternatively, use a string literal and explicitly cast to the desired DECFLOAT type.

The length of DECFLOAT literals cannot exceed 1024 characters. Scientific notation is required for greater values. For example, \(0.0<1020 \text{ zeroes}>11\) cannot be used as a literal, but the equivalent in scientific notation, \(1.1E-1022\), is valid. Similarly, \(10<1022 \text{ zeroes}>0\) can be presented as \(1.0E1024\). Literals with more than 34 significant digits are rounded using the DECFLOAT rounding mode of the session.
### DECFLOAT and Functions

#### Use with Standard Functions

A number of standard scalar functions can be used with expressions and values of the DECFLOAT type. They are:

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS</td>
<td>Absolute value</td>
</tr>
<tr>
<td>CEILING</td>
<td>Ceiling value</td>
</tr>
<tr>
<td>EXP</td>
<td>Exponential</td>
</tr>
<tr>
<td>FLOOR</td>
<td>Floor value</td>
</tr>
<tr>
<td>LN</td>
<td>Natural logarithm</td>
</tr>
<tr>
<td>LOG</td>
<td>Logarithm</td>
</tr>
<tr>
<td>LOG10</td>
<td>Logarithm base 10</td>
</tr>
<tr>
<td>POWER</td>
<td>Power</td>
</tr>
<tr>
<td>SIGN</td>
<td>Sign value</td>
</tr>
<tr>
<td>SQRT</td>
<td>Square root</td>
</tr>
</tbody>
</table>

The aggregate functions SUM, AVG, MAX and MIN work with DECFLOAT data, as do all the statistical aggregates (including but not limited to STDDEV or CORR).

### Special Functions for DECFLOAT

Firebird supports four functions, designed to support DECFLOAT data specifically:

**COMPARE_DECFLOAT**
- compares two DECFLOAT values to be equal, different or unordered

**NORMALIZE_DECFLOAT**
- takes a single DECFLOAT argument and returns it in its simplest form

**QUANTIZE**
- takes two DECFLOAT arguments and returns the first argument scaled using the second value as a pattern

**TOTALORDER**
- performs an exact comparison on two DECFLOAT values

Detailed descriptions are available in the Special Functions for DECFLOAT section of the Built-in Scalar Functions chapter.

### 3.3. Fixed-Point Data Types

Fixed-point data types ensure the predictability of multiplication and division operations, making them the choice for storing monetary values. Firebird implements two fixed-point data types: NUMERIC and DECIMAL.

According to the SQL standard, both types limit the stored number to the declared scale (the number of digits after the decimal point). The standard defines different treatment of the precision for each type: precision for NUMERIC columns is exactly “as declared”, while DECIMAL columns accepts numbers whose precision is at least equal to what was declared.

The behaviour of both NUMERIC and DECIMAL in Firebird is like the SQL-standard DECIMAL; the precision is at least equal to what was declared.

For instance, NUMERIC(4, 2) defines a number consisting altogether of four digits, including two digits after the decimal point; that is, it can have up to two digits before the point[3] and no more
than two digits after the point. If the number 3.1415 is written to a column with this data type definition, the value of 3.14 will be saved in the NUMERIC(4, 2) column.

The form of declaration for fixed-point data, for instance, NUMERIC(p, s), is common to both types. The s argument in this template is scale. Understanding the mechanism for storing and retrieving fixed-point data should help to visualise why: for storage, the number is multiplied by 10^s (10 to the power of s), converting it to an integer; when read, the integer is converted back by multiplying by 10^-s (or, dividing by 10^s).

The method of storing fixed-point data in the database depends on several factors: declared precision, database dialect, declaration type.

Table 5. Method of Physical Storage for Fixed-Point Numbers

<table>
<thead>
<tr>
<th>Precision</th>
<th>Data type</th>
<th>Dialect 1</th>
<th>Dialect 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 4</td>
<td>NUMERIC</td>
<td>SMALLINT</td>
<td>SMALLINT</td>
</tr>
<tr>
<td>1 - 4</td>
<td>DECIMAL</td>
<td>INTEGER</td>
<td>INTEGER</td>
</tr>
<tr>
<td>5 - 9</td>
<td>NUMERIC or DECIMAL</td>
<td>INTEGER</td>
<td>INTEGER</td>
</tr>
<tr>
<td>10 - 18</td>
<td>NUMERIC or DECIMAL</td>
<td>DOUBLE PRECISION</td>
<td>BIGINT</td>
</tr>
<tr>
<td>19 - 38</td>
<td>NUMERIC or DECIMAL</td>
<td>INT128</td>
<td>INT128</td>
</tr>
</tbody>
</table>

Numerics with precision less than 19 digits use SMALLINT, INTEGER, BIGINT or DOUBLE PRECISION as the base data type, depending on the number of digits and SQL dialect. When precision is between 19 and 38 digits an INT128 is used as the base data type, and the actual precision is always extended to the full 38 digits.

For complex calculations, those digits are cast internally to DECFLOAT(34). The result of various mathematical operations, such as LOG(), EXP() and so on, and aggregate functions using a high precision numeric argument, will be DECFLOAT(34).

### 3.3.1. NUMERIC

**Data Type Declaration Format**

```
NUMERIC [(precision [, scale])]
```

**Table 6. NUMERIC Type Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision, between 1 and 38. Defaults to 9.</td>
</tr>
<tr>
<td>scale</td>
<td>Scale, between 0 and precision. Defaults to 0.</td>
</tr>
</tbody>
</table>

**Storage Examples**

Further to the explanation above, Firebird will store NUMERIC data according the declared precision and scale. Some more examples are:
Always keep in mind that the storage format depends on the precision. For instance, you define the column type as `NUMERIC(2,2)` presuming that its range of values will be -0.99...0.99. However, the actual range of values for the column will be -327.68...327.67, which is due to storing the `NUMERIC(2,2)` data type in the `SMALLINT` format. In storage, the `NUMERIC(4,2)`, `NUMERIC(3,2)` and `NUMERIC(2,2)` data types are the same. This means that if you need to store data in a column with the `NUMERIC(2,2)` data type and limit the range to -0.99...0.99, you will have to create a `CHECK` constraint for it.

### 3.3.2. DECIMAL

**Data Type Declaration Format**

```sql
{ DECIMAL | DEC } [(precision [, scale])]
```

**Table 7. DECIMAL Type Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision, between 1 and 38. Defaults to 9.</td>
</tr>
<tr>
<td>scale</td>
<td>Scale, between 0 and <code>precision</code>. Defaults to 0.</td>
</tr>
</tbody>
</table>

**Storage Examples**

The storage format in the database for DECIMAL is similar to NUMERIC, with some differences that are easier to observe with the help of some more examples:

| DECIMAL(4) stored as | INTEGER (exact data) |
| DECIMAL(4,2)         | INTEGER (data * 10³) |
| DECIMAL(10,4) (Dialect 1) | DOUBLE PRECISION |
|                      (Dialect 3) | BIGINT (data * 10⁴) |
| DECIMAL(38,6)        | INT128 (data * 10⁶) |

### 3.4. Data Types for Dates and Times

The DATE, TIME and TIMESTAMP data types are used to work with data containing dates and times.

Time zone support is available using the types TIME WITH TIME ZONE and TIMESTAMP WITH TIME ZONE. In this language reference, we’ll use TIME and TIMESTAMP to refer both to the specific types without time zone — TIME [WITHOUT TIME ZONE] and TIMESTAMP [WITHOUT TIME ZONE] — and aspects of both the without time zone and with time zone types, which one we mean is usually clear from the context.
The data types `TIME WITHOUT TIME ZONE`, `TIMESTAMP WITHOUT TIME ZONE` and `DATE` are defined to use the session time zone when converting from or to a `TIME WITH TIME ZONE` or `TIMESTAMP WITH TIME ZONE`. `TIME` and `TIMESTAMP` are synonymous to their respective `WITHOUT TIME ZONE` data types.

Dialect 3 supports all the five types, while Dialect 1 has only `DATE`. The `DATE` type in Dialect 3 is “date-only”, whereas the Dialect 1 `DATE` type stores both date and time-of-day, equivalent to `TIMESTAMP` in Dialect 3. Dialect 1 has no “date-only” type.

Dialect 1 `DATE` data can be defined alternatively as `TIMESTAMP` and this is recommended for new definitions in Dialect 1 databases.

Fractions of Seconds

If fractions of seconds are stored in date and time data types, Firebird stores them to ten-thousandths of a second (100 microseconds or deci-milliseconds). If a lower granularity is preferred, the fraction can be specified explicitly as thousandths, hundredths or tenths of a second, or second, in Dialect 3 databases of ODS 11 or higher.

Some Useful Knowledge about Sub-second Precision

The time-part of a `TIME` or `TIMESTAMP` is a 32-bit integer, with room for deci-milliseconds (or 100 microseconds) precision and time values are stored as the number of deci-milliseconds elapsed since midnight. The actual precision of values stored in or read from time(stamp) functions and variables is:

- `CURRENT_TIME` and `LOCALTIME` default to seconds precision and can be specified up to milliseconds precision with `CURRENT_TIME({0|1|2|3})` or `LOCALTIME({0|1|2|3})`
- `CURRENT_TIMESTAMP` and `LOCALTIMESTAMP` default to milliseconds precision. Precision from seconds to milliseconds can be specified with `CURRENT_TIMESTAMP({0|1|2|3})` or `LOCALTIMESTAMP({0|1|2|3})`
- Literal 'NOW' defaults to milliseconds precision
- Functions `DATEADD()` and `DATEDIFF()` support up to deci-milliseconds precision with `MILLISECOND`
- The `EXTRACT()` function returns up to deci-milliseconds precision with the `SECOND` and `MILLISECOND` arguments
- the ‘+’ and ‘-’ operators work with deci-milliseconds precision.

Deci-milliseconds precision is not supported by all drivers and access components. The best assumption to make from all this is that, although Firebird stores `TIME` and the `TIMESTAMP` time-part values as the number of deci-milliseconds \(10^4\) seconds elapsed since midnight, the actual precision could vary from seconds to milliseconds.
Storage of Time Zone Types

The time zone types are stored as values at UTC (offset 0), using the structure of `TIME` or `TIMESTAMP` + two extra bytes for time zone information (either an offset in minutes, or the id of a named time zone). Storing as UTC allows Firebird to index and compare two values in different time zones.

Storing at UTC has some caveats:

- When you use named zones, and the time zone rules for that zone change, the UTC time stays the same, but the local time in the named zone may change.
- For `TIME WITH TIME ZONE`, calculating a time zone offset for a named zone to get the local time in the zone applies the rules valid at the 1st of January 2020 to ensure a stable value. This may result in unexpected or confusing results.
- When the rules of a named time zone changes, a value in the affected date range may no longer match the intended value if the actual offset in that named zone changes.

3.4.1. DATE

Syntax

```
DATE
```

The `DATE` data type in Dialect 3 stores only date without time. The available range for storing data is from January 01, 1 to December 31, 9999.

In Dialect 1, `DATE` is an alias for `TIMESTAMP`. Dialect 1 has no “date-only” type.

In Dialect 1, date literals without a time part, as well as casts of date mnemonics 'TODAY', 'YESTERDAY' and 'TOMORROW' automatically get a zero time part.

If you need to store a Dialect 1 timestamp literal with an explicit zero time-part, the engine will accept a literal like '2016-12-25 00:00:00.0000'. However, '2016-12-25' would have the same effect, with fewer keystrokes!

Storage of Dates

Internally, Firebird stores dates in a 32-bit integer as a `Modified Julian Date`, or the number of days since 1858-11-17. An additional restriction is imposed, limiting valid dates to the range from 0001-01-01 AD to 9999-12-31 AD.

3.4.2. TIME
Syntax

```
TIME [{ WITHOUT | WITH } TIME ZONE]
```

For a bare `TIME`, `WITHOUT TIME ZONE` is assumed.

The `TIME` data type is available in Dialect 3 only. It stores the time of day within the range from 00:00:00.0000 to 23:59:59.9999.

If you need to get the time-part from `DATE` in Dialect 1, you can use the `EXTRACT` function.

**Examples Using `EXTRACT()`**

```
EXTRACT (HOUR FROM DATE_FIELD)
EXTRACT (MINUTE FROM DATE_FIELD)
EXTRACT (SECOND FROM DATE_FIELD)
```

See also the `EXTRACT()` function in the chapter entitled *Built-in Scalar Functions*.

**TIME [WITHOUT TIME ZONE]**

The `TIME` (or synonym `TIME WITHOUT TIME ZONE`) represents a time without time zone information.

**TIME WITH TIME ZONE**

The `TIME WITH TIME ZONE` represents a time with time zone information (either an offset or a named zone).

Firebird uses the ICU implementation of the IANA Time Zone Database for named zones.

**Examples Using `EXTRACT()`**

```
EXTRACT (TIMEZONE_HOUR FROM TIME_TZ_FIELD)
EXTRACT (TIMEZONE_MINUTE FROM TIME_TZ_FIELD)
```

### 3.4.3. TIMESTAMP

**Syntax**

```
TIMESTAMP [{ WITHOUT | WITH } TIME ZONE]
```

For a bare `TIMESTAMP`, `WITHOUT TIME ZONE` is assumed.

The `TIMESTAMP` data type is available in Dialect 3 and Dialect 1. It comprises two 32-bit integers — a date-part and a time-part — to form a structure that stores both date and time-of-day. In Dialect 1, `DATE` is an alias for `TIMESTAMP`.

The `EXTRACT` function works equally well with `TIMESTAMP` as with the Dialect 1 `DATE` type.
**TIMESTAMP [WITHOUT TIME ZONE]**

The **TIMESTAMP** (or synonym **TIMESTAMP WITHOUT TIME ZONE**) represents a time and date without time zone information.

**TIMESTAMP WITH TIME ZONE**

The **TIMESTAMP WITH TIME ZONE** represents a time with time zone information (either an offset or a named zone).

### 3.4.4. Session Time Zone

As the name implies, the session time zone can be different for each database attachment. It can be set explicitly in the DPB with the item `isc_dpb_session_time_zone`; otherwise, by default, it uses the same time zone as the operating system of the Firebird server process. This default can be overridden in `firebird.conf`, setting `DefaultTimeZone`.

Drivers may apply different defaults, for example specifying the client time zone as the default session time zone. Check your driver documentation for details.

Subsequently, the time zone can be changed to a given time zone using a **SET TIME ZONE** statement or reset to its original value with **SET TIME ZONE LOCAL** or **ALTER SESSION RESET**.

### 3.4.5. Time Zone Format

A time zone is specified as a string, either a time zone region (for example, 'America/Sao_Paulo') or a displacement from GMT in hours:minutes (for example, '-03:00').

A time/timestamp with time zone is considered equal to another time/timestamp with time zone if their conversions to UTC are equivalent. For example, time '10:00 -02:00' and time '09:00 -03:00' are equivalent, since both are the same as time '12:00 GMT'.

The same equivalence applies in **UNIQUE** constraints and for sorting purposes.

### 3.4.6. Operations Using Date and Time Values

The method of storing date and time values makes it possible to involve them as operands in some arithmetic operations. In storage, a date value or date-part of a timestamp is represented as the number of days elapsed since "date zero" — November 17, 1858 — whilst a time value or the time-part of a timestamp is represented as the number of deci-milliseconds (100 microseconds) since midnight.

An example is to subtract an earlier date, time or timestamp from a later one, resulting in an interval of time, in days and fractions of days.

**Table 8. Arithmetic Operations for Date and Time Data Types**

<table>
<thead>
<tr>
<th>Operand 1</th>
<th>Operation</th>
<th>Operand 2</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>DATE</td>
<td>+</td>
<td>TIME</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td><strong>Operand 1</strong></td>
<td><strong>Operation</strong></td>
<td><strong>Operand 2</strong></td>
<td><strong>Result</strong></td>
</tr>
<tr>
<td>---------------</td>
<td>---------------</td>
<td>---------------</td>
<td>------------</td>
</tr>
<tr>
<td>DATE</td>
<td>+</td>
<td>TIME WITH TIME ZONE</td>
<td>TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td>DATE</td>
<td>+</td>
<td>Numeric value n</td>
<td>DATE increased by n whole days. Fractional values are rounded to the nearest integer</td>
</tr>
<tr>
<td>TIME</td>
<td>+</td>
<td>DATE</td>
<td>TIMESTAMP</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>+</td>
<td>DATE</td>
<td>TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td>TIME</td>
<td>+</td>
<td>Numeric value n</td>
<td>TIME increased by n seconds. The fractional part is taken into account</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>+</td>
<td>Numeric value n</td>
<td>TIME WITH TIME ZONE increased by n seconds. The fractional part is taken into account</td>
</tr>
<tr>
<td>TIMESTAMP</td>
<td>+</td>
<td>Numeric value n</td>
<td>TIMESTAMP, where the date will advance by the number of days and part of a day represented by number n — so “+ 2.75” will push the date forward by 2 days and 18 hours</td>
</tr>
<tr>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>+</td>
<td>Numeric value n</td>
<td>TIMESTAMP WITH TIME ZONE, where the date will advance by the number of days and part of a day represented by number n — so “+ 2.75” will push the date forward by 2 days and 18 hours</td>
</tr>
<tr>
<td>DATE</td>
<td>-</td>
<td>DATE</td>
<td>Number of days elapsed, within the range DECIMAL(9, 0)</td>
</tr>
<tr>
<td>DATE</td>
<td>-</td>
<td>Numeric value n</td>
<td>DATE reduced by n whole days. Fractional values are rounded to the nearest integer</td>
</tr>
<tr>
<td>TIME</td>
<td>-</td>
<td>TIME</td>
<td>Number of seconds elapsed, within the range DECIMAL(9, 4)</td>
</tr>
<tr>
<td>TIME</td>
<td>-</td>
<td>TIME WITH TIME ZONE</td>
<td>The without time zone value is converted to WITH TIME ZONE in the current session time zone. Number of seconds elapsed between the UTC values, within the range DECIMAL(9, 4). Also applies when swapping types.</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>-</td>
<td>TIME WITH TIME ZONE</td>
<td>Number of seconds elapsed between the UTC values, within the range DECIMAL(9, 4)</td>
</tr>
<tr>
<td>TIME</td>
<td>-</td>
<td>Numeric value n</td>
<td>TIME reduced by n seconds. The fractional part is taken into account</td>
</tr>
</tbody>
</table>
### Notes

In Dialect 1, the **DATE** type is considered an alias of **TIMESTAMP**.

**See also**

**DATEADD, DATEDIFF**

#### 3.4.7. Supplemental Time Zone Features

Firebird provides a number of features to discover time zone information.

**Virtual table RDB$TIME_ZONES**

A virtual table listing time zones supported in the engine.

See also **RDB$TIME_ZONES** in System Tables.

**Package RDB$TIME_ZONE_UTIL**

A package of time zone utility functions and procedures.

See also **RDB$TIME_ZONE_UTIL** in System Packages.

**Updating the Time Zone Database**

Time zones are often changed: of course, when it happens, it is desirable to update the time zone database as soon as possible.

Firebird stores **WITH TIME ZONE** values translated to UTC time. Suppose a value is created with one time zone database, and a later update of that database changes the information in the range of our
stored value. When that value is read, it will be returned as different to the value that was stored initially.

Firebird uses the IANA time zone database through the ICU library. The ICU library included in the Firebird kit (Windows), or installed in a POSIX operating system, can sometimes have an outdated time zone database.

An updated database can be found on this page on the FirebirdSQL GitHub. Filename le.zip stands for little-endian and is the necessary file for most computer architectures (Intel/AMD compatible x86 or x64), while be.zip stands for big-endian architectures and is necessary mostly for RISC computer architectures. The content of the zip file must be extracted in the /tzdata sub-directory of the Firebird installation, overwriting existing *.res files belonging to the database.

/tzdata is the default directory where Firebird looks for the time zone database. It can be overridden with the ICU_TIMEZONE_FILES_DIR environment variable.

### 3.5. Character Data Types

For working with character data, Firebird has the fixed-length CHAR and the variable-length VARCHAR data types. The maximum size of text data stored in these data types is 32,767 bytes for CHAR and 32,765 bytes for VARCHAR. The maximum number of characters that will fit within these limits depends on the character set used for the data under consideration. The collation does not affect this maximum, although it may affect the maximum size of any index that involves the column.

If no character set is explicitly specified when defining a character object, the default character set of the database — at time of defining the object — will be used. If the database does not have a default character set defined, the object gets the character set NONE.

#### 3.5.1. Unicode

Most current development tools support Unicode, implemented in Firebird with the character sets UTF8 and UNICODE_FSS. UTF8 comes with collations for many languages. UNICODE_FSS is more limited and was previously used mainly by Firebird internally for storing metadata. Keep in mind that one UTF8 character occupies up to 4 bytes, thus limiting the size of CHAR fields to 8,191 characters (32,767/4).

The actual “bytes per character” value depends on the range the character belongs to. Non-accented Latin letters occupy 1 byte, Cyrillic letters from the WIN1251 encoding occupy 2 bytes in UTF8, characters from other encodings may occupy up to 4 bytes.

The UTF8 character set implemented in Firebird supports the latest version of the Unicode standard, thus recommending its use for international databases.

#### 3.5.2. Client Character Set

While working with strings, it is essential to keep the character set of the client connection in mind. If there is a mismatch between the character sets of the stored data and that of the client
connection, the output results for string columns are automatically re-encoded, both when data are sent from the client to the server and when they are sent back from the server to the client. For example, if the database was created in the WIN1251 encoding but KOI8R or UTF8 is specified in the client’s connection parameters, the mismatch will be transparent.

### 3.5.3. Special Character Sets

**Character set NONE**

The character set **NONE** is a *special character set* in Firebird. It can be characterized such that each byte is a part of a string, but the string is stored in the system without any clues about what constitutes any character: character encoding, collation, case, etc. are simply unknown. It is the responsibility of the client application to deal with the data and provide the means to interpret the string of bytes in some way that is meaningful to the application and the human user.

**Character set OCTETS**

Data in **OCTETS** encoding are treated as bytes that may not be interpreted as characters. **OCTETS** provides a way to store binary data. The database engine has no concept of what it is meant to do with a string of bytes in **OCTETS**, other than store and retrieve it. Again, the client side is responsible for validating the data, presenting them in formats that are meaningful to the application and its users and handling any exceptions arising from decoding and encoding them. **CHAR** and **VARCHAR** with character set **OCTETS** have synonyms **BINARY** and **VARBINARY**.

### 3.5.4. Collation

Each character set has a default collation (**COLLATE**) that specifies the collation order (or, collation sequence, or collating sequence). Usually, it provides nothing more than ordering based on the numeric code of the characters and a basic mapping of upper- and lower-case characters. If some behaviour is needed for strings that is not provided by the default collation and a suitable alternative collation is supported for that character set, a **COLLATE** collation clause can be specified in the column definition.

A **COLLATE** collation clause can be applied in other contexts besides the column definition. For comparison operations, it can be added in the **WHERE** clause of a **SELECT** statement. If output needs to be sorted in a special alphabetic sequence, or case-insensitively, and the appropriate collation exists, then a **COLLATE** clause can be included with the **ORDER BY** clause when rows are being sorted on a character field and with the **GROUP BY** clause in case of grouping operations.

**Case-Insensitive Searching**

For a case-insensitive search, the **UPPER** function could be used to convert both the search argument and the searched strings to upper-case before attempting a match:

```sql
... 
  where upper(name) = upper(:flt_name)
```

For strings in a character set that has a case-insensitive collation available, you can apply the collation, to compare the search argument and the searched strings directly. For example, using the
WIN1251 character set, the collation `PXW_CYRL` is case-insensitive for this purpose:

```
... WHERE FIRST_NAME COLLATE PXW_CYRL >= :FLT_NAME ...
... ORDER BY NAME COLLATE PXW_CYRL
```

See also

CONTAINING

UTF8 Collations

The following table shows the possible collations for the UTF8 character set.

<table>
<thead>
<tr>
<th>Collation</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCS_BASIC</td>
<td>Collation works according to the position of the character in the table (binary).</td>
</tr>
<tr>
<td>UNICODE</td>
<td>Collation works according to the UCA algorithm (Unicode Collation Algorithm) (alphabetical).</td>
</tr>
<tr>
<td>UTF8</td>
<td>The default, binary collation, identical to UCS_BASIC, which was added for SQL compatibility</td>
</tr>
<tr>
<td>UNICODE_CI</td>
<td>Case-insensitive collation, works without taking character case into account.</td>
</tr>
<tr>
<td>UNICODE_CI_AI</td>
<td>Case-insensitive, accent-insensitive collation, works alphabetically without taking character case or accents into account.</td>
</tr>
</tbody>
</table>

Example

An example of collation for the UTF8 character set without taking into account the case or accentuation of characters (similar to `COLLATE PXW_CYRL` in the earlier example).

```
... ORDER BY NAME COLLATE UNICODE_CI_AI
```

3.5.5. Character Indexes

The maximum length for an index key equals one quarter of the page size, i.e. from 1,024 — for page size 4,096 — to 8,192 bytes — for page size 32,768. The maximum length of an indexed string is 9 bytes less than that quarter-page limit.

Calculating Maximum Length of an Indexed String Field

The following formula calculates the maximum length of an indexed string (in characters):
max_char_length = FLOOR((page_size / 4 - 9) / N)

where $N$ is the number of bytes per character in the character set.

The table below shows the maximum length of an indexed string (in characters), according to page size and character set, calculated using this formula.

**Table 10. Maximum Index Lengths by Page Size and Character Size**

<table>
<thead>
<tr>
<th>Page Size</th>
<th>Bytes per character</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>4,096</td>
<td>1,015</td>
</tr>
<tr>
<td>8,192</td>
<td>2,039</td>
</tr>
<tr>
<td>16,384</td>
<td>4,087</td>
</tr>
<tr>
<td>32,768</td>
<td>8,183</td>
</tr>
</tbody>
</table>

With case-insensitive collations (“_CI”), one character in the index key will occupy not 4, but 6 (six) bytes, so the maximum key length for a page of—for example—4,096 bytes, will be 169 characters.

See also
CREATE DATABASE, Collation, SELECT, WHERE, GROUP BY, ORDER BY

3.5.6. Character Types in Detail

**BINARY**

Data Type Declaration Format

BINARY [(length)]

**Table 11. BINARY Type Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>Length in bytes between 1 and 32,767; defaults to 1.</td>
</tr>
</tbody>
</table>

BINARY is a fixed-length binary data type, and is an SQL standard-compliant alias for `CHAR(length) CHARACTER SET OCTETS`. Values shorter than the declared length are padded with NUL (0x00) up to the declared length.

Some tools may report the type as `CHAR CHARACTER SET OCTETS` instead of `BINARY`.

See also
CHAR, VARBINARY
CHAR

Data Type Declaration Format

```
{CHAR | CHARACTER} [(length)]
[CHARACTER SET <set>] [COLLATE <name>]
```

Table 12. CHAR Type Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>Length in characters, defaults to 1. A valid length is from 1 to the maximum number of characters that can be accommodated within 32,767 bytes.</td>
</tr>
<tr>
<td>set</td>
<td>Character set name</td>
</tr>
<tr>
<td>name</td>
<td>Collation name</td>
</tr>
</tbody>
</table>

CHAR is a fixed-length character data type. Values shorter than the declared length are padded with spaces up to the declared length. The pad character does not have to be a space (0x20); it depends on the character set. For example, the pad character for the OCTETS character set is NUL (0x00).

Fixed-length character data can be used to store codes whose length is standard and has a definite “width”. An example of such a code is an EAN13 barcode — 13 characters, all filled.

- CHAR CHARACTER SET OCTETS has the alias BINARY
- Formally, the COLLATE clause is not part of the data type declaration, and its position depends on the syntax of the statement.

See also

BINARY, VARCHAR

VARBINARY

Data Type Declaration Format

```
{VARBINARY | BINARY VARYING} (length)
```

Table 13. VARBINARY Type Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>Length in bytes between 1 and 32,765</td>
</tr>
</tbody>
</table>

VARBINARY is a variable-length binary type, and is an SQL standard-compliant alias for VARCHAR(length) CHARACTER SET OCTETS.

- Some tools may report the type as VARCHAR CHARACTER SET OCTETS instead of VARBINARY.

See also
**VARCHAR, BINARY**

**VARCHAR**

*Data Type Declaration Format*

```
{VARCHAR | {CHAR | CHARACTER} VARYING} (length)
[CHARACTER SET <set>] [COLLATE <name>]
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>length</td>
<td>Length in characters. A valid length is from 1 to the maximum number of</td>
</tr>
<tr>
<td></td>
<td>characters that can be accommodated within 32,765 bytes.</td>
</tr>
<tr>
<td>set</td>
<td>Character set name</td>
</tr>
<tr>
<td>name</td>
<td>Collation name</td>
</tr>
</tbody>
</table>

**Table 14. VARCHAR Type Parameters**

VARCHAR is a variable-length character data type, up to a maximum of 32,765 bytes. The stored structure is equal to the actual size of the data plus 2 bytes to record the length of the data.

All characters that are sent from the client application to the database are considered meaningful, including leading and trailing spaces.

- VARCHAR CHARACTER SET OCTETS has the alias VARBINARY
- Formally, the COLLATE clause is not part of the data type declaration, and its position depends on the syntax of the statement.

*See also*

**VARBINARY, CHAR**

**NCHAR**

*Data Type Declaration Format*

```
{NCHAR | NATIONAL {CHAR | CHARACTER}} [(length)]
```

NCHAR is a fixed-length character data type with the ISO8859_1 character set. In all other respects it is the same as CHAR.

- If no length is specified, it is taken to be 1.

A similar data type is available for the variable-length string type: NATIONAL {CHAR | CHARACTER} VARYING.

*See also*

**CHAR, VARCHAR**
3.6. Boolean Data Type

3.6.1. BOOLEAN

Data Type Declaration Format

```
BOOLEAN
```

The SQL-compliant BOOLEAN data type (8 bits) comprises the distinct truth values TRUE and FALSE. Unless prohibited by a NOT NULL constraint, the BOOLEAN data type also supports the truth value UNKNOWN as the null value. The specification does not make a distinction between the NULL value of this data type, and the truth value UNKNOWN that is the result of an SQL predicate, search condition, or Boolean value expression: they may be used interchangeably to mean the same thing.

As with many programming languages, the SQL BOOLEAN values can be tested with implicit truth values. For example, field1 OR field2 and NOT field1 are valid expressions.

The IS Operator

Predicates can use the operator Boolean IS [NOT] for matching. For example, field1 IS FALSE, or field1 IS NOT TRUE.

- Equivalence operators ("=", "!="", "<>" and so on) are valid in all comparisons.

BOOLEAN Examples

1. Inserting and selecting

```
CREATE TABLE TBOOL (ID INT, BVAL BOOLEAN);
COMMIT;

INSERT INTO TBOOL VALUES (1, TRUE);
INSERT INTO TBOOL VALUES (2, 2 = 4);
INSERT INTO TBOOL VALUES (3, NULL = 1);
COMMIT;

SELECT * FROM TBOOL;
    ID    BVAL
    =========== ========
       1 <true>
       2 <false>
       3 <null>
```

2. Test for TRUE value

```
SELECT * FROM TBOOL WHERE BVAL;
    ID    BVAL
    =========
```
3. Test for FALSE value

SELECT * FROM TBOOL WHERE BVAL IS FALSE;

<table>
<thead>
<tr>
<th>ID</th>
<th>BVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;true&gt;</td>
</tr>
<tr>
<td>2</td>
<td>&lt;false&gt;</td>
</tr>
</tbody>
</table>

4. Test for UNKNOWN value

SELECT * FROM TBOOL WHERE BVAL IS UNKNOWN;

<table>
<thead>
<tr>
<th>ID</th>
<th>BVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;null&gt;</td>
</tr>
</tbody>
</table>

5. Boolean values in SELECT list

SELECT ID, BVAL, BVAL AND ID < 2 FROM TBOOL;

<table>
<thead>
<tr>
<th>ID</th>
<th>BVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;true&gt; &lt;true&gt;</td>
</tr>
<tr>
<td>2</td>
<td>&lt;false&gt; &lt;false&gt;</td>
</tr>
<tr>
<td>3</td>
<td>&lt;null&gt; &lt;false&gt;</td>
</tr>
</tbody>
</table>

6. PSQL declaration with start value

DECLARE VARIABLE VAR1 BOOLEAN = TRUE;

7. Valid syntax, but as with a comparison with NULL, will never return any record

SELECT * FROM TBOOL WHERE BVAL = UNKNOWN;
SELECT * FROM TBOOL WHERE BVAL <> UNKNOWN;

**Use of Boolean Against Other Data Types**

Although BOOLEAN is not inherently convertible to any other data type, the strings 'true' and 'false' (case-insensitive) will be implicitly cast to BOOLEAN in value expressions. For example:

```sql
if (true > 'false') then ... 
```
The value 'false' is converted to BOOLEAN. Any attempt to use the Boolean operators AND, NOT, OR and IS will fail. NOT 'False', for example, is invalid.

A BOOLEAN can be explicitly converted to and from string with CAST. UNKNOWN is not available for any form of casting.

### Other Notes
- The type is represented in the API with the FB_BOOLEAN type and FB_TRUE and FB_FALSE constants.
- The value TRUE is greater than the value FALSE.

### 3.7. Binary Data Types

The types BINARY and VARBINARY are covered earlier in section Character Data Types.

BLOBs (Binary Large Objects) are complex structures used to store text and binary data of an undefined length, often very large.

#### Syntax

```sql
BLOB [SUB_TYPE <subtype>]
  [SEGMENT SIZE <segment size>]
  [CHARACTER SET <character set>]
  [COLLATE <collation name>]
```

If the SUB_TYPE and CHARACTER SET clauses are absent, then subtype BINARY (or 0) is used. If the SUB_TYPE clause is absent and the CHARACTER SET clause is present, then subtype TEXT (or 1) is used.

#### Shortened syntax

```sql
BLOB (<segment size>)
BLOB (<segment size>, <subtype>)
BLOB (, <subtype>)
```

Formally, the COLLATE clause is not part of the data type declaration, and its position depends on the syntax of the statement.

#### Segment Size

Specifying the BLOB segment size is a throwback to times past, when applications for working with BLOB data were written in C (Embedded SQL) with the help of the gpre pre-compiler. Nowadays, it is effectively irrelevant. The segment size for BLOB data is determined by the client side and is usually larger than the data page size, in any case.
3.7.1. BLOB Subtypes

The optional SUB_TYPE parameter specifies the nature of data written to the column. Firebird provides two pre-defined subtypes for storing user data:

**Subtype 0: BINARY**

If a subtype is not specified, the specification is assumed to be for untyped data and the default SUB_TYPE BINARY (or SUB_TYPE 0) is applied. This is the subtype to specify when the data are any form of binary file or stream: images, audio, word-processor files, PDFs and so on.

**Subtype 1: TEXT**

Subtype 1 has an alias, TEXT, which can be used in declarations and definitions. For instance, BLOB SUB_TYPE TEXT (or BLOB SUB_TYPE 1). It is a specialized subtype used to store plain text data that is too large to fit into a string type. A CHARACTER SET may be specified, if the field is to store text with a different encoding to that specified for the database. A COLLATE clause is also supported.

Specifying CHARACTER SET without specifying a SUB_TYPE implies SUB_TYPE TEXT.

**Custom Subtypes**

It is also possible to add custom data subtypes, for which the range of enumeration from -1 to -32,768 is reserved. Custom subtypes enumerated with positive numbers are not allowed, as the Firebird engine uses the numbers from 2-upward for some internal subtypes in metadata. Custom subtype aliases can be inserted into the RDB$TYPES table by users with the system privilege CREATE_USER_TYPES.

3.7.2. BLOB Specifics

**Size**

The maximum size of a BLOB field depends on the page size of the database, whether the blob value is created as a stream blob or a segmented blob, and if segmented, the actual segment sizes used when populating the blob. For most built-in functions, the maximum size of a BLOB field is 4 GB, or data beyond the 4 GB limit is not addressable. For a page size of 4 KB (4096 bytes) the maximum size is slightly less than 4 GB.

**Operations and Expressions**

Text BLOBs of any length and any character set—including multi-byte—can be operands for practically any statement or internal functions. The following operators are fully supported:

\[
\begin{align*}
&= & &\text{(assignment)} \\
&\neq, <, <\!, =, >, \ge & &\text{(comparison)} \\
\&\& & &\text{(concatenation)} \\
\text{BETWEEN, IS [NOT] DISTINCT FROM,} \\
\text{IN, ANY | SOME,} \\
\text{ALL}
\end{align*}
\]

As an efficient alternative to concatenation, you can also use BLOB_APPEND() or the functions and
procedures of system package \texttt{RDB$BLOB\_UTIL}.

Partial support:

- An error occurs with these if the search argument is larger than or equal to 32 KB:
  
  \textbf{STARTING [WITH], LIKE, CONTAINING}

- Aggregation clauses work not on the contents of the field itself, but on the BLOB ID. Aside from that, there are some quirks:

  \begin{verbatim}
  SELECT DISTINCT ORDER BY GROUP BY
  \end{verbatim}

  returns several NULL values by mistake if they are present

  —

  concatenates the same strings if they are adjacent to each other, but does not do it if they are remote from each other

**BLOB Storage**

- By default, a regular record is created for each BLOB, and it is stored on a data page that is allocated for it. If the entire BLOB fits onto this page, it is called a \textit{level 0 BLOB}. The number of this special record is stored in the table record and occupies 8 bytes.

- If a BLOB does not fit onto one data page, its contents are put onto separate pages allocated exclusively to it (blob pages), while the numbers of these pages are stored into the BLOB record. This is a \textit{level 1 BLOB}.

- If the array of page numbers containing the BLOB data does not fit onto a data page, the array is put on separate blob pages, while the numbers of these pages are put into the BLOB record. This is a \textit{level 2 BLOB}.

- Levels higher than 2 are not supported.

\textit{See also}  
\texttt{FILTER, DECLARE FILTER, BLOB\_APPEND(), RDB$BLOB\_UTIL}

### 3.8. Array Types

Firebird does not offer much in the way of language or tools for working with the contents of arrays, and there are no plans to improve this. This limits the usefulness and accessibility of array types. Therefore, the general advice is: do not use arrays.

The support of arrays in the Firebird DBMS is a departure from the traditional relational model. Supporting arrays in the DBMS could make it easier to solve some data-processing tasks involving large sets of similar data.

Arrays in Firebird are stored in BLOB of a specialized type. Arrays can be one-dimensional and multi-dimensional and of any data type except BLOB and ARRAY.
Example

```
CREATE TABLE SAMPLE_ARR (  
    ID INTEGER NOT NULL PRIMARY KEY,  
    ARR_INT INTEGER [4]  
);
```

This example will create a table with a field of the array type consisting of four integers. The subscripts of this array are from 1 to 4.

### 3.8.1. Specifying Explicit Boundaries for Dimensions

By default, dimensions are 1-based — subscripts are numbered from 1. To specify explicit upper and lower bounds of the subscript values, use the following syntax:

```
[' <lower>:<upper> ']
```

### 3.8.2. Adding More Dimensions

A new dimension is added using a comma in the syntax. In this example we create a table with a two-dimensional array, with the lower bound of subscripts in both dimensions starting from zero:

```
CREATE TABLE SAMPLE_ARR2 (  
    ID INTEGER NOT NULL PRIMARY KEY,  
    ARR_INT INTEGER [0:3, 0:3]  
);
```

The database employee.fdb, found in the ../examples/empbuild directory of any Firebird distribution package, contains a sample stored procedure showing some simple work with arrays:

### 3.8.3. PSQL Source for SHOW_LANGS, a procedure involving an array

```
CREATE OR ALTER PROCEDURE SHOW_LANGS (  
    CODE VARCHAR(5),  
    GRADE SMALLINT,  
    CTY VARCHAR(15))  
RETURNS (LANGUAGES VARCHAR(15))  
AS  
DECLARE VARIABLE I INTEGER;  
BEGIN  
    I = 1;  
    WHILE (I <= 5) DO  
    BEGIN  
        SELECT LANGUAGE_REQ[:I]  
        FROM JOB  
        WHERE (JOB_CODE = :CODE)
```
If the features described are enough for your tasks, you might consider using arrays in your projects. Currently, no improvements are planned to enhance support for arrays in Firebird.

3.9. Special Data Types

“Special” data types ...

3.9.1. SQL_NULL Data Type

The SQL_NULL type holds no data, but only a state: NULL or NOT NULL. It is not available as a data type for declaring table fields, PSQL variables or parameter descriptions. This data type exists to support the use of untyped parameters in expressions involving the IS NULL predicate.

An evaluation problem occurs when optional filters are used to write queries of the following type:

WHERE col1 = :param1 OR :param1 IS NULL

After processing, at the API level, the query will look like this:

WHERE col1 = ? OR ? IS NULL

This is a case where the developer writes an SQL query and considers :param1 as though it were a variable that they can refer to twice. However, at the API level, the query contains two separate and independent parameters. The server cannot determine the type of the second parameter since it comes in association with IS NULL.

The SQL_NULL data type solves this problem. Whenever the engine encounters an “? IS NULL” predicate in a query, it assigns the SQL_NULL type to the parameter, which will indicate that parameter is only about “nullness” and the data type or the value need not be addressed.

The following example demonstrates its use in practice. It assumes two named parameters — say, :size and :colour — which might, for example, get values from on-screen text fields or drop-down lists. Each named parameter corresponds with two positional parameters in the query.
```
SELECT
  SH.SIZE, SH.COLOUR, SH.PRICE
FROM SHIRTS SH
WHERE (SH.SIZE = ? OR ? IS NULL)
  AND (SH.COLOUR = ? OR ? IS NULL)
```

Explaining what happens here assumes the reader is familiar with the Firebird API and the passing of parameters in XSQLVAR structures — what happens under the surface will not be of interest to those who are not writing drivers or applications that communicate using the “naked” API.

The application passes the parameterized query to the server in the usual positional ?-form. Pairs of “identical” parameters cannot be merged into one, so for the two optional filters in the example, four positional parameters are needed: one for each ? in our example.

After the call to `isc_dsdl_describe_bind()`, the SQLTYPE of the second and fourth parameters will be set to SQL_NULL. Firebird has no knowledge of their special relation with the first and third parameters: that responsibility lies entirely on the application side.

Once the values for size and colour have been set (or left unset) by the user, and the query is about to be executed, each pair of XSQLVARs must be filled as follows:

**User has supplied a value**

  First parameter (value compare): set `sqldata` to the supplied value and `*sqlind` to 0 (for NOT NULL)

  Second parameter (NULL test): set `sqldata` to null (null pointer, not SQL NULL) and `*sqlind` to 0 (for NOT NULL)

**User has left the field blank**

  Both parameters: set `sqldata` to null (null pointer, not SQL NULL) and `*sqlind` to -1 (indicating NULL)

In other words: The value compare parameter is always set as usual. The SQL_NULL parameter is set the same, except that `sqldata` remains null at all times.

### 3.10. Conversion of Data Types

When composing an expression or specifying an operation, the aim should be to use compatible data types for the operands. When a need arises to use a mixture of data types, it should prompt you to look for a way to convert incompatible operands before subjecting them to the operation. The ability to convert data may well be an issue if you are working with Dialect 1 data.

#### 3.10.1. Explicit Data Type Conversion

The [CAST function](https://www.firebirdsql.org/java/) enables explicit conversion between many pairs of data types.
Syntax

CAST (<expression> AS <target_type>)

<target_type> ::= <domain_or_non_array_type> | <array_datatype>

<domain_or_non_array_type> ::= !! See Scalar Data Types Syntax !!

<array_datatype> ::= !! See Array Data Types Syntax !!

See also CAST() in Chapter Built-in Scalar Functions.

Casting to a Domain

When you cast to a domain, any constraints declared for it are taken into account, i.e. NOT NULL or CHECK constraints. If the value does not pass the check, the cast will fail.

If TYPE OF is additionally specified — casting to its base type — any domain constraints are ignored during the cast. If TYPE OF is used with a character type (CHAR/VARCHAR), the character set and collation are retained.

Casting to TYPE OF COLUMN

When operands are cast to the type of a column, the specified column may be from a table or a view.

Only the type of the column itself is used. For character types, the cast includes the character set, but not the collation. The constraints and default values of the source column are not applied.

Example

```
CREATE TABLE TTT (  
  S VARCHAR (40) CHARACTER SET UTF8 COLLATE UNICODE_CI_AI  
);  
COMMIT;

SELECT  
  CAST ('I have many friends' AS TYPE OF COLUMN TTT.S)  
FROM RDB$DATABASE;
```

Conversions Possible for the CAST Function

*Table 15. Conversions with CAST*

<table>
<thead>
<tr>
<th>From Data Type</th>
<th>To Data Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numeric types</td>
<td>Numeric types, [VAR]CHAR, BLOB</td>
</tr>
</tbody>
</table>
From Data Type | To Data Type
---|---
[V]AR[CHAR] | [V]AR[CHAR], BLOB, Numeric types, DATE, TIME, TIMESTAMP, BOOLEAN
BLOB | [V]AR[CHAR], BLOB, Numeric types, DATE, TIME, TIMESTAMP, BOOLEAN
DATE, TIME | [V]AR[CHAR], BLOB, TIMESTAMP
TIMESTAMP | [V]AR[CHAR], BLOB, DATE, TIME
BOOLEAN | BOOLEAN, [V]AR[CHAR], BLOB

To convert string data types to the BOOLEAN type, the value must be (case-insensitive) 'true' or 'false', or NULL.

Keep in mind that partial information loss is possible. For instance, when you cast the TIMESTAMP data type to the DATE data type, the time-part is lost.

Datetime Formats

To cast string data types to the DATE, TIME or TIMESTAMP data types, you need the string argument to be one of the predefined datetime mnemonics (see Table 16) or a representation of the date in one of the allowed datetime formats (see Datetime Format Syntax).

Table 16. Predefined Datetime Mnemonics

<table>
<thead>
<tr>
<th>Literal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>'NOW'</td>
<td>Current date and time</td>
</tr>
<tr>
<td>'TODAY'</td>
<td>Current date</td>
</tr>
<tr>
<td>'TOMORROW'</td>
<td>Current date + 1 (day)</td>
</tr>
<tr>
<td>'YESTERDAY'</td>
<td>Current date - 1 (day)</td>
</tr>
</tbody>
</table>

Casting the date mnemonics 'TODAY', 'TOMORROW' or 'YESTERDAY' to a TIMESTAMP WITH TIME ZONE will produce a value at 00:00:00 UTC rebased to the session time zone.

For example cast('TODAY' as timestamp with time zone) on 2021-05-02 20:00 - 2021-05-03 19:59 New York (or 2021-05-03 00:00 - 2021-05-03 23:59 UTC) with session time zone America/New_York will produce a value TIMESTAMP '2021-05-02 20:00:00.0000 America/New_York', while cast('TODAY' as date) or CURRENT_DATE will produce either DATE '2021-05-02' or DATE '2021-05-03' depending on the actual date.

Sample Date Literal Interpretations

```sql
select 
    cast('04.12.2014' as date) as d1, -- DD.MM.YYYY 
    cast('04 12 2014' as date) as d2, -- MM DD YYYY 
    cast('4-12-2014' as date) as d3, -- MM-DD-YYYY 
    cast('04/12/2014' as date) as d4, -- MM/DD/YYYY 
    cast('04.12.14' as date) as d5, -- DD.MM.YY 
    -- DD.MM with current year
```
Shorthand Casts for Datetime Data Types

Firebird allows the use of a shorthand “C-style” type syntax for casts from string to the types DATE, TIME and TIMESTAMP. The SQL standard calls these “datetime literals”.

Syntax

<data_type> 'date_format_string'

See also Datetime Literals.

These literal expressions are evaluated directly during parsing, as though the statement were already prepared for execution. As this produced unexpected or confusing results when using the datetime mnemonics like 'NOW', especially in PSQL code, the datetime mnemonics are no longer allowed in datetime literals since Firebird 4.0.

To use datetime mnemonics, use the full CAST syntax. An example of using such an expression in a trigger:

```
NEW.CHANGE_DATE = CAST('now' AS TIMESTAMP);
```
3.10.2. Implicit Data Type Conversion

Implicit data conversion is not possible in Dialect 3 — the CAST function is almost always required to avoid data type clashes.

In Dialect 1, in many expressions, one type is implicitly cast to another without the need to use the CAST function. For instance, the following statement in Dialect 1 is valid:

```
UPDATE ATABLE
  SET ADATE = '25.12.2016' + 1
```

The string literal will be cast to the DATE type implicitly.

In Dialect 3, this statement will raise error 35544569, “Dynamic SQL Error: expression evaluation not supported, Strings cannot be added or subtracted in dialect 3” — a cast will be needed:

```
UPDATE ATABLE
  SET ADATE = CAST ('25.12.2016' AS DATE) + 1
```

Or, with a datetime literal:

```
UPDATE ATABLE
  SET ADATE = DATE '25.12.2016' + 1
```

In Dialect 1, mixing integer data and numeric strings is usually possible because the parser will try to cast the string implicitly. For example,

```
2 + '1'
```

will be executed correctly.

In Dialect 3, an expression like this will raise an error, so you will need to write it as a CAST expression:

```
2 + CAST('1' AS SMALLINT)
```

The exception to the rule is during string concatenation.

**Implicit Conversion During String Concatenation**

When multiple data elements are being concatenated, all non-string data will undergo implicit conversion to string, if possible.
3.11. Custom Data Types — Domains

In Firebird, the concept of a “user-defined data type” is implemented in the form of the *domain*. Creating a domain does not truly create a new data type, of course. A domain provides the means to encapsulate an existing data type with a set of attributes and make this “capsule” available for reuse across the whole database. If several tables need columns defined with identical or nearly identical attributes, a domain makes sense.

Domain usage is not limited to column definitions for tables and views. Domains can be used to declare input and output parameters and variables in PSQL code.

3.11.1. Domain Attributes

A domain definition has required and optional attributes. The *data type* is a required attribute. Optional attributes include:

- a default value
- to allow or forbid NULL
- CHECK constraints
- character set (for character data types and text BLOB fields)
- collation (for character data types)

*Sample domain definition*

```sql
CREATE DOMAIN BOOL3 AS SMALLINT
    CHECK (VALUE IS NULL OR VALUE IN (0, 1));
```

*See also*

Explicit Data Type Conversion for the description of differences in the data conversion mechanism when domains are specified for the *TYPE OF* and *TYPE OF COLUMN* modifiers.

3.11.2. Domain Override

While defining a column using a domain, it is possible to override some attributes inherited from the domain. *Table 17* summarises the rules for domain override.

*Table 17. Rules for Overriding Domain Attributes in Column Definition*
### 3.11.3. Creating and Administering Domains

A domain is created with the DDL statement `CREATE DOMAIN`. 

#### Short Syntax

```sql
CREATE DOMAIN name [AS] <type>
  [DEFAULT {<literal> | NULL | <context_var>}] 
  [NOT NULL] [CHECK (<condition>)]
  [COLLATE <collation>]
```

*See also* `CREATE DOMAIN` in the *Data Definition (DDL) Statements* chapter.

#### Altering a Domain

To change the attributes of a domain, use the DDL statement `ALTER DOMAIN`. With this statement you can:

- rename the domain
- change the data type
- drop the current default value
- set a new default value
- drop the NOT NULL constraint
- set the NOT NULL constraint
- drop an existing CHECK constraint
- add a new CHECK constraint
### Short Syntax

**ALTER DOMAIN**

```sql
name

{[TO  new_name]}

{[SET DEFAULT { <literal> | NULL | <context_var>} | DROP DEFAULT]}

{[SET | DROP} NOT NULL ]

{[ADD [CONSTRAINT] CHECK (<dom_condition>) | DROP CONSTRAINT]}

{[TYPE <datatype>]}
```

### Example

```
ALTER DOMAIN STORE_GRP SET DEFAULT -1;
```

When changing a domain, its dependencies must be taken into account: whether there are table columns, any variables, input and/or output parameters with the type of this domain declared in the PSQL code. If you change domains in haste, without carefully checking them, your code may stop working!

![Warning](image)

When you convert data types in a domain, you must not perform any conversions that may result in data loss. Also, for example, if you convert `VARCHAR` to `INTEGER`, check carefully that all data using this domain can be successfully converted.

**See also**

`ALTER DOMAIN` in the *Data Definition (DDL) Statements* chapter.

### Deleting (Dropping) a Domain

The DDL statement **DROP DOMAIN** deletes a domain from the database, provided it is not in use by any other database objects.

#### Syntax

```
DROP DOMAIN name
```

#### Example

```
DROP DOMAIN Test_Domain
```

**See also**

`DROP DOMAIN` in the *Data Definition (DDL) Statements* chapter.

### 3.12. Data Type Declaration Syntax

This section documents the syntax of declaring data types. Data type declaration commonly occurs in **DDL statements**, but also in **CAST** and **EXECUTE BLOCK**.
The syntax documented below is referenced from other parts of this language reference.

### 3.12.1. Scalar Data Types Syntax

The scalar data types are simple data types that hold a single value. For reasons of organisation, the syntax of BLOB types are defined separately in [BLOB Data Types Syntax](#).

**Scalar Data Types Syntax**

```
<domain_or_non_array_type> ::= 
   <scalar_datatype> 
   | <blob_datatype> 
   | [TYPE OF] domain 
   | TYPE OF COLUMN rel.col

<scalar_datatype> ::= 
   SMALLINT | INT[EGER] | BIGINT | INT128 
   | REAL | FLOAT [(bin_prec)] | DOUBLE PRECISION 
   | DECIMAL [(dec_prec)] 
   | BOOLEAN 
   | DATE 
   | TIME [{WITHOUT | WITH} TIME ZONE] 
   | TIMESTAMP [{WITHOUT | WITH} TIME ZONE] 
   | {DECIMAL | DEC | NUMERIC} [(precision [, scale])] 
   | {VARCHAR | {CHAR | CHARACTER} VARYING} (length) 
   | {CHAR | CHARACTER} [(length)] [CHARACTER SET charset] 
   | {NCHAR | NATIONAL {CHARACTER | CHAR}} VARYING (length) 
   | {NCHAR | NATIONAL {CHARACTER | CHAR}} [(length)] 
   | BINARY [(length)] 
   | {VARBINARY | BINARY VARYING} (length)
```

**Table 18. Arguments for the Scalar Data Types Syntax**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>domain</td>
<td>Domain (only non-array domains)</td>
</tr>
<tr>
<td>rel</td>
<td>Name of a table or view</td>
</tr>
<tr>
<td>col</td>
<td>Name of a column in a table or view (only columns of a non-array type)</td>
</tr>
<tr>
<td>bin_prec</td>
<td>Binary precision, default is 24.</td>
</tr>
<tr>
<td></td>
<td>1 - 24: 32-bit single precision</td>
</tr>
<tr>
<td></td>
<td>25 - 53: 64-bit double precision (synonym of DOUBLE PRECISION)</td>
</tr>
<tr>
<td>dec_prec</td>
<td>Decimal precision of DECIMAL, either 16 or 34; Default is 34</td>
</tr>
<tr>
<td>precision</td>
<td>Numeric precision in decimal digits. From 1 to 38</td>
</tr>
<tr>
<td>scale</td>
<td>Scale, or number of decimals. From 0 to 38. It must be less than or equal to precision</td>
</tr>
</tbody>
</table>
Use of Domains in Declarations

A domain name can be specified as the type of a PSQL parameter or local variable. The parameter or variable will inherit all domain attributes. If a default value is specified for the parameter or variable, it overrides the default value specified in the domain definition.

If the TYPE OF clause is added before the domain name, only the data type of the domain is used: any of the other attributes of the domain—NOT NULL constraint, CHECK constraints, default value—are neither checked nor used. However, if the domain is of a text type, its character set and collation are always used.

Use of Column Type in Declarations

Input and output parameters or local variables can also be declared using the data type of columns in existing tables and views. The TYPE OF COLUMN clause is used for that, specifying `relationname.columnname` as its argument.

When TYPE OF COLUMN is used, the parameter or variable inherits only the data type and— for string types—the character set and collation. The constraints and default value of the column are ignored.

3.12.2. BLOB Data Types Syntax

The BLOB data types hold binary, character or custom format data of unspecified size. For more information, see Binary Data Types.

**BLOB Data Types Syntax**

```sql
<blob_datatype> ::= 
    BLOB [SUB_TYPE { subtype_num | subtype_name }] 
    [SEGMENT SIZE seglen] [CHARACTER SET charset] 
    | BLOB [(seglen [, subtype_num])] 
    | BLOB [,( subtype_num)]
```

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>charset</td>
<td>Character set (ignored for subtypes other than TEXT/1).</td>
</tr>
<tr>
<td>subtype_num</td>
<td>BLOB subtype number</td>
</tr>
<tr>
<td>Argument</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>subtype_name</td>
<td>BLOB subtype mnemonic name; this can be TEXT, BINARY, or one of the (other) standard or custom names defined in RDB$TYPES for RDB$FIELD_NAME = 'RDB$FIELD_SUB_TYPE'.</td>
</tr>
<tr>
<td>seglen</td>
<td>Segment size, cannot be greater than 65,535, defaults to 80 when not specified. See also Segment Size</td>
</tr>
</tbody>
</table>

If the SUB_TYPE and CHARACTER SET clauses are absent, then subtype BINARY (or 0) is used. If the SUB_TYPE clause is absent and the CHARACTER SET clause is present, then subtype TEXT (or 1) is used.

3.12.3. Array Data Types Syntax

The array data types hold multiple scalar values in a single or multi-dimensional array. For more information, see Array Types

**Array Data Types Syntax**

```
<array_datatype> ::= {SMALLINT | INT[TEGR] | BIGINT | INT128} <array_dim>
| {REAL | FLOAT [(bin_prec)] | DOUBLE PRECISION} <array_dim>
| DECIMAL [(dec_prec)] <array_dim>
| BOOLEAN <array_dim>
| DATE <array_dim>
| TIME [{WITHOUT | WITH} TIME ZONE] <array_dim>
| TIMESTAMP [{WITHOUT | WITH} TIME ZONE] <array_dim>
| {DECIMAL | DEC | NUMERIC} [(precision [, scale])] <array_dim>
| {VARCHAR | {CHAR | CHARACTER} VARYING} (length)
| {CHAR | CHARACTER} [[(length)] <array_dim>
| CHARACTER SET charset]
| {NCHAR | NATIONAL {CHARACTER | CHAR}} VARYING (length)
| {NCHAR | NATIONAL {CHARACTER | CHAR}} [(length)] <array_dim>
| BINARY [(length)] <array_dim>
| {VARBINARY | BINARY VARYING} (length) <array_dim>

<array_dim> ::= ['[', [m:]n [,,[m:]n ... ] ']'
```

Table 20. Arguments for the Array Data Types Syntax

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>array_dim</td>
<td>Array dimensions</td>
</tr>
<tr>
<td>bin_prec</td>
<td>Binary precision, default is 24.</td>
</tr>
</tbody>
</table>

1 - 24: 32-bit single precision
25 - 53: 64-bit double precision (synonym of DOUBLE PRECISION)
## Chapter 3. Data Types and Subtypes

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>dec_prec</td>
<td>Decimal precision of DECFLOAT, either 16 or 34; default is 34</td>
</tr>
<tr>
<td>precision</td>
<td>Numeric precision in decimal digits. From 1 to 38</td>
</tr>
<tr>
<td>scale</td>
<td>Scale, or number of decimals. From 0 to 38. It must be less than or equal to <code>precision</code></td>
</tr>
<tr>
<td>length</td>
<td>The maximum length of a string, in characters, or — for BINARY and VARBINARY — bytes; optional for fixed-width character types, defaults to 1</td>
</tr>
<tr>
<td>charset</td>
<td>Character set</td>
</tr>
<tr>
<td>m, n</td>
<td>Integer numbers defining the index range of an array dimension</td>
</tr>
</tbody>
</table>

[1] in practice, the actual range is determined by the backing type, for `NUMERIC(4, s)` that is `SMALLINT`, which means it can store $[-327.68, 327.67]$
Chapter 4. Common Language Elements

This chapter covers the elements that are common throughout the implementation of the SQL language — the expressions that are used to extract and operate on conditions about data and the predicates that test the truth of those assertions.

4.1. Expressions

SQL expressions provide formal methods for evaluating, transforming and comparing values. SQL expressions may include table columns, variables, constants, literals, various statements and predicates and also other expressions. The complete list of possible tokens in expressions follows.

Description of Expression Elements

Column name

Identifier of a column from a specified table used in evaluations or as a search condition. A column of the array type cannot be an element in an expression except when used with the IS [NOT] NULL predicate.

Array element

An expression may contain a reference to an array member i.e., <array_name>[s], where s is the subscript of the member in the array <array_name>

Arithmetic operators

The +, -, *, / characters used to calculate values

Concatenation operator

The || (“double-pipe”) operator used to concatenate strings

Logical operators

The reserved words NOT, AND and OR, used to combine simple search conditions to create complex conditions

Comparison operators

The symbols =, <>, !=-, ^=, <, <=, >, >=, !<, ^<, !>, ^> and ^>

Comparison predicates

LIKE, STARTING WITH, CONTAINING, SIMILAR TO, BETWEEN, IS [NOT] NULL, IS [NOT] {TRUE | FALSE | UNKNOWN} and IS [NOT] DISTINCT FROM

Existential predicates

Predicates used to check the existence of values in a set. The IN predicate can be used both with sets of comma-separated constants and with subqueries that return a single column. The EXISTS, SINGULAR, ALL, ANY and SOME predicates can be used only with sub-queries.

Constant or Literal

Numbers, or string literals enclosed in apostrophes or Q-strings, Boolean values TRUE, FALSE and UNKNOWN, NULL
Datetime literal

An expression, similar to a string literal enclosed in apostrophes, that can be interpreted as a date, time or timestamp value. Datetime literals can be strings of characters and numerals, such as `TIMESTAMP '2016-12-25 15:30:35'`, that can be resolved as datetime value.

Datetime mnemonics

A string literal with a description of a desired datetime value that can be cast to a datetime type. For example, 'TODAY', 'NOW'.

Context variable

An internally-defined context variable

Local variable

Declared local variable, input or output parameter of a PSQL module (stored procedure, stored function, trigger, or unnamed PSQL block in DSQL)

Positional parameter

A member of an ordered group of one or more unnamed parameters passed to a stored procedure or prepared query

Subquery

A `SELECT` statement enclosed in parentheses that returns a single (scalar) value or, when used in existential predicates, a set of values

Function identifier

The identifier of an internal, packaged, stored or external function in a function expression

Type cast

An expression explicitly converting data of one data type to another using the `CAST function` (`CAST (value AS datatype)`). For datetime literals only, the shorthand syntax `<datatype> <value>` is also supported (DATE '2016-12-25').

Conditional expression

Expressions using CASE and related internal functions

Parentheses

Bracket pairs (…) used to group expressions. Operations inside the parentheses are performed before operations outside them. When nested parentheses are used, the most deeply nested expressions are evaluated first and then the evaluations move outward through the levels of nesting.

COLLATE clause

Clause applied to CHAR and VARCHAR types to specify the character-set-specific collation to use in string comparisons

NEXT VALUE FOR sequence

Expression for obtaining the next value of a specified generator (sequence). The internal function `GEN_ID()` does the same.
AT expression

Expression to change the time zone of a datetime.

4.1.1. Literals (Constants)

A literal — or constant — is a value that is supplied directly in an SQL statement, not derived from an expression, a parameter, a column reference nor a variable. It can be a string or a number.

String Literals

A string literal is a series of characters enclosed between a pair of apostrophes (“single quotes”). The maximum length of a string literal is 32,765 for CHAR/VARCHAR, or 65,533 bytes for BLOB; the maximum character count will be determined by the number of bytes used to encode each character.

Formally, the syntax of a normal string literal is:

Character String Literal Syntax

```
<char-literal> ::= 
    [<introducer> charset-name] <quote> [<char>...] <quote> 
    [{ <separator> <quote> [<char>...] <quote> }]... ] 

<separator> ::= 
    { <comment> | <white space> } 

<introducer> ::= underscore (U+005F) 
<quote> ::= apostrophe (U+0027) 
<char> ::= character representation; 
          apostrophe is escaped by doubling
```

- Double quotes are not valid for quoting strings. The SQL standard reserves double quotes for a different purpose: delimiting or quoting identifiers.
- If a literal apostrophe is required within a string constant, it is “escaped” by prefixing it with another apostrophe. For example, 'Mother O''Reilly''s home-made hooch'. Or use the alternative quote literal: q'{Mother O'Reilly's home-made hooch}'
- Care should be taken with the string length if the value is to be written to a CHAR or VARCHAR column. The maximum length for a CHAR or VARCHAR literal is 32,765 bytes.

The character set of a string constant is assumed to be the same as the character set of its destined storage.

Examples

```
-- Literal containing single quote
select 'O''Reilly' from RDB$DATABASE;
```
String Literals in Hexadecimal Notation

String literals can also be entered in hexadecimal notation, so-called “binary strings”. Each pair of hex digits defines one byte in the string. Strings entered this way will be type BINARY (a.k.a. CHAR CHARACTER SET OCTETS) by default, unless the introducer syntax is used to force a string to be interpreted as another character set.

Binary String Literal Syntax

```
<binary-literal> ::= 
   [[<introducer> charsetname] X <quote> [<space>...]] 
   [{ <hexit> [<space>...] <hexit> [<space>...] }... <quote> 
   [{ <separator> <quote> [<space>...] 
   [{ <hexit> [<space>...] <hexit> [<space>...] }... <quote> }]... 

<hexit> ::= one of 0..9, A..F, a..f 
<space> ::= the space character (U+0020)
```

Examples

```
select x'4E657276656E' from rdb$database
-- returns 4E657276656E, a 6-byte 'binary' string

select _ascii x'4E657276656E' from rdb$database
-- returns 'Nerven' (same string, now interpreted as ASCII text)

select _iso8859_1 x'53E46765' from rdb$database
-- returns 'Säge' (4 chars, 4 bytes)

select _utf8 x'53C3A46765' from rdb$database
-- returns 'Säge' (4 chars, 5 bytes)

-- Group per byte (whitespace inside literal)
select _win1252 x'42 49 4e 41 52 59'
from RDB$DATABASE;
-- output: BINARY
```
Notes
The client interface determines how binary strings are displayed to the user. The
\textit{isql} utility, for example, uses upper case letters A-F, while FlameRobin uses lower
case letters. Other client programs may use other conventions, such as displaying
spaces between the byte pairs: '4E 65 72 76 6E'.

The hexadecimal notation allows any byte value (including 00) to be inserted at
any position in the string. However, if you want to coerce it to anything other than
\textsc{OCTETS}, it is your responsibility to supply the bytes in a sequence that is valid for
the target character set.

The usage of the _\texttt{win1252} introducer in above example is a non-standard
extension and equivalent to an explicit cast to a \textsc{CHAR} of appropriate length with
character set \textsc{WIN1252}.

Alternative String Literals
It is possible to use a character, or character pair, other than the doubled (escaped) apostrophe, to
embed a quoted string inside another string without the need to escape the quote. The keyword \texttt{q} or
\texttt{Q} preceding a quoted string informs the parser that certain left-right pairs or pairs of identical
characters within the string are the delimiters of the embedded string literal.

Syntax

\begin{verbatim}
<alternative string literal> ::= 
  { q | Q } <quote> <start char> [<char> ...] <end char> <quote>
\end{verbatim}

Rules

When <\texttt{start char}> is ‘(’, ‘{’, [‘ or <’, <\texttt{end char}> is paired up with its respective
“partner”, viz. ‘)’, ‘}’, ]’ and >’. In other cases, <\texttt{end char}> is the same as <\texttt{start}
\texttt{char}>.

Inside the string, i.e. <\texttt{char}> items, single quotes can be used without escaping.
Each quote will be part of the result string.

Examples

\begin{verbatim}
select q'{abc{def}ghi}' from rdb$database; -- result: abc{def}ghi
select q'!That's a string!' from rdb$database; -- result: That's a string
\end{verbatim}
Introducer Syntax for String Literals

If necessary, a string literal may be preceded by a character set name, itself prefixed with an underscore “_”. This is known as introducer syntax. Its purpose is to inform the engine about how to interpret and store the incoming string.

Example

```
INSERT INTO People
VALUES (_ISO8859_1 'Hans-Jörg Schäfer')
```

Number Literals

A number literal is any valid number in a supported notation:

- In SQL, for numbers in the standard decimal notation, the decimal point is always represented by period character (‘.’, full-stop, dot); thousands are not separated. Inclusion of commas, blanks, etc. will cause errors.

- Exponential notation is supported. For example, 0.0000234 can be expressed as 2.34e-5. However, while the literal 0.0000234 is a `NUMERIC(18,7)`, the literal 2.34e-5 is a `DOUBLE PRECISION`.

- Hexadecimal notation — see below.

The format of the literal decides the type (<d> for a decimal digit, <h> for a hexadecimal digit):

<table>
<thead>
<tr>
<th>Format</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>&lt;d&gt;[&lt;d&gt; …]</code></td>
<td>INTEGER, BIGINT, INT128 or DECFLOAT(34) (depends on if value fits in the type). DECFLOAT(34) is used for values that do not fit in INT128.</td>
</tr>
<tr>
<td>`0{x</td>
<td>X} &lt;h&gt;[&lt;h&gt; …]`</td>
</tr>
<tr>
<td><code>&lt;d&gt;[&lt;d&gt; …] &quot;.&quot; [&lt;d&gt; …]</code></td>
<td>NUMERIC(18, n), NUMERIC(38, n) or DECFLOAT(34) where n depends on the number of digits after the decimal point, and precision on the total number of digits. For backwards compatibility, some values of 19 digits are mapped to NUMERIC(18, n). DECFLOAT(34) is used when the unscaled value does not fit in INT128.</td>
</tr>
<tr>
<td><code>&lt;d&gt;[&lt;d&gt; …][&quot;.&quot; [&lt;d&gt; …]] E </code>&lt;d&gt;[&lt;d&gt; …]`</td>
<td>DOUBLE PRECISION or DECFLOAT(34), where DECFLOAT is used only if the number of digits is 20 or higher, or the absolute exponent is 309 or greater.</td>
</tr>
</tbody>
</table>
Hexadecimal Notation for Numbers

Integer values can also be entered in hexadecimal notation. Numbers with 1-8 hex digits will be interpreted as type INTEGER; numbers with 9-16 hex digits as type BIGINT; numbers with 17-32 hex digits as type INT128.

Syntax

```
0{x|X}<hexdigits>
```

```
<hexdigits> ::= 1-32 of <hexdigit>
<hexdigit>   ::= one of 0..9, A..F, a..f
```

Examples

```
select 0x6FAA0D3 from rdb$database           -- returns 117088467
select 0x4F9 from rdb$database               -- returns 1273
select 0x6E44F9A8 from rdb$database          -- returns 1850014120
select 0x9E44F9A8 from rdb$database          -- returns -1639646808 (an INTEGER)
select 0x09E44F9A8 from rdb$database         -- returns 2655320488 (a BIGINT)
select 0x28ED678A4C987 from rdb$database     -- returns 720001751632263
select 0xFFFFFFFFFFFFFFFF from rdb$database  -- returns -1
```

Hexadecimal Value Ranges

- Hex numbers in the range 0 … 7FFF FFFF are positive INTEGERs with values between 0 … 2147483647 decimal. To coerce a number to BIGINT, prepend enough zeroes to bring the total number of hex digits to nine or above. That changes the type but not the value.
- Hex numbers between 8000 0000 … FFFF FFFF require some attention:
  - When written with eight hex digits, as in 0x9E44F9A8, a value is interpreted as 32-bit INTEGER. Since the leftmost bit (sign bit) is set, it maps to the negative range -2147483648 … -1 decimal.
  - With one or more zeroes prepended, as in 0x09E44F9A8, a value is interpreted as 64-bit BIGINT in the range 0000 0000 8000 0000 … 0000 0000 FFFF FFFF. The sign bit is not set now, so they map to the positive range 2147483648 … 4294967295 decimal.

Thus, in this range, and for 16 vs 16+ digits, prepending a mathematically insignificant 0 results in a different value. This is something to be aware of.

- Hex numbers between 0 0000 0001 … 7FFF FFFF FFFF FFFF are all positive BIGINT.
- Hex numbers between 8000 0000 0000 0000 … FFFF FFFF FFFF FFFF are all negative BIGINT.
- Hex numbers between 0 0000 0000 0001 … 7FFF FFFF FFFF FFFF FFFF FFFF FFFF are all positive INT128
- Hex numbers between 8000 0000 0000 0000 0000 0000 0000 0000 … FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF FFFF are all negative INT128
- A SMALLINT cannot be written in hex, strictly speaking, since even 0x0 and 0x1 are evaluated as INTEGER. However, if you write a positive integer within the 16-bit range 0x0000 (decimal zero) to
0x7FFF (decimal 32767) it will be converted to SMALLINT transparently.

It is possible to write to a negative SMALLINT in hex, using a 4-byte hex number within the range 0xFFFF8000 (decimal -32768) to 0xFFFFFFFF (decimal -1).

**Boolean Literals**

A Boolean literal is one of TRUE, FALSE or UNKNOWN.

**Datetime Literals**

Formally, the SQL standard defines datetime literals as a prefix `DATE`, `TIME` and `TIMESTAMP` followed by a string literal with a datetime format. Historically, Firebird documentation has referred to these datetime literals as “shorthand casts”.

Since Firebird 4.0, the use of **datetime mnemonics** in datetime literals (e.g. `DATE 'TODAY'`) is no longer allowed.

The format of datetime literals and strings in Firebird 4.0 and higher is more strict compared to earlier Firebird versions.

**Datetime Literal Syntax**

```sql
<datetime_literal> ::= 
  DATE '<date_format>'
  | TIME { '<time_format>' | '<time_tz_format>' }
  | TIMESTAMP { '<timestamp_format>' | '<timestamp_tz_format>' }
```

**Datetime Format Syntax**

```sql
<date_format> ::= 
  [YYYY<p>][MM<p>][DD<p>]
  | MM<p>DD{<p>{ YYYY | YY }}
  | DD<p>MM{<p>{ YYYY | YY }}

<time_format> ::= HH[:,mm[,SS[,fNNN]]]

<timestamp_format> ::= <date_format> [<space> <time_format>]

<time_zone> ::= 
  { + | - }HH:MM
  | time zone name (e.g. Europe/Berlin)

<time_tz_format> ::= <time_format> [<space>] <time_zone>

<timestamp_tz_format> ::= <timestamp_format> [<space>] <time_zone>

<p> ::= whitespace | . | - | /
<f> ::= : | .
```
Table 21. Date and Time Literal Format Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>datetime_literal</td>
<td>Datetime literal</td>
</tr>
<tr>
<td>date_format</td>
<td>Format of date</td>
</tr>
<tr>
<td>time_format</td>
<td>Format of time</td>
</tr>
<tr>
<td>timestamp_format</td>
<td>Format of timestamp</td>
</tr>
<tr>
<td>time_zone</td>
<td>Format of time zone</td>
</tr>
<tr>
<td>time_tz_format</td>
<td>Format of time with time zone</td>
</tr>
<tr>
<td>timestamp_tz_format</td>
<td>Format of timestamp with time zone</td>
</tr>
<tr>
<td>YYYY</td>
<td>Four-digit year</td>
</tr>
<tr>
<td>YY</td>
<td>Two-digit year</td>
</tr>
<tr>
<td>MM</td>
<td>Month It may contain 1 or 2 digits (1-12 or 01-12). You can also specify the three-letter shorthand name or the full name of a month in English. Case-insensitive</td>
</tr>
<tr>
<td>DD</td>
<td>Day. It may contain 1 or 2 digits (1-31 or 01-31)</td>
</tr>
<tr>
<td>HH</td>
<td>Hour. It may contain 1 or 2 digits (0-23 or 00-23)</td>
</tr>
<tr>
<td>mm</td>
<td>Minutes. It may contain 1 or 2 digits (0-59 or 00-59)</td>
</tr>
<tr>
<td>SS</td>
<td>Seconds. It may contain 1 or 2 digits (0-59 or 00-59)</td>
</tr>
<tr>
<td>NNNN</td>
<td>Ten-thousandths of a second. It may contain from 1 to 4 digits (0-9999)</td>
</tr>
<tr>
<td>p</td>
<td>A date separator, any of permitted characters. Leading and trailing spaces are ignored. The choice of separator in a date decides whether the parser reads MM&lt;p&gt;DD or DD&lt;p&gt;MM.</td>
</tr>
<tr>
<td>f</td>
<td>Fractional seconds separator</td>
</tr>
</tbody>
</table>

⚠️ Use of the complete specification of the year in the four-digit form — YYYY — is strongly recommended, to avoid confusion in date calculations and aggregations.

Example

```sql
-- 1
UPDATE PEOPLE
SET AGECAT = 'SENIOR'
WHERE BIRTHDATE < DATE '1-Jan-1943';

-- 2
INSERT INTO APPOINTMENTS
(EMPLOYEE_ID, CLIENT_ID, APP_DATE, APP_TIME)
VALUES (973, 8804, DATE '1-Jan-2021' + 2, TIME '16:00');

-- 3
NEW.LASTMOD = TIMESTAMP '1-Jan-2021 16:00';
```
Although the Firebird datetime syntax is flexible, to avoid ambiguity we recommend using the ISO-8601 order (year-month-day), ‘-’ as the date separator, 4 digits for year, 2 digits for month, day, minute and second, : as the time separator, and ‘.’ as second fractions separator. This format is also the only one defined in the SQL standard.

In short, use `TIMESTAMP '2021-05-03 04:05:00.1 +02:00'`, not `TIMESTAMP '3.5.21 4:5:0:1 +2:0'`.

### 4.1.2. SQL Operators

SQL operators comprise operators for comparing, calculating, evaluating and concatenating values.

**Operator Precedence**

SQL Operators are divided into four types. Each operator type has a *precedence*, a ranking that determines the order in which operators and the values obtained with their help are evaluated in an expression. The higher the precedence of the operator type is, the earlier it will be evaluated. Each operator has its own precedence within its type, that determines the order in which they are evaluated in an expression.

Operators with the same precedence are evaluated from left to right. To force a different evaluation order, operations can be grouped by means of parentheses.

**Table 22. Operator Type Precedence**

<table>
<thead>
<tr>
<th>Operator Type</th>
<th>Precedence</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concatenation</td>
<td>1</td>
<td>Strings are concatenated before any other operations take place</td>
</tr>
<tr>
<td>Arithmetic</td>
<td>2</td>
<td>Arithmetic operations are performed after strings are concatenated, but before comparison and logical operations</td>
</tr>
<tr>
<td>Comparison</td>
<td>3</td>
<td>Comparison operations take place after string concatenation and arithmetic operations, but before logical operations</td>
</tr>
<tr>
<td>Logical</td>
<td>4</td>
<td>Logical operators are executed after all other types of operators</td>
</tr>
</tbody>
</table>

**Concatenation Operator**

The concatenation operator — two pipe characters known as “double pipe” or ‘|’ — concatenates two character strings to form a single string. Character strings can be literals or values obtained from columns or other expressions.

**Example**

```sql
SELECT LAST_NAME || ', ' || FIRST_NAME AS FULL_NAME
```
FROM EMPLOYEE

See also

BLOB_APPEND()

Arithmetic Operators

Table 23. Arithmetic Operator Precedence

<table>
<thead>
<tr>
<th>Operator</th>
<th>Purpose</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>+signed_number</td>
<td>Unary plus</td>
<td>1</td>
</tr>
<tr>
<td>-signed_number</td>
<td>Unary minus</td>
<td>1</td>
</tr>
<tr>
<td>*</td>
<td>Multiplication</td>
<td>2</td>
</tr>
<tr>
<td>/</td>
<td>Division</td>
<td>2</td>
</tr>
<tr>
<td>+</td>
<td>Addition</td>
<td>3</td>
</tr>
<tr>
<td>-</td>
<td>Subtraction</td>
<td>3</td>
</tr>
</tbody>
</table>

Example

```
UPDATE T
  SET A = 4 + 1/(B-C)*D
```

Where operators have the same precedence, they are evaluated in left-to-right sequence.

Comparison Operators

Table 24. Comparison Operator Precedence

<table>
<thead>
<tr>
<th>Operator</th>
<th>Purpose</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS</td>
<td>Checks that the expression on the left is (not) NULL or the Boolean value on the right</td>
<td>1</td>
</tr>
<tr>
<td>=</td>
<td>Is equal to, is identical to</td>
<td>2</td>
</tr>
<tr>
<td>&lt;&gt; ! = ~ = ^=</td>
<td>Is not equal to</td>
<td>2</td>
</tr>
<tr>
<td>&gt;</td>
<td>Is greater than</td>
<td>2</td>
</tr>
<tr>
<td>&lt;</td>
<td>Is less than</td>
<td>2</td>
</tr>
<tr>
<td>&gt;=</td>
<td>Is greater than or equal to</td>
<td>2</td>
</tr>
<tr>
<td>&lt;=</td>
<td>Is less than or equal to</td>
<td>2</td>
</tr>
<tr>
<td>!&gt;, ~&gt;, ^&gt;</td>
<td>Is not greater than</td>
<td>2</td>
</tr>
<tr>
<td>!&lt;, ~&lt;, ^&lt;</td>
<td>Is not less than</td>
<td>2</td>
</tr>
</tbody>
</table>

This group also includes comparison predicates BETWEEN, LIKE, CONTAINING, SIMILAR TO and others.
Example

IF (SALARY > 1400) THEN
...

See also

Other Comparison Predicates.

Logical Operators

Table 25. Logical Operator Precedence

<table>
<thead>
<tr>
<th>Operator</th>
<th>Purpose</th>
<th>Precedence</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOT</td>
<td>Negation of a search condition</td>
<td>1</td>
</tr>
<tr>
<td>AND</td>
<td>Combines two or more predicates, each of which must be true for the entire predicate to be true</td>
<td>2</td>
</tr>
<tr>
<td>OR</td>
<td>Combines two or more predicates, of which at least one predicate must be true for the entire predicate to be true</td>
<td>3</td>
</tr>
</tbody>
</table>

Example

IF (A < B OR (A > C AND A > D) AND NOT (C = D)) THEN ...

NEXT VALUE FOR

Result type
BIGINT — dialect 2 and 3
INTEGER — dialect 1

Syntax

NEXT VALUE FOR sequence-name

NEXT VALUE FOR returns the next value of a sequence. Sequence is the SQL-standard term for what is historically called a generator in Firebird and its ancestor, InterBase. The NEXT VALUE FOR operator is equivalent to the legacy \texttt{GEN\_ID (\ldots, increment) function} with \texttt{increment} the increment stored in the metadata of the sequence. It is the recommended syntax for retrieving the next sequence value.

Unlike the \texttt{GEN\_ID} function, the NEXT VALUE FOR expression does not take any parameters and thus provides no way to retrieve the current value of a sequence, nor to step the next value by a different value than the \texttt{increment} configured for the sequence. \texttt{GEN\_ID (\ldots, \texttt{<step value>})} is still needed for these tasks. A step value of 0 returns the current sequence value.

The \texttt{increment} of a sequence can be configured with the \texttt{INCREMENT} clause of CREATE SEQUENCE or ALTER SEQUENCE.
In dialect 1, the result type is \texttt{INTEGER}, in dialect 2 and 3 it is \texttt{BIGINT}.

\textit{Example}

\begin{verbatim}
NEW.CUST_ID = NEXT VALUE FOR CUSTSEQ;
\end{verbatim}

\textit{See also}

\texttt{SEQUENCE (GENERATOR), GEN_ID()}

\textbf{AT Time Zone Expression}

\textit{Syntax}

\begin{verbatim}
<at expr> ::= <expr> AT { TIME ZONE <time zone string> | LOCAL }
\end{verbatim}

The \texttt{AT} expression expresses a datatime value in a different time zone, while keeping the same UTC instant.

\texttt{AT} translates a time/timestamp value to its corresponding value in another time zone. If \texttt{LOCAL} is used, the value is converted to the session time zone.

When \texttt{expr} is a \texttt{WITHOUT TIME ZONE} type, \texttt{expr} is first converted to a \texttt{WITH TIME ZONE} in the session time zone and then transformed to the specified time zone.

\textit{Examples}

\begin{verbatim}
select time '12:00 GMT' at time zone '-03:00' from rdb$database;
select current_timestamp at time zone 'America/Sao_Paulo' from rdb$database;
select timestamp '2018-01-01 12:00 GMT' at local from rdb$database;
\end{verbatim}

\textbf{4.1.3. Conditional Expressions}

A conditional expression is one that returns different values according to how a certain condition is met. It is composed by applying a conditional function construct, of which Firebird supports several. This section describes only one conditional expression construct: \texttt{CASE}. All other conditional expressions apply internal functions derived from \texttt{CASE} and are described in \textit{Conditional Functions}.

\texttt{CASE}

The \texttt{CASE} construct returns a single value from a number of possible values. Two syntactic variants are supported:

- The \texttt{simple CASE}, comparable to a \texttt{case construct} in Pascal or a \texttt{switch} in C
- The \texttt{searched CASE}, which works like a series of \texttt{if … else if … else if} clauses.

\textit{Simple CASE}
When this variant is used, `test-expr` is compared to the first `expr`, second `expr` and so on, until a match is found, and the corresponding result is returned. If no match is found, `defaultresult` from the optional ELSE clause is returned. If there are no matches and no ELSE clause, NULL is returned.

The matching works as the “=” operator. That is, if `test-expr` is NULL, it does not match any `expr`, not even an expression that resolves to NULL.

The returned result does not have to be a literal value: it might be a field or variable name, compound expression or NULL literal.

**Example**

```sql
SELECT
    NAME, 
    AGE, 
    CASE UPPER(SEX) 
    WHEN 'M' THEN 'Male' 
    WHEN 'F' THEN 'Female' 
    ELSE 'Unknown' 
    END GENDER, 
    RELIGION
FROM PEOPLE
```

A short form of the simple CASE construct is the `DECODE` function.

**Searched CASE**

**Syntax**

```sql
CASE
WHEN <bool_expr> THEN <result>
[WHEN <bool_expr> THEN <result> ...]
[ELSE <defaultresult>]
END
```

The `bool_expr` expression is one that gives a ternary logical result: TRUE, FALSE or NULL. The first expression to return TRUE determines the result. If no expressions return TRUE, `defaultresult` from the optional ELSE clause is returned as the result. If no expressions return TRUE and there is no ELSE clause, the result will be NULL.
As with the simple CASE construct, the result need not be a literal value: it might be a field or variable name, a compound expression, or be NULL.

Example

```sql
CANVOTE = CASE
  WHEN AGE >= 18 THEN 'Yes'
  WHEN AGE < 18 THEN 'No'
  ELSE 'Unsure'
END
```

4.1.4. NULL in Expressions

NULL is not a value in SQL, but a state indicating that the value of the element either is unknown or it does not exist. It is not a zero, nor a void, nor an “empty string”, and it does not act like any value.

When you use NULL in numeric, string or date/time expressions, the result will always be NULL. When you use NULL in logical (Boolean) expressions, the result will depend on the type of the operation and on other participating values. When you compare a value to NULL, the result will be unknown.

⚠️ In SQL, the logical result unknown is also represented by NULL.

Consult the Firebird Null Guide for more in-depth coverage of Firebird’s NULL behaviour.

Expressions Returning NULL

Expressions in this list will always return NULL:

```sql
1 + 2 + 3 + NULL
'Home ' || 'sweet ' || NULL
MyField = NULL
MyField <> NULL
NULL = NULL
not (NULL)
```

If it seems difficult to understand why, remember that NULL is a state that stands for “unknown”.

NULL in Logical Expressions

It has already been shown that NOT (NULL) results in NULL. The interaction is a bit more complicated for the logical AND and logical OR operators:

```sql
NULL or false  → NULL
NULL or true   → true
NULL or NULL   → NULL
NULL and false → false
NULL and true  → NULL
```
As a basic rule-of-thumb, if substituting TRUE for NULL produces a different result than substituting FALSE, the outcome of the original expression is *unknown*, or NULL.

**Examples**

- \((1 = \text{NULL}) \text{ or } (1 <> 1)\) -- returns NULL
- \((1 = \text{NULL}) \text{ or FALSE}\) -- returns NULL
- \((1 = \text{NULL}) \text{ or } (1 = 1)\) -- returns TRUE
- \((1 = \text{NULL}) \text{ or TRUE}\) -- returns TRUE
- \((1 = \text{NULL}) \text{ or } (1 = \text{NULL})\) -- returns NULL
- \((1 = \text{NULL}) \text{ or UNKNOWN}\) -- returns NULL
- \((1 = \text{NULL}) \text{ and } (1 <> 1)\) -- returns FALSE
- \((1 = \text{NULL}) \text{ and FALSE}\) -- returns FALSE
- \((1 = \text{NULL}) \text{ and } (1 = 1)\) -- returns NULL
- \((1 = \text{NULL}) \text{ and TRUE}\) -- returns NULL
- \((1 = \text{NULL}) \text{ and } (1 = \text{NULL})\) -- returns NULL
- \((1 = \text{NULL}) \text{ and UNKNOWN}\) -- returns NULL

**4.1.5. Subqueries**

A subquery is a special form of expression that is a query embedded within another query. Subqueries are written in the same way as regular SELECT queries, but they must be enclosed in parentheses. Subquery expressions can be used in the following ways:

- To specify an output column in the SELECT list
- To obtain values or conditions for search predicates (the WHERE, HAVING clauses).
- To produce a set that the enclosing query can select from, as though were a regular table or view. Subqueries like this appear in the FROM clause (derived tables) or in a Common Table Expression (CTE)

**Correlated Subqueries**

A subquery can be _correlated_. A query is correlated when the subquery and the main query are interdependent. To process each record in the subquery, it is necessary to fetch a record in the main query, i.e. the subquery fully depends on the main query.

**Sample Correlated Subquery**

```
SELECT *
FROM Customers C
WHERE EXISTS
  (SELECT *
   FROM Orders O
   WHERE C.cnum = O.cnum
   AND O.adate = DATE '10.03.1990');
```
When subqueries are used to get the values of the output column in the SELECT list, a subquery must return a *scalar* result (see below).

**Scalar Results**

Subqueries used in search predicates, other than existential and quantified predicates, must return a *scalar* result; that is, not more than one column from not more than one matching row or aggregation. If the query returns more columns or rows, a run-time error will occur (“Multiple rows in a singleton select...”).

Although it is reporting a genuine error, the message can be slightly misleading. A “singleton SELECT” is a query that must not be capable of returning more than one row. However, “singleton” and “scalar” are not synonymous: not all singleton SELECTS are required to be scalar; and single-column selects can return multiple rows for existential and quantified predicates.

**Subquery Examples**

1. A subquery as the output column in a SELECT list:

   ```sql
   SELECT 
     e.first_name, 
     e.last_name, 
    (SELECT 
     sh.new_salary 
    FROM 
     salary_history sh 
    WHERE 
     sh.emp_no = e.emp_no 
    ORDER BY sh.change_date DESC ROWS 1) AS last_salary 
FROM 
  employee e
   ```

2. A subquery in the WHERE clause for obtaining the employee’s maximum salary and filtering by it:

   ```sql
   SELECT 
     e.first_name, 
     e.last_name, 
     e.salary 
FROM 
  employee e 
WHERE 
  e.salary = ( 
    SELECT MAX(ie.salary) 
    FROM 
  employee ie 
  )
   ```
4.2. Predicates

A predicate is a simple expression asserting some fact, let’s call it \( P \). If \( P \) resolves as TRUE, it succeeds. If it resolves to FALSE or NULL (UNKNOWN), it fails. A trap lies here, though: suppose the predicate, \( P \), returns FALSE. In this case \( \text{NOT}(P) \) will return TRUE. On the other hand, if \( P \) returns NULL (unknown), then \( \text{NOT}(P) \) returns NULL as well.

In SQL, predicates can appear in CHECK constraints, WHERE and HAVING clauses, CASE expressions, the IIF() function and in the ON condition of JOIN clauses, and anywhere a normal expression can occur.

4.2.1. Conditions

A condition — or Boolean expression — is a statement about the data that, like a predicate, can resolve to TRUE, FALSE or NULL. Conditions consist of one or more predicates, possibly negated using \( \text{NOT} \) and connected by \( \text{AND} \) and \( \text{OR} \) operators. Parentheses may be used for grouping predicates and controlling evaluation order.

A predicate may embed other predicates. Evaluation sequence is in the outward direction, i.e. the innermost predicates are evaluated first. Each “level” is evaluated in precedence order until the truth value of the ultimate condition is resolved.

4.2.2. Comparison Predicates

A comparison predicate consists of two expressions connected with a comparison operator. There are six traditional comparison operators:

\[ =, >, <, \geq, \leq, \neq \]

For the complete list of comparison operators with their variant forms, see Comparison Operators.

If one of the sides (left or right) of a comparison predicate has NULL in it, the value of the predicate will be UNKNOWN.

Examples

1. Retrieve information about computers with the CPU frequency not less than 500 MHz and the price lower than $800:

```sql
SELECT *
FROM Pc
WHERE speed >= 500 AND price < 800;
```

2. Retrieve information about all dot matrix printers that cost less than $300:

```sql
SELECT *
FROM Printer
```
WHERE ptrtype = 'matrix' AND price < 300;

3. The following query will return no data, even if there are printers with no type specified for them, because a predicate that compares NULL with NULL returns NULL:

SELECT *
FROM Printer
WHERE ptrtype = NULL AND price < 300;

On the other hand, ptrtype can be tested for NULL and return a result: it is just that it is not a comparison test:

SELECT *
FROM Printer
WHERE ptrtype IS NULL AND price < 300;

— see IS [NOT] NULL.

Note about String Comparison

When CHAR and VARCHAR fields are compared for equality, trailing spaces are ignored in all cases.

Other Comparison Predicates

Other comparison predicates are marked by keyword symbols.

BETWEEN

Syntax

\<value\> [NOT] BETWEEN \<value_1\> AND \<value_2\>

The BETWEEN predicate tests whether a value falls within a specified range of two values. (NOT BETWEEN tests whether the value does not fall within that range.)

The operands for BETWEEN predicate are two arguments of compatible data types. The BETWEEN predicate in Firebird is asymmetrical — if the lower bound is not the first argument, the BETWEEN predicate will return FALSE. The search is inclusive (the values represented by both arguments are included in the search). In other words, the BETWEEN predicate could be rewritten:

\<value\> >= \<value_1\> AND \<value\> <= \<value_2\>

When BETWEEN is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if it is available.
Example

```sql
SELECT *
FROM EMPLOYEE
WHERE HIRE_DATE BETWEEN date '1992-01-01' AND CURRENT_DATE
```

**LIKE**

**Syntax**

```sql
<match_value> [NOT] LIKE <pattern>
[ESCAPE <escape character>]
```

```plaintext
<match_value> ::= character-type expression
<pattern> ::= search pattern
<escape character> ::= escape character
```

The LIKE predicate compares the character-type expression with the pattern defined in the second expression. Case- or accent-sensitivity for the comparison is determined by the collation that is in use. A collation can be specified for either operand, if required.

**Wildcards**

Two wildcard symbols are available for use in the search pattern:

- the percentage symbol (%) will match any sequence of zero or more characters in the tested value
- the underscore character (_) will match any single character in the tested value

If the tested value matches the pattern, taking into account wildcard symbols, the predicate is TRUE.

**Using the ESCAPE Character Option**

If the search string contains either of the wildcard symbols, the ESCAPE clause can be used to specify an escape character. The escape character must precede the `%` or `_` symbol in the search string, to indicate that the symbol is to be interpreted as a literal character.

**Examples using LIKE**

1. Find the numbers of departments whose names start with the word “Software”:

   ```sql
   SELECT DEPT_NO
   FROM DEPT
   WHERE DEPT_NAME LIKE 'Software%';
   ```

   It is possible to use an index on the DEPT_NAME field if it exists.
About LIKE and the Optimizer

The LIKE predicate itself does not use an index. However, if the predicate takes the form of LIKE 'string%', it will be converted to the STARTING WITH predicate, which will use an index. This optimization only works for literal patterns, not for parameters.

So, if you need to search for the beginning of a string, it is recommended to use the STARTING WITH predicate instead of the LIKE predicate.

2. Search for employees whose names consist of 5 letters, start with the letters “Sm” and end with “th”. The predicate will be true for such names as “Smith” and “Smyth”.

```sql
SELECT first_name
FROM employee
WHERE first_name LIKE 'Sm_th'
```

3. Search for all clients whose address contains the string “Rostov”:

```sql
SELECT *
FROM CUSTOMER
WHERE ADDRESS LIKE '%Rostov%'
```

If you need to do a case-insensitive search for something enclosed inside a string (LIKE '%Abc%'), use of the CONTAINING predicate is recommended, in preference to the LIKE predicate.

4. Search for tables containing the underscore character in their names. The ‘#’ character is used as the escape character:

```sql
SELECT RDB$RELATION_NAME
FROM RDB$RELATIONS
WHERE RDB$RELATION_NAME LIKE '%#_%' ESCAPE '#'
```

See also

STARTING WITH, CONTAINING, SIMILAR TO

STARTING WITH

Syntax

<value> [NOT] STARTING WITH <value>
The **STARTING WITH** predicate searches for a string or a string-like type that starts with the characters in its *value* argument. The case- and accent-sensitivity of **STARTING WITH** depends on the collation of the first *value*.

When **STARTING WITH** is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if it exists.

**Example**

Search for employees whose last names start with “Jo”:

```
SELECT LAST_NAME, FIRST_NAME
FROM EMPLOYEE
WHERE LAST_NAME STARTING WITH 'Jo'
```

**See also**

**LIKE**

**CONTAINING**

**Syntax**

```
<value> [NOT] CONTAINING <value>
```

The **CONTAINING** predicate searches for a string or a string-like type looking for the sequence of characters that matches its argument. It can be used for an alphanumeric (string-like) search on numbers and dates. A **CONTAINING** search is not case-sensitive. However, if an accent-sensitive collation is in use then the search will be accent-sensitive.

**Examples**

1. Search for projects whose names contain the substring “Map”:

```
SELECT * 
FROM PROJECT
WHERE PROJ_NAME CONTAINING 'Map';
```

Two rows with the names “AutoMap” and “MapBrowser port” are returned.

2. Search for changes in salaries with the date containing number 84 (in this case, it means changes that took place in 1984):

```
SELECT *
FROM SALARY_HISTORY
WHERE CHANGE_DATE CONTAINING 84;
```

**See also**

**LIKE**
SIMILAR TO

Syntax

string-expression \[\text{NOT}\] SIMILAR TO \langle pattern\rangle \[\text{ESCAPE} \langle \text{escape-char} \rangle\]

\langle pattern\rangle ::= an SQL regular expression
\langle escape-char \rangle ::= a single character

SIMILAR TO matches a string against an SQL regular expression pattern. Unlike in some other languages, the pattern must match the entire string to succeed—matching a substring is not enough. If any operand is NULL, the result is NULL. Otherwise, the result is TRUE or FALSE.

If a literal pattern is used, and it doesn't start with a wildcard or other special regex character, SIMILAR TO can use an index.

Syntax: SQL Regular Expressions

The following syntax defines the SQL regular expression format. It is a complete and correct top-down definition. It is also highly formal and long, and may be daunting to anyone who hasn't already some experience with regular expressions (or with highly formal, rather long top-down definitions). Feel free to skip it and read the next section, Building Regular Expressions, which uses a bottom-up approach, aimed at the rest of us.

\langle regular expression \rangle ::= \langle regular term \rangle \['\|' \langle regular term \rangle ...\]
\langle regular term \rangle ::= \langle regular factor \rangle ...
\langle regular factor \rangle ::= \langle regular primary \rangle \[\langle quantifier \rangle\]
\langle quantifier \rangle ::= ? | * | + | '{' \langle m\rangle \[,[\langle n\rangle]\] '}'
\langle m\rangle, \langle n\rangle ::= unsigned int, with \langle m\rangle <= \langle n\rangle if both present

\langle regular primary \rangle ::=  
  \langle character \rangle | \langle character class \rangle | %  
  | (\langle regular expression \rangle)
\langle character \rangle ::= \langle escaped character \rangle | \langle non-escaped character \rangle
\langle escaped character \rangle ::=  
  \langle escape-char \rangle \langle special character \rangle | \langle escape-char \rangle \langle escape-char \rangle
\langle special character \rangle ::= any of the characters \[()|^-+*%_?\{
\langle non-escaped character \rangle ::=  
  any character that is not a \langle special character \rangle  
  and not equal to \langle escape-char \rangle \text{ (if defined)}
\langle character class \rangle ::=
Building Regular Expressions

In this section are the elements and rules for building SQL regular expressions.

Characters

Within regular expressions, most characters represent themselves. The only exceptions are the special characters below:

```
[ ] ( ) | ^ - + * % _ ? { }
```

... and the escape character, if it is defined.

A regular expression that contains no special characters or escape characters matches only strings that are identical to itself (subject to the collation in use). That is, it functions just like the `=` operator:

- 'Apple' similar to 'Apple' -- true
- 'Apples' similar to 'Apple' -- false
- 'Apple' similar to 'Apples' -- false
- 'APPLE' similar to 'Apple'  -- depends on collation

Wildcards

The known SQL wildcards `\_' and `%` match any single character and a string of any length, respectively:

- 'Birne' similar to 'B\_rne' -- true
- 'Birne' similar to 'B\_ne' -- false
- 'Birne' similar to 'B\%ne' -- true
- 'Birne' similar to 'Bir\%ne\%' -- true
- 'Birne' similar to 'Birr\%ne' -- false

Notice how `%` also matches the empty string.
Character Classes

A bunch of characters enclosed in brackets define a character class. A character in the string matches a class in the pattern if the character is a member of the class:

```
'Citroen' similar to 'Cit[arju]oen'  -- true
'Citroen' similar to 'Ci[tr]oen'    -- false
'Citroen' similar to 'Ci[tr][tr]oen' -- true
```

As can be seen from the second line, the class only matches a single character, not a sequence.

Within a class definition, two characters connected by a hyphen define a range. A range comprises the two endpoints and all the characters that lie between them in the active collation. Ranges can be placed anywhere in the class definition without special delimiters to keep them apart from the other elements.

```
'Datte' similar to 'Dat[q-u]e'      -- true
'Datte' similar to 'Dat[abq-uy]e'   -- true
'Datte' similar to 'Dat[bcg-km-pwz]e' -- false
```

Predefined Character Classes

The following predefined character classes can also be used in a class definition:

```
[:ALPHA:]
  Latin letters a..z and A..Z. With an accent-insensitive collation, this class also matches accented forms of these characters.

[:DIGIT:]
  Decimal digits 0..9.

[:ALNUM:]
  Union of [:ALPHA:] and [:DIGIT:].

[:UPPER:]
  Uppercase Latin letters A..Z. Also matches lowercase with case-insensitive collation and accented forms with accent-insensitive collation.

[:LOWER:]
  Lowercase Latin letters a..z. Also matches uppercase with case-insensitive collation and accented forms with accent-insensitive collation.

[:SPACE:]
  Matches the space character (ASCII 32).

[:WHITESPACE:]
  Matches horizontal tab (ASCII 9), linefeed (ASCII 10), vertical tab (ASCII 11), formfeed (ASCII 12),
```
carriage return (ASCII 13) and space (ASCII 32).

Including a predefined class has the same effect as including all its members. Predefined classes are only allowed within class definitions. If you need to match against a predefined class and nothing more, place an extra pair of brackets around it.

```
'Erdbeere' similar to 'Erd[[:ALNUM:]]eere' -- true
'Erdbeere' similar to 'Erd[[:DIGIT:]]eere' -- false
'Erdbeere' similar to 'Erd[a[:SPACE:]b]eere' -- true
'Erdbeere' similar to [[:ALPHA:]] -- false
'E' similar to [[:ALPHA:]] -- false
```

If a class definition starts with a caret, everything that follows is excluded from the class. All other characters match:

```
'Framboise' similar to 'Fra[^ck-p]boise' -- false
'Framboise' similar to 'Fr[^a][^a]boise' -- false
'Framboise' similar to 'Fra[^[:DIGIT:]]boise' -- true
```

If the caret is not placed at the start of the sequence, the class contains everything before the caret, except for the elements that also occur after the caret:

```
'Grapefruit' similar to 'Grap[a-m^f-i]fruit' -- true
'Grapefruit' similar to 'Grap[abc^xyz]fruit' -- false
'Grapefruit' similar to 'Grap[abc^de]fruit' -- false
'Grapefruit' similar to 'Grap[abe^de]fruit' -- false
'3' similar to '[:DIGIT:]^4-8' -- true
'6' similar to '[:DIGIT:]^4-8' -- false
```

Lastly, the already mentioned wildcard ‘_’ is a character class of its own, matching any single character.

**Quantifiers**

A question mark (‘?’) immediately following a character or class indicates that the preceding item may occur 0 or 1 times to match:

```
'Hallon' similar to 'Hal?on' -- false
'Hallon' similar to 'Hal?lon' -- true
'Hallon' similar to 'Hall?on' -- true
'Hallon' similar to 'Hallo?on' -- false
'Hallon' similar to 'Halx?on' -- true
'Hallon' similar to 'H[a-c]?llon[x-z]?' -- true
```

An asterisk (‘*’) immediately following a character or class indicates that the preceding item may
occur 0 or more times to match:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Icaque' similar to 'Ica*que'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Icaque' similar to 'Icar*que'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Icaque' similar to 'I[a-c]*que'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Icaque' similar to '_*'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Icaque' similar to '[[[:ALPHA:]]]*'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Icaque' similar to 'Ica[xyz]*e'</td>
<td>-- false</td>
</tr>
</tbody>
</table>

A plus sign (‘+’) immediately following a character or class indicates that the preceding item must occur 1 or more times to match:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Jujube' similar to 'Ju_+'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Jujube' similar to 'Ju+jube'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Jujube' similar to 'Jujuber+'</td>
<td>-- false</td>
</tr>
<tr>
<td>'Jujube' similar to 'J[jux]+be'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Jujube' similar to 'J[[[:DIGIT:]]]+ujube'</td>
<td>-- false</td>
</tr>
</tbody>
</table>

If a character or class is followed by a number enclosed in braces (‘{’ and ‘}’), it must be repeated exactly that number of times to match:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Kiwi' similar to 'Ki{2}wi'</td>
<td>-- false</td>
</tr>
<tr>
<td>'Kiwi' similar to 'K[ipw]{2}i'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Kiwi' similar to 'K[ipw]{2}'</td>
<td>-- false</td>
</tr>
<tr>
<td>'Kiwi' similar to 'K[ipw]{3}'</td>
<td>-- true</td>
</tr>
</tbody>
</table>

If the number is followed by a comma (‘,’), the item must be repeated at least that number of times to match:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Limone' similar to 'Li{2,}mone'</td>
<td>-- false</td>
</tr>
<tr>
<td>'Limone' similar to 'Li{1,}mone'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Limone' similar to 'Li[nezom]{2,}'</td>
<td>-- true</td>
</tr>
</tbody>
</table>

If the braces contain two numbers separated by a comma, the second number not smaller than the first, then the item must be repeated at least the first number and at most the second number of times to match:

<table>
<thead>
<tr>
<th>Pattern</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Mandarijn' similar to 'M[a-p]{2,5}rijn'</td>
<td>-- true</td>
</tr>
<tr>
<td>'Mandarijn' similar to 'M[a-p]{2,3}rijn'</td>
<td>-- false</td>
</tr>
<tr>
<td>'Mandarijn' similar to 'M[a-p]{2,3}arijn'</td>
<td>-- true</td>
</tr>
</tbody>
</table>

The quantifiers ‘?’, ‘*’ and ‘+’ are shorthand for \{0,1\}, \{0,\} and \{1,\}, respectively.
OR-ing Terms

Regular expression terms can be OR'ed with the `'|' operator. A match is made when the argument string matches at least one of the terms:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Nektarin' similar to 'Nektarin'</td>
<td>false</td>
</tr>
<tr>
<td>'Nektarin' similar to 'Nektarin</td>
<td>Persika'</td>
</tr>
<tr>
<td>'Nektarin' similar to 'M_+</td>
<td>N_+</td>
</tr>
</tbody>
</table>

Subexpressions

One or more parts of the regular expression can be grouped into subexpressions (also called subpatterns) by placing them between parentheses (`'(' and ')'`). A subexpression is a regular expression in its own right. It can contain all the elements allowed in a regular expression, and can also have quantifiers added to it.

<table>
<thead>
<tr>
<th>Expression</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Orange' similar to 'O(ra</td>
<td>ri</td>
</tr>
<tr>
<td>'Orange' similar to 'O(r[a-e])nge'</td>
<td>true</td>
</tr>
<tr>
<td>'Orange' similar to 'O(ra){2,4}nge'</td>
<td>false</td>
</tr>
<tr>
<td>'Orange' similar to 'O(ra){2,4}nge'</td>
<td>true</td>
</tr>
</tbody>
</table>

Escaping Special Characters

To match against a character that is special in regular expressions, that character has to be escaped. There is no default escape character; the user specifies one when needed:

<table>
<thead>
<tr>
<th>Expression</th>
<th>Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Peer (Poire)' similar to 'P[^ ]+(P[^ ]+)' escape ''</td>
<td>true</td>
</tr>
<tr>
<td>'Pera [Pear]' similar to 'P[^ ]+#[P[^ ]]+#)' escape '#'</td>
<td>true</td>
</tr>
<tr>
<td>'Pårön-äppledryck' similar to 'P%$-ä%' escape '$'</td>
<td>true</td>
</tr>
<tr>
<td>'Pärondryck' similar to 'P%--ä%' escape '-'</td>
<td>false</td>
</tr>
</tbody>
</table>

The last line demonstrates that the escape character can also escape itself, if needed.

IS [NOT] DISTINCT FROM

Syntax

<operand1> IS [NOT] DISTINCT FROM <operand2>

Two operands are considered DISTINCT (different) if they have a different value or if one of them is NULL and the other non-null. They are considered NOT DISTINCT (equal) if they have the same value or if both of them are NULL.

IS [NOT] DISTINCT FROM always returns TRUE or FALSE and never UNKNOWN (NULL) (unknown value). Operators `=' and `<>`, conversely, will return UNKNOWN (NULL) if one or both operands are NULL.

Table 26. Results of Various Comparison Predicates
### Operand values

<table>
<thead>
<tr>
<th></th>
<th>=</th>
<th>IS NOT DISTINCT FROM</th>
<th>&lt;&gt;</th>
<th>IS DISTINCT FROM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Same value</td>
<td>TRUE</td>
<td>TRUE</td>
<td>FALSE</td>
<td>FALSE</td>
</tr>
<tr>
<td>Different values</td>
<td>FALSE</td>
<td>FALSE</td>
<td>TRUE</td>
<td>TRUE</td>
</tr>
<tr>
<td>Both NULL</td>
<td>UNKNOWN</td>
<td>TRUE</td>
<td>UNKNOWN</td>
<td>FALSE</td>
</tr>
<tr>
<td>One NULL, one non-NULL</td>
<td>UNKNOWN</td>
<td>FALSE</td>
<td>UNKNOWN</td>
<td>TRUE</td>
</tr>
</tbody>
</table>

### Examples

```sql
SELECT ID, NAME, TEACHER
FROM COURSES
WHERE START_DAY IS NOT DISTINCT FROM END_DAY;
```

-- PSQL fragment

```sql
IF (NEW.JOB IS DISTINCT FROM OLD.JOB)
THEN POST_EVENT 'JOB_CHANGED';
```

### See also

**IS [NOT] NULL, Boolean IS [NOT]**

### Boolean IS [NOT]

#### Syntax

```
<value> IS [NOT] { TRUE | FALSE | UNKNOWN }
```

The IS predicate with Boolean literal values checks if the expression on the left side matches the Boolean value on the right side. The expression on the left side must be of type BOOLEAN, otherwise an exception is raised.

The IS [NOT] UNKNOWN is equivalent to IS [NOT] NULL.

The right side of the predicate only accepts the literals TRUE, FALSE, UNKNOWN, and NULL. It does not accept expressions.

### Using the IS predicate with a Boolean data type

```sql
-- Checking FALSE value
SELECT * FROM TBOOL WHERE BVAL IS FALSE;
```

<table>
<thead>
<tr>
<th>ID</th>
<th>BVAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>&lt;false&gt;</td>
</tr>
</tbody>
</table>

```sql
-- Checking UNKNOWN value
SELECT * FROM TBOOL WHERE BVAL IS UNKNOWN;
```
See also

**IS [NOT] NULL**

**Syntax**

\[ <value> \text{ IS [NOT] NULL} \]

Since NULL is not a value, these operators are not comparison operators. The IS [NOT] NULL predicate tests that the expression on the left side has a value (IS NOT NULL) or has no value (IS NULL).

**Example**

Search for sales entries that have no shipment date set for them:

```sql
SELECT * FROM SALES
WHERE SHIP_DATE IS NULL;
```

**Note regarding the IS predicates**

The IS predicates take precedence above the others.

**4.2.3. Existential Predicates**

This group of predicates includes those that use subqueries to submit values for all kinds of assertions in search conditions. Existential predicates are so called because they use various methods to test for the existence or non-existence of some condition, returning TRUE if the existence or non-existence is confirmed or FALSE otherwise.

**EXISTS**

**Syntax**

\[ \text{[NOT]} \text{ EXISTS (<select_stmt>)} \]

The EXISTS predicate uses a subquery expression as its argument. It returns TRUE if the subquery result contains at least one row, otherwise it returns FALSE.

**NOT EXISTS** returns FALSE if the subquery result contains at least one row, otherwise it returns TRUE.

**Note**

The subquery can specify multiple columns, or SELECT *, because the evaluation is made on the number of rows that match its criteria, not on the data.
Examples

1. Find those employees who have projects.

```sql
SELECT *
FROM employee
WHERE EXISTS(SELECT *
FROM employee_project ep
WHERE ep.emp_no = employee.emp_no)
```

2. Find those employees who have no projects.

```sql
SELECT *
FROM employee
WHERE NOT EXISTS(SELECT *
FROM employee_project ep
WHERE ep.emp_no = employee.emp_no)
```

**IN**

**Syntax**

```sql
<value> [NOT] IN (<select_stmt> | <value_list>)
[value_list] ::= <value_1> [, <value_2> ...]
```

The IN predicate tests whether the value of the expression on the left side is present in the set of values specified on the right side. The set of values cannot have more than 65535 items. The IN predicate can be replaced with the following equivalent forms:

```sql
(<value> = <value_1> [OR <value> = <value_2> ...])
<value> = { ANY | SOME } (<select_stmt>)
```

When the IN predicate is used in the search conditions of DML queries, the Firebird optimizer can use an index on the searched column, if a suitable one exists. Lists that are known to be constant are pre-evaluated as invariants and cached as a binary search tree, making comparisons faster if the condition needs to be tested for many rows or if the value list is long.

In its second form, the IN predicate tests whether the value of the expression on the left side is present — or not present, if NOT IN is used — in the result of the subquery on the right side.

The subquery must specify only one column, otherwise the error “count of column list and variable list do not match” will occur.

Queries using an IN predicate with a subquery can be replaced with a similar query using the EXISTS predicate. For example, the following query:
SELECT
    model, speed, hd
FROM PC
WHERE
model IN (SELECT model
    FROM product
    WHERE maker = 'A');

can be replaced with a similar one using the EXISTS predicate:

SELECT
    model, speed, hd
FROM PC
WHERE
    EXISTS (SELECT *
        FROM product
        WHERE maker = 'A'
        AND product.model = PC.model);

However, a query using NOT IN with a subquery does not always give the same result as its NOT EXISTS counterpart. The reason is that EXISTS always returns TRUE or FALSE, whereas IN returns NULL in one of these two cases:

a. when the test value is NULL and the IN () list is not empty
b. when the test value has no match in the IN () list and at least one list element is NULL

It is in only these two cases that IN () will return NULL while the EXISTS predicate will return FALSE (“no matching row found”). In a search or, for example, an IF (…) statement, both results mean “failure”, and it makes no difference to the outcome.

For the same data, NOT IN () will return NULL, while NOT EXISTS will return TRUE, leading to opposite results.

As an example, suppose you have the following query:

-- Looking for people who were not born
-- on the same day as any famous New York citizen
SELECT P1.name AS NAME
FROM Personnel P1
WHERE P1.birthday NOT IN (SELECT C1.birthday
    FROM Celebrities C1
    WHERE C1.birthcity = 'New York');

Now, assume that the NY celebrities list is not empty and contains at least one NULL birthday. Then for every citizen who does not share his birthday with a NY celebrity, NOT IN will return NULL, because that is what IN does. The search condition is thereby not satisfied and the citizen will be left out of the SELECT result, which is wrong.
For citizens whose birthday does match with a celebrity's birthday, NOT IN will correctly return FALSE, so they will be left out too, and no rows will be returned.

If the NOT EXISTS form is used:

```sql
-- Looking for people who were not born
-- on the same day as any famous New York citizen
SELECT P1.name AS NAME
FROM Personnel P1
WHERE NOT EXISTS (SELECT *
    FROM Celebrities C1
    WHERE C1.birthcity = 'New York'
    AND C1.birthday = P1.birthday);
```

non-matches will have a NOT EXISTS result of TRUE and their records will be in the result set.

If there is any chance of NULLs being encountered when searching for a non-match, you will want to use NOT EXISTS.

**Examples of use**

1. Find employees with the names “Pete”, “Ann” and “Roger”:

```sql
SELECT *
FROM Employee
WHERE FIRST_NAME IN ('Pete', 'Ann', 'Roger');
```

2. Find all computers that have models whose manufacturer starts with the letter “A”:

```sql
SELECT model, speed, hd
FROM PC
WHERE model IN (SELECT model
    FROM product
    WHERE maker STARTING WITH 'A');
```

**See also**

EXIST

SINGULAR

**Syntax**

```
[NOT] SINGULAR (<select_stmt>)
```

The SINGULAR predicate takes a subquery as its argument and evaluates it as TRUE if the subquery
returns exactly one row, otherwise the predicate is evaluated as FALSE. The subquery may list several output columns since the rows are not returned anyway, they are only tested for (singular) existence. For brevity, people usually specify ‘SELECT *’. The SINGULAR predicate can return only two values: TRUE or FALSE.

Example
Find those employees who have only one project.

```
SELECT *
FROM employee
WHERE SINGULAR(SELECT *
                 FROM employee_project ep
                 WHERE ep.emp_no = employee.emp_no)
```

4.2.4. Quantified Subquery Predicates

A quantifier is a logical operator that sets the number of objects for which this condition is true. It is not a numeric quantity, but a logical one that connects the condition with the full set of possible objects. Such predicates are based on logical universal and existential quantifiers that are recognised in formal logic.

In subquery expressions, quantified predicates make it possible to compare separate values with the results of subqueries; they have the following common form:

```
<value expression> <comparison operator> <quantifier> <subquery>
```

**ALL**

**Syntax**

```
<value> <op> ALL (<select_stmt>)
```

When the ALL quantifier is used, the predicate is TRUE if every value returned by the subquery satisfies the condition in the predicate of the main query.

Example
Show only those clients whose ratings are higher than the rating of every client in Paris.

```
SELECT c1.*
FROM Customers c1
WHERE c1.rating > ALL
    (SELECT c2.rating
     FROM Customers c2
     WHERE c2.city = 'Paris')
```

⚠️ If the subquery returns an empty set, the predicate is TRUE for every left-side value,
regardless of the operator. This may appear to be contradictory, because every left-side value will thus be considered both smaller and greater than, both equal to and unequal to, every element of the right-side stream.

Nevertheless, it aligns perfectly with formal logic: if the set is empty, the predicate is true for every row in the set.

**ANY and SOME**

**Syntax**

```
<value> <op> {ANY | SOME} (<select_stmt>)
```

The quantifiers *ANY* and *SOME* are identical in their behaviour. Both are specified in the SQL standard, and they be used interchangeably to improve the readability of operators. When the *ANY* or the *SOME* quantifier is used, the predicate is `TRUE` if any of the values returned by the subquery satisfies the condition in the predicate of the main query. If the subquery returns no rows at all, the predicate is automatically considered as `FALSE`.

**Example**

Show only those clients whose ratings are higher than those of one or more clients in Rome.

```sql
SELECT *
FROM Customers
WHERE rating > ANY
    (SELECT rating
     FROM Customers
     WHERE city = 'Rome')
```
Chapter 5. Data Definition (DDL) Statements

DDL is the data definition language subset of Firebird's SQL language. DDL statements are used to create, alter and drop database objects. When a DDL statement is committed, the metadata for the object are created, altered or deleted.

5.1. DATABASE

This section describes how to create a database, connect to an existing database, alter the file structure of a database and how to drop a database. It also shows two methods to back up a database and how to switch the database to the “copy-safe” mode for performing an external backup safely.

5.1.1. CREATE DATABASE

Creates a new database

Available in
DSQL, ESQL

Syntax

```sql
CREATE {DATABASE | SCHEMA} <filespec>
  [<db_initial_option> [<db_initial_option> ...]]
  [<db_config_option> [<db_config_option> ...]]
```

```sql
<db_initial_option> ::= 
  USER username 
  | PASSWORD 'password'
  | ROLE rolename
  | PAGE_SIZE [=] size
  | LENGTH [=] num [PAGE[S]]
  | SET NAMES 'charset'
```

```sql
<db_config_option> ::= 
  DEFAULT CHARACTER SET default_charset
  [COLLATION collation] -- not supported in ESQL
  | <sec_file>
  | DIFFERENCE FILE 'diff_file' -- not supported in ESQL
```

```sql
<filespec> ::= "'" [server_spec]{filepath | db_alias} "'"
```

```sql
<server_spec> ::= 
  host[/{port | service}]:
  | <protocol>://[host::{port | service}]/
```

```sql
<protocol> ::= inet | inet4 | inet6 | xnet
```

```sql
<sec_file> ::= 
```
Each `db_initial_option` and `db_config_option` can occur at most once, except `sec_file`, which can occur zero or more times.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filespec</td>
<td>File specification for primary database file</td>
</tr>
<tr>
<td>server_spec</td>
<td>Remote server specification. Some protocols require specifying a hostname. Optionally includes a port number or service name. Required if the database is created on a remote server.</td>
</tr>
<tr>
<td>filepath</td>
<td>Full path and file name including its extension. The file name must be specified according to the rules of the platform file system being used.</td>
</tr>
<tr>
<td>db_alias</td>
<td>Database alias previously created in the <code>databases.conf</code> file</td>
</tr>
<tr>
<td>host</td>
<td>Host name or IP address of the server where the database is to be created</td>
</tr>
<tr>
<td>port</td>
<td>The port number where the remote server is listening (parameter <code>RemoteServicePort</code> in <code>firebird.conf</code> file)</td>
</tr>
<tr>
<td>service</td>
<td>Service name. Must match the parameter value of <code>RemoteServiceName</code> in <code>firebird.conf</code> file</td>
</tr>
<tr>
<td>username</td>
<td>Username of the owner of the new database. The maximum length is 63 characters. The username can optionally be enclosed in single or double quotes. When a username is enclosed in double quotes, it is case-sensitive following the rules for quoted identifiers. When enclosed in single quotes, it behaves as if the value was specified without quotes. The user must be an administrator or have the <code>CREATE DATABASE</code> privilege.</td>
</tr>
<tr>
<td>password</td>
<td>Password of the user as the database owner. When using the Legacy_Auth authentication plugin, only the first 8 characters are used. Case-sensitive</td>
</tr>
<tr>
<td>rolename</td>
<td>The name of the role whose rights should be taken into account when creating a database. The role name can be enclosed in single or double quotes. When the role name is enclosed in double quotes, it is case-sensitive following the rules for quoted identifiers. When enclosed in single quotes, it behaves as if the value was specified without quotes.</td>
</tr>
<tr>
<td>size</td>
<td>Page size for the database, in bytes. Possible values are 4096, 8192, 16384 and 32768. The default page size is 8192.</td>
</tr>
<tr>
<td>num</td>
<td>Maximum size of the primary database file, or a secondary file, in pages</td>
</tr>
<tr>
<td>charset</td>
<td>Specifies the character set of the connection available to a client connecting after the database is successfully created. Single quotes are required.</td>
</tr>
<tr>
<td>default_charset</td>
<td>Specifies the default character set for string data types</td>
</tr>
</tbody>
</table>
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>collation</td>
<td>Default collation for the default character set</td>
</tr>
<tr>
<td>sec_file</td>
<td>File specification for a secondary file</td>
</tr>
<tr>
<td>pagenum</td>
<td>Starting page number for a secondary database file</td>
</tr>
<tr>
<td>diff_file</td>
<td>File path and name for DIFFERENCE files (.delta files) for backup mode</td>
</tr>
</tbody>
</table>

The `CREATE DATABASE` statement creates a new database. You can use `CREATE DATABASE` or `CREATE SCHEMA`. They are synonymous, but we recommend to always use `CREATE DATABASE` as this may change in a future version of Firebird.

A database consists of one or more files. The first (main) file is called the *primary file*, subsequent files are called *secondary file(s)*.

### Multi-file Databases

Nowadays, multi-file databases are considered an anachronism. It made sense to use multi-file databases on old file systems where the size of any file is limited. For instance, you could not create a file larger than 4 GB on FAT32.

The primary file specification is the name of the database file and its extension with the full path to it according to the rules of the OS platform file system being used. The database file must not exist at the moment the database is being created. If it does exist, you will get an error message, and the database will not be created.

If the full path to the database is not specified, the database will be created in one of the system directories. The particular directory depends on the operating system. For this reason, unless you have a strong reason to prefer that situation, always specify either the absolute path or an *alias*, when creating a database.

### Using a Database Alias

You can use aliases instead of the full path to the primary database file. Aliases are defined in the `databases.conf` file in the following format:

```plaintext
alias = filepath
```

Executing a `CREATE DATABASE` statement requires special consideration in the client application or database driver. As a result, it is not always possible to execute a `CREATE DATABASE` statement. Some drivers provide other ways to create databases. For example, Jaybird provides the class `org.firebirdsql.management.FBManager` to programmatically create a database.

If necessary, you can always fall back to `isql` to create a database.

### Creating a Database on a Remote Server

If you create a database on a remote server, you need to specify the remote server specification.
The remote server specification depends on the protocol being used. If you use the TCP/IP protocol to create a database, the primary file specification should look like this:

```
host[/{port|service}]:{filepath | db_alias}
```

Firebird also has a unified URL-like syntax for the remote server specification. In this syntax, the first part specifies the name of the protocol, then a host name or IP address, port number, and path of the primary database file, or an alias.

The following values can be specified as the protocol:

- **inet**
  - TCP/IP (first tries to connect using the IPv6 protocol, if it fails, then IPv4)
- **inet4**
  - TCP/IP v4
- **inet6**
  - TCP/IP v6
- **xnet**
  - local protocol (does not include a host, port and service name)

```
<protocol>://[host[:{port | service}]/]{filepath | db_alias}
```

**Optional Parameters for CREATE DATABASE**

**USER and PASSWORD**

The username and the password of an existing user in the security database (security5.fdb or whatever is configured in the `SecurityDatabase` configuration). You do not have to specify the username and password if the `ISC_USER` and `ISC_PASSWORD` environment variables are set. The user specified in the process of creating the database will be its owner. This will be important when considering database and object privileges.

**ROLE**

The name of the role (usually RDB$ADMIN), which will be taken into account when creating the database. The role must be assigned to the user in the applicable security database.

**PAGE_SIZE**

The desired database page size. This size will be set for the primary file and all secondary files of the database. If you specify the database page size less than 4,096, it will be automatically rounded up to 4,096. Other values not equal to either 4,096, 8,192, 16,384 or 32,768 will be changed to the closest smaller supported value. If the database page size is not specified, the default value of 8,192 is used.

ℹ️ **Bigger Isn’t Always Better.**
Larger page sizes can fit more records on a single page, have wider indexes, and more indexes, but they will also waste more space for blobs (compare the wasted space of a 3KB blob on page size 4096 with one on 32768: +/- 1KB vs +/- 29KB), and increase memory consumption of the page cache.

**LENGTH**

The maximum size of the primary or secondary database file, in pages. When a database is created, its primary and secondary files will occupy the minimum number of pages necessary to store the system data, regardless of the value specified in the LENGTH clause. The LENGTH value does not affect the size of the only (or last, in a multi-file database) file. The file will keep increasing its size automatically when necessary.

**SET NAMES**

The character set of the connection available after the database is successfully created. The character set NONE is used by default. Notice that the character set should be enclosed in a pair of apostrophes (single quotes).

**DEFAULT CHARACTER SET**

The default character set for creating data structures of string data types. Character sets are used for CHAR, VARCHAR and BLOB SUB_TYPE TEXT data types. The character set NONE is used by default. It is also possible to specify the default COLLATION for the default character set, making that collation the default for the default character set. The default will be used for the entire database except where an alternative character set, with or without a specified collation, is used explicitly for a field, domain, variable, cast expression, etc.

**STARTING AT**

The database page number at which the next secondary database file should start. When the previous file is fully filled with data according to the specified page number, the system will start adding new data to the next database file.

**DIFFERENCE FILE**

The path and name for the file delta that stores any mutations to the database file after it has been switched to the “copy-safe” mode by the ALTER DATABASE BEGIN BACKUP statement. For the detailed description of this clause, see ALTER DATABASE.

**Specifying the Database Dialect**

Databases are created in Dialect 3 by default. For the database to be created in Dialect 1, you will need to execute the statement SET SQL DIALECT 1 from script or the client application, e.g. in isql, before the CREATE DATABASE statement.

**Who Can Create a Database**

The CREATE DATABASE statement can be executed by:

- *Administrators*
- Users with the CREATE DATABASE privilege
Examples Using `CREATE DATABASE`

1. Creating a database in Windows, located on disk D with a page size of 4,096. The owner of the database will be the user `wizard`. The database will be in Dialect 1, and will use WIN1251 as its default character set.

```sql
SET SQL DIALECT 1;
CREATE DATABASE 'D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 4096 DEFAULT CHARACTER SET WIN1251;
```

2. Creating a database in the Linux operating system with a page size of 8,192 (default). The owner of the database will be the user `wizard`. The database will be in Dialect 3 and will use UTF8 as its default character set, with `UNICODE_CI_AI` as the default collation.

```sql
CREATE DATABASE '/home/firebird/test.fdb'
USER 'wizard' PASSWORD 'player'
DEFAULT CHARACTER SET UTF8 COLLATION UNICODE_CI_AI;
```

3. Creating a database on the remote server “baseserver” with the path specified in the alias “test” that has been defined previously in the file `databases.conf`. The TCP/IP protocol is used. The owner of the database will be the user `wizard`. The database will be in Dialect 3 and will use UTF8 as its default character set.

```sql
CREATE DATABASE 'baseserver:test'
USER 'wizard' PASSWORD 'player'
DEFAULT CHARACTER SET UTF8;
```

4. Creating a database in Dialect 3 with UTF8 as its default character set. The primary file will contain up to 10,000 pages with a page size of 8,192. As soon as the primary file has reached the maximum number of pages, Firebird will start allocating pages to the secondary file `test.fdb2`. If that file is filled up to its maximum as well, `test.fdb3` becomes the recipient of all new page allocations. As the last file, it has no page limit imposed on it by Firebird. New allocations will continue for as long as the file system allows it or until the storage device runs out of free space. If a `LENGTH` parameter were supplied for this last file, it would be ignored.

```sql
SET SQL DIALECT 3;
CREATE DATABASE 'baseserver:D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 8192
DEFAULT CHARACTER SET UTF8
FILE 'D:\test.fdb2'
STARTING AT PAGE 10001
FILE 'D:\test.fdb3'
STARTING AT PAGE 20001;
```
5. Creating a database in Dialect 3 with UTF8 as its default character set. The primary file will contain up to 10,000 pages with a page size of 8,192. As far as file size and the use of secondary files are concerned, this database will behave exactly like the one in the previous example.

```sql
SET SQL DIALECT 3;
CREATE DATABASE 'baseserver:D:\test.fdb'
USER 'wizard' PASSWORD 'player'
PAGE_SIZE = 8192
LENGTH 10000 PAGES
DEFAULT CHARACTER SET UTF8
FILE 'D:\test.fdb2'
FILE 'D:\test.fdb3'
STARTING AT PAGE 20001;
```

See also

ALTER DATABASE, DROP DATABASE

5.1.2. ALTER DATABASE

Alters the file organisation of a database, toggles its “copy-safe” state, manages encryption, and other database-wide configuration

Available in

DSQL, ESQL — limited feature set

Syntax

```
ALTER {DATABASE | SCHEMA} <alter_db_option> [<alter_db_option> ...]

<alter_db_option> ::= 
| <add_sec_clause>
| {ADD DIFFERENCE FILE 'diff_file' | DROP DIFFERENCE FILE}
| {BEGIN | END} BACKUP
| SET DEFAULT CHARACTER SET charset
| {ENCRYPT WITH plugin_name [KEY key_name] | DECRYPT}
| SET LINGER TO linger_duration
| DROP LINGER
| SET DEFAULT SQL SECURITY {INVOKER | DEFINER}
| {ENABLE | DISABLE} PUBLICATION
| INCLUDE <pub_table_filter> TO PUBLICATION
| EXCLUDE <pub_table_filter> FROM PUBLICATION

<add_sec_clause> ::= ADD <sec_file> [<sec_file> ...]

<sec_file> ::= 
| FILE 'filepath'
| [STARTING [AT [PAGE]] pagenum]
| [LENGTH [=.] num [PAGE[S]]]```
Multiple files can be added in one ADD clause:

```
ALTER DATABASE
   ADD FILE x LENGTH 8000
   FILE y LENGTH 8000
   FILE z
```

Multiple occurrences of `add_sec_clause` (ADD FILE clauses) are allowed; an ADD FILE clause that adds multiple files (as in the example above) can be mixed with others that add only one file.

### Table 28. ALTER DATABASE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>add_sec_clause</code></td>
<td>Adding a secondary database file</td>
</tr>
<tr>
<td><code>sec_file</code></td>
<td>File specification for secondary file</td>
</tr>
<tr>
<td><code>filepath</code></td>
<td>Full path and file name of the delta file or secondary database file</td>
</tr>
<tr>
<td><code>pagenum</code></td>
<td>Page number from which the secondary database file is to start</td>
</tr>
<tr>
<td><code>num</code></td>
<td>Maximum size of the secondary file in pages</td>
</tr>
<tr>
<td><code>diff_file</code></td>
<td>File path and name of the .delta file (difference file)</td>
</tr>
<tr>
<td><code>charset</code></td>
<td>New default character set of the database</td>
</tr>
<tr>
<td><code>linger_duration</code></td>
<td>Duration of linger delay in seconds; must be greater than or equal to 0 (zero)</td>
</tr>
<tr>
<td><code>plugin_name</code></td>
<td>The name of the encryption plugin</td>
</tr>
<tr>
<td><code>key_name</code></td>
<td>The name of the encryption key</td>
</tr>
<tr>
<td><code>pub_table_filter</code></td>
<td>Filter of tables to include to or exclude from publication</td>
</tr>
<tr>
<td><code>table_name</code></td>
<td>Name (identifier) of a table</td>
</tr>
</tbody>
</table>

The ALTER DATABASE statement can:

- add secondary files to a database
- switch a single-file database into and out of the “copy-safe” mode (DSQL only)
- set or unset the path and name of the delta file for physical backups (DSQL only)

**Note:** `SCHEMA` is currently a synonym for `DATABASE`; this may change in a future version, so we recommend to always use `DATABASE`
Who Can Alter the Database

The ALTER DATABASE statement can be executed by:

- Administrators
- Users with the ALTER DATABASE privilege

Parameters for ALTER DATABASE

ADD (FILE)

Adds secondary files to the database. It is necessary to specify the full path to the file and the name of the secondary file. The description for the secondary file is similar to the one given for the CREATE DATABASE statement.

ADD DIFFERENCE FILE

Specifies the path and name of the difference file (or, delta file) that stores any mutations to the database whenever it is switched to the “copy-safe” mode. This clause does not add a file, but it configures name and path of the delta file when the database is in “copy-safe” mode. To change the existing setting, you should delete the previously specified description of the delta file using the DROP DIFFERENCE FILE clause before specifying the new description of the delta file. If the path and name of the delta file are not configured, the file will have the same path and name as the database, but with the .delta file extension.

If only a filename is specified, the delta file will be created in the current directory of the server. On Windows, this will be the system directory — a very unwise location to store volatile user files and contrary to Windows file system rules.

DROP DIFFERENCE FILE

Deletes the description (path and name) of the difference file specified previously in the ADD DIFFERENCE FILE clause. This does not delete a file, but DROP DIFFERENCE FILE clears (resets) the path and name of the delta file from the database header. Next time the database is switched to the “copy-safe” mode, the default values will be used (i.e. the same path and name as those of the database, but with the .delta extension).

BEGIN BACKUP

Switches the database to the “copy-safe” mode. ALTER DATABASE with this clause freezes the main database file, making it possible to back it up safely using file system tools, even if users are connected and performing operations with data. Until the backup state of the database is reverted to NORMAL, all changes made to the database will be written to the delta (difference) file.

Despite its name, the ALTER DATABASE BEGIN BACKUP statement does not start a backup process, but only freezes the database, to create the conditions for doing a task that requires the database file to be read-only temporarily.

END BACKUP

Switches the database from the “copy-safe” mode to the normal mode. A statement with this
clause merges the difference file with the main database file and restores the normal operation of the database. Once the END BACKUP process starts, the conditions no longer exist for creating safe backups by means of file system tools.

Use of BEGIN BACKUP and END BACKUP and copying the database files with filesystem tools, is not safe with multi-file databases! Use this method only on single-file databases.

Making a safe backup with the gbak utility remains possible at all times, although it is not recommended running gbak while the database is in LOCKED or MERGE state.

SET DEFAULT CHARACTER SET
Changes the default character set of the database. This change does not affect existing data or columns. The new default character set will only be used in subsequent DDL commands. To modify the default collation, use ALTER CHARACTER SET on the default character set of the database.

ENCRIPT WITH
See Encrypting a Database in the Security chapter.

DECRYPT
See Decrypting a Database in the Security chapter.

SET LINGER TO
Sets the linger-delay. The linger-delay applies only to Firebird SuperServer, and is the number of seconds the server keeps a database file (and its caches) open after the last connection to that database was closed. This can help to improve performance at low cost, when the database is opened and closed frequently, by keeping resources “warm” for the next connection.

This mode can be useful for web applications—without a connection pool—where connections to the database usually “live” for a very short time.

The SET LINGER TO and DROP LINGER clauses can be combined in a single statement, but the last clause “wins”. For example, ALTER DATABASE SET LINGER TO 5 DROP LINGER will set the linger-delay to 0 (no linger), while ALTER DATABASE DROP LINGER SET LINGER to 5 will set the linger-delay to 5 seconds.

DROP LINGER
Drops the linger-delay (sets it to zero). Using DROP LINGER is equivalent to using SET LINGER TO 0.

Dropping LINGER is not an ideal solution for the occasional need to turn it off for once-only operations where the server needs a forced shutdown. The gfix utility now has the -NoLinger switch, which will close the specified database immediately after the last attachment is gone, regardless of the LINGER setting in the database. The LINGER setting is retained and works normally the next time.
The same one-off override is also available through the Services API, using the tag `isc_spb_prp_nolinger`, e.g. (in one line):

```
fbsvcmgr host:service_mgr user sysdba password xxx
    action_properties dbname employee prp_nolinger
```

The DROP LINGER and SET LINGER TO clauses can be combined in a single statement, but the last clause “wins”.

**SET DEFAULT SQL SECURITY**

Specifies the default SQL SECURITY option to apply at runtime for objects without the SQL Security property set. See also *SQL Security* in chapter *Security*.

**ENABLE PUBLICATION**

Enables publication of this database for replication. Replication begins (or continues) with the next transaction started after this transaction commits.

**DISABLE PUBLICATION**

Enables publication of this database for replication. Replication is disabled immediately after commit.

**EXCLUDE … FROM PUBLICATION**

Excludes tables from publication. If the INCLUDE ALL TO PUBLICATION clause is used, all tables created afterward will also be replicated, unless overridden explicitly in the CREATE TABLE statement.

**INCLUDE … TO PUBLICATION**

Includes tables to publication. If the INCLUDE ALL TO PUBLICATION clause is used, all tables created afterward will also be replicated, unless overridden explicitly in the CREATE TABLE statement.

**Replication**

- Other than the syntax, configuring Firebird for replication is not covered in this language reference.
- All replication management commands are DDL statements and thus effectively executed at the transaction commit time.

**Examples of ALTER DATABASE Usage**

1. Adding a secondary file to the database. As soon as 30000 pages are filled in the previous primary or secondary file, the Firebird engine will start adding data to the secondary file `test4.fdb`.

```
ALTER DATABASE
    ADD FILE 'D:\test4.fdb'
    STARTING AT PAGE 30001;
```
2. Specifying the path and name of the delta file:

   ```sql
   ALTER DATABASE ADD DIFFERENCE FILE 'D:\test.diff';
   ```

3. Deleting the description of the delta file:

   ```sql
   ALTER DATABASE DROP DIFFERENCE FILE;
   ```

4. Switching the database to the “copy-safe” mode:

   ```sql
   ALTER DATABASE BEGIN BACKUP;
   ```

5. Switching the database back from the “copy-safe” mode to the normal operation mode:

   ```sql
   ALTER DATABASE END BACKUP;
   ```

6. Changing the default character set for a database to WIN1251

   ```sql
   ALTER DATABASE SET DEFAULT CHARACTER SET WIN1252;
   ```

7. Setting a `linger`-delay of 30 seconds

   ```sql
   ALTER DATABASE SET LINGER TO 30;
   ```

8. Encrypting the database with a plugin called `DbCrypt`

   ```sql
   ALTER DATABASE ENCRYPT WITH DbCrypt;
   ```

9. Decrypting the database

   ```sql
   ALTER DATABASE DECRIPT;
   ```

See also
**CREATE DATABASE, DROP DATABASE**

### 5.1.3. DROP DATABASE

Drops (deletes) the database of the current connection

*Available in*  
DSQL, ESQL

**Syntax**

```
DROP DATABASE
```

The `DROP DATABASE` statement deletes the current database. Before deleting a database, you have to connect to it. The statement deletes the primary file, all secondary files and all shadow files.

Contrary to `CREATE DATABASE` and `ALTER DATABASE`, `DROP SCHEMA` is not a valid alias for `DROP DATABASE`. This is intentional.

**Who Can Drop a Database**

The `DROP DATABASE` statement can be executed by:

- Administrators
- Users with the `DROP DATABASE` privilege

**Example of DROP DATABASE**

Deleting the current database

```
DROP DATABASE;
```

*See also*  
CREATE DATABASE, ALTER DATABASE

### 5.2. SHADOW

A *shadow* is an exact, page-by-page copy of a database. Once a shadow is created, all changes made in the database are immediately reflected in the shadow. If the primary database file becomes unavailable for some reason, the DBMS will switch to the shadow.

This section describes how to create and delete shadow files.

#### 5.2.1. CREATE SHADOW

Creates a shadow file for the current database

*Available in*
DSQL, ESQL

Syntax

```
CREATE SHADOW <sh_num> [{AUTO | MANUAL}] [CONDITIONAL]
  'filepath' [LENGTH [=] num [PAGE[S]]]
  [<secondary_file> ...]

<secondary_file> ::= FILE 'filepath'
  [STARTING [AT [PAGE]] pagenum]
  [LENGTH [=] num [PAGE[S]]]
```

Table 29. CREATE SHADOW Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sh_num</td>
<td>Shadow number — a positive number identifying the shadow set</td>
</tr>
<tr>
<td>filepath</td>
<td>The name of the shadow file and the path to it, in accord with the rules of</td>
</tr>
<tr>
<td></td>
<td>the operating system</td>
</tr>
<tr>
<td>num</td>
<td>Maximum shadow size, in pages</td>
</tr>
<tr>
<td>secondary_file</td>
<td>Secondary file specification</td>
</tr>
<tr>
<td>page_num</td>
<td>The number of the page at which the secondary shadow file should start</td>
</tr>
</tbody>
</table>

The CREATE SHADOW statement creates a new shadow. The shadow starts duplicating the database right at the moment it is created. It is not possible for a user to connect to a shadow.

Like a database, a shadow may be multi-file. The number and size of a shadow's files are not related to the number and size of the files of the shadowed database.

The page size for shadow files is set to be equal to the database page size and cannot be changed.

If a calamity occurs involving the original database, the system converts the shadow to a copy of the database and switches to it. The shadow is then unavailable. What happens next depends on the MODE option.

**AUTO | MANUAL Modes**

When a shadow is converted to a database, it becomes unavailable. A shadow might alternatively become unavailable because someone accidentally deletes its file, or the disk space where the shadow files are stored is exhausted or is itself damaged.

- If the AUTO mode is selected (the default value), shadowing ceases automatically, all references to it are deleted from the database header, and the database continues functioning normally.

  If the CONDITIONAL option was set, the system will attempt to create a new shadow to replace the lost one. It does not always succeed, however, and a new one may need to be created manually.

- If the MANUAL mode attribute is set when the shadow becomes unavailable, all attempts to connect to the database and to query it will produce error messages. The database will remain
inaccessible until either the shadow again becomes available, or the database administrator deletes it using the DROP SHADOW statement. MANUAL should be selected if continuous shadowing is more important than uninterrupted operation of the database.

**Options for CREATE SHADOW**

**LENGTH**

Specifies the maximum size of the primary or secondary shadow file in pages. The LENGTH value does not affect the size of the only shadow file, nor the last if it is a set. The last (or only) file will keep automatically growing as long as it is necessary.

**STARTING AT**

Specifies the shadow page number at which the next shadow file should start. The system will start adding new data to the next shadow file when the previous file is filled with data up to the specified page number.

You can verify the sizes, names and location of the shadow files by connecting to the database using *isql* and running the command `SHOW DATABASE;`

**Who Can Create a Shadow**

The CREATE SHADOW statement can be executed by:

- Administrators
- Users with the ALTER DATABASE privilege

**Examples Using CREATE SHADOW**

1. Creating a shadow for the current database as “shadow number 1”:

   ```
   CREATE SHADOW 1 'g:\data\test.shd';
   ```

2. Creating a multi-file shadow for the current database as “shadow number 2”:

   ```
   CREATE SHADOW 2 'g:\data\test.sh1'
   LENGTH 8000 PAGES
   FILE 'g:\data\test.sh2';
   ```

**See also**

CREATE DATABASE, DROP SHADOW

### 5.2.2. DROP SHADOW

Drops (deletes) a shadow file from the current database

*Available in*
DSQL, ESQL

Syntax

```sql
DROP SHADOW sh_num
    [{DELETE | PRESERVE} FILE]
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sh_num</td>
<td>Shadow number — a positive number identifying the shadow set</td>
</tr>
</tbody>
</table>

The `DROP SHADOW` statement deletes the specified shadow for the current database. When a shadow is dropped, all files related to it are deleted and shadowing to the specified `sh_num` ceases. The optional `DELETE FILE` clause makes this behaviour explicit. On the contrary, the `PRESERVE FILE` clause will remove the shadow from the database, but the file itself will not be deleted.

**Who Can Drop a Shadow**

The `DROP SHADOW` statement can be executed by:

- **Administrators**
- Users with the `ALTER DATABASE` privilege

**Example of DROP SHADOW**

Deleting “shadow number 1”.

```sql
DROP SHADOW 1;
```

See also

CREATE SHADOW

## 5.3. DOMAIN

`DOMAIN` is one of the object types in a relational database. A domain is created as a specific data type with attributes attached to it (think of attributes like length, precision or scale, nullability, check constraints). Once a domain has been defined in the database, it can be reused repeatedly to define table columns, PSQL arguments and PSQL local variables. Those objects inherit all attributes of the domain. Some attributes can be overridden when the new object is defined, if required.

This section describes the syntax of statements used to create, alter and drop domains. A detailed description of domains and their usage can be found in Custom Data Types — Domains.

### 5.3.1. CREATE DOMAIN

Creates a new domain
Available in
DSQL, ESQL

Syntax

```
CREATE DOMAIN name [AS] <datatype>
   [DEFAULT {<literal> | NULL | <context_var>}]
   [NOT NULL] [CHECK (<dom_condition>)]
   [COLLATE collation_name]

<datatype> ::=<scalar_datatype> | <blob_datatype> | <array_datatype>

<scalar_datatype> ::=% See Scalar Data Types Syntax !%

<blob_datatype> ::=% See BLOB Data Types Syntax !%

<array_datatype> ::=% See Array Data Types Syntax !%

<dom_condition> ::=<val> <operator> <val>
   | <val> [NOT] BETWEEN <val> AND <val>
   | <val> [NOT] IN ({<val> [, <val> ...] | <select_list>})
   | <val> IS [NOT] NULL
   | <val> IS [NOT] DISTINCT FROM <val>
   | <val> [NOT] CONTAINING <val>
   | <val> [NOT] STARTING [WITH] <val>
   | <val> [NOT] LIKE <val> [ESCAPE <val>]
   | <val> [NOT] SIMILAR TO <val> [ESCAPE <val>]
   | <val> <operator> {ALL | SOME | ANY} (<select_list>)
   | [NOT] EXISTS (<select_expr>)
   | [NOT] SINGULAR (<select_expr>)
   | <dom_condition>
   | NOT <dom_condition>
   | <dom_condition> OR <dom_condition>
   | <dom_condition> AND <dom_condition>

<operator> ::=<> | != | ^= | ~= | = | < | > | <= | >=
   | !< | ^< | <= | !> | ^> | >=

<val> ::=VALUE
   | <literal>
   | <context_var>
   | <expression>
   | NULL
   | NEXT VALUE FOR genname
```
The `CREATE DOMAIN` statement creates a new domain.

Any SQL data type can be specified as the domain type.

**Type-specific Details**

**Array Types**

- If the domain is to be an array, the base type can be any SQL data type except `BLOB` and `array`.
- The dimensions of the array are specified between square brackets.
- For each array dimension, one or two integer numbers define the lower and upper boundaries of its index range:
  - By default, arrays are 1-based. The lower boundary is implicit and only the upper
boundary need be specified. A single number smaller than 1 defines the range \( num..1 \) and a number greater than 1 defines the range \( 1..num \).

- Two numbers separated by a colon (‘:’) and optional whitespace, the second greater than the first, can be used to define the range explicitly. One or both boundaries can be less than zero, as long as the upper boundary is greater than the lower.

- When the array has multiple dimensions, the range definitions for each dimension must be separated by commas and optional whitespace.

- Subscripts are validated only if an array actually exists. It means that no error messages regarding invalid subscripts will be returned if selecting a specific element returns nothing or if an array field is NULL.

**String Types**

You can use the `CHARACTER SET` clause to specify the character set for the `CHAR`, `VARCHAR` and `BLOB` (SUB_TYPE TEXT) types. If the character set is not specified, the character set specified as `DEFAULT CHARACTER SET` of the database will be used. If the database has no default character set, the character set `NONE` is applied by default when you create a character domain.

With character set `NONE`, character data are stored and retrieved the way they were submitted. Data in any encoding can be added to a column based on such a domain, but it is impossible to add this data to a column with a different encoding. Because no transliteration is performed between the source and destination encodings, errors may result.

**DEFAULT Clause**

The optional `DEFAULT` clause allows you to specify a default value for the domain. This value will be added to the table column that inherits this domain when the `INSERT` statement is executed, if no value is specified for it in the DML statement. Local variables and arguments in PSQL modules that reference this domain will be initialized with the default value. For the default value, use a literal of a compatible type or a context variable of a compatible type.

**NOT NULL Constraint**

Columns and variables based on a domain with the `NOT NULL` constraint will be prevented from being written as `NULL`, i.e. a value is required.

When creating a domain, take care to avoid specifying limitations that would contradict one another. For instance, `NOT NULL` and `DEFAULT NULL` are contradictory.

**CHECK Constraint(s)**

The optional `CHECK` clause specifies constraints for the domain. A domain constraint specifies conditions that must be satisfied by the values of table columns or variables that inherit from the domain. A condition must be enclosed in parentheses. A condition is a logical expression (also called a predicate) that can return the Boolean results `TRUE`, `FALSE` and `UNKNOWN`. A condition is considered satisfied if the predicate returns the value `TRUE` or “unknown value” (equivalent to `NULL`). If the predicate returns `FALSE`, the condition for acceptance is not met.
VALUE Keyword
The keyword VALUE in a domain constraint substitutes for the table column that is based on this domain or for a variable in a PSQL module. It contains the value assigned to the variable or the table column. VALUE can be used anywhere in the CHECK constraint, though it is usually used in the left part of the condition.

COLLATE
The optional COLLATE clause allows you to specify the collation if the domain is based on one of the string data types, including BLOBs with text subtypes. If no collation is specified, the collation will be the one that is default for the specified character set at the time the domain is created.

Who Can Create a Domain
The CREATE DOMAIN statement can be executed by:

- Administrators
- Users with the CREATE DOMAIN privilege

CREATE DOMAIN Examples
1. Creating a domain that can take values greater than 1,000, with a default value of 10,000.

   ```sql
   CREATE DOMAIN CUSTNO AS INTEGER DEFAULT 10000 CHECK (VALUE > 1000);
   ```

2. Creating a domain that can take the values 'Yes' and 'No' in the default character set specified during the creation of the database.

   ```sql
   CREATE DOMAIN D_BOOLEAN AS CHAR(3) CHECK (VALUE IN ('Yes', 'No'));
   ```

3. Creating a domain with the UTF8 character set and the UNICODE_CI_AI collation.

   ```sql
   CREATE DOMAIN FIRSTNAME AS VARCHAR(30) CHARACTER SET UTF8 COLLATE UNICODE_CI_AI;
   ```

4. Creating a domain of the DATE type that will not accept NULL and uses the current date as the default value.

   ```sql
   CREATE DOMAIN D_DATE AS DATE DEFAULT CURRENT_DATE NOT NULL;
   ```
5. Creating a domain defined as an array of 2 elements of the NUMERIC(18, 3) type. The starting array index is 1.

```sql
CREATE DOMAIN D_POINT AS NUMERIC(18, 3) [2];
```

Domains defined over an array type may be used only to define table columns. You cannot use array domains to define local variables in PSQL modules.

6. Creating a domain whose elements can be only country codes defined in the COUNTRY table.

```sql
CREATE DOMAIN D_COUNTRYCODE AS CHAR(3)
CHECK (EXISTS(SELECT * FROM COUNTRY WHERE COUNTRYCODE = VALUE));
```

The example is given only to show the possibility of using predicates with queries in the domain test condition. It is not recommended to create this style of domain in practice unless the lookup table contains data that are never deleted.

See also

ALTER DOMAIN, DROP DOMAIN

5.3.2. ALTER DOMAIN

Alters the attributes of a domain or renames a domain

Available in

DSQL, ESQL

Syntax

```sql
ALTER DOMAIN domain_name
    [TO new_name]
    [TYPE <datatype>]
    [{SET DEFAULT {<literal> | NULL | <context_var>} | DROP DEFAULT}]
    [{SET | DROP} NOT NULL]
    [{ADD [CONSTRAINT] CHECK (<dom_condition>) | DROP CONSTRAINT}]
```

```
<datatype> ::= <scalar_datatype> | <blob_datatype>
```

```
<scalar_datatype> ::= !! See Scalar Data Types Syntax !!
```

```
<blob_datatype> ::= !! See BLOB Data Types Syntax !!
```
Table 32. ALTER DOMAIN Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>new_name</td>
<td>New name for domain. The maximum length is 63 characters</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is compatible with <code>datatype</code></td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable whose type is compatible with <code>datatype</code></td>
</tr>
</tbody>
</table>

The `ALTER DOMAIN` statement enables changes to the current attributes of a domain, including its name. You can make any number of domain alterations in one `ALTER DOMAIN` statement.

**ALTER DOMAIN clauses**

**TO name**

Renames the domain, as long as there are no dependencies on the domain, i.e. table columns, local variables or procedure arguments referencing it.

**SET DEFAULT**

Sets a new default value for the domain, replacing any existing default.

**DROP DEFAULT**

Deletes a previously specified default value and replace it with NULL.

**SET NOT NULL**

 Adds a `NOT NULL` constraint to the domain; columns or parameters of this domain will be prevented from being written as NULL, i.e. a value is `required`.

Adding a `NOT NULL` constraint to an existing domain will subject all columns using this domain to a full data validation, so ensure that the columns have no nulls before attempting the change.

**DROP NOT NULL**

Drops the `NOT NULL` constraint from the domain.

An explicit `NOT NULL` constraint on a column that depends on a domain prevails over the domain. In this situation, the modification of the domain to make it nullable does not propagate to the column.

**ADD CONSTRAINT CHECK**

Adds a `CHECK` constraint to the domain. If the domain already has a `CHECK` constraint, it has to be deleted first, using an `ALTER DOMAIN` statement that includes a `DROP CONSTRAINT` clause.

**TYPE**

Changes the data type of the domain to a different, compatible one. The system will forbid any change to the type that could result in data loss. An example would be if the number of
characters in the new type were smaller than in the existing type. When you alter the attributes of a domain, existing PSQL code may become invalid. For information on how to detect it, read the piece entitled *The RDB$VALID_BLR Field* in Appendix A.

**What ALTER DOMAIN Cannot Alter**

- If the domain was declared as an array, it is not possible to change its type or its dimensions; nor can any other type be changed to an array type.
- The collation cannot be changed without dropping the domain and recreating it with the desired attributes.

**Who Can Alter a Domain**

The `ALTER DOMAIN` statement can be executed by:

- **Administrators**
- The owner of the domain
- Users with the `ALTER ANY DOMAIN` privilege

Domain alterations can be prevented by dependencies from objects to which the user does not have sufficient privileges.

**ALTER DOMAIN Examples**

1. Changing the data type to `INTEGER` and setting or changing the default value to 2,000:

   ```sql
   ALTER DOMAIN CUSTNO
   TYPE INTEGER
   SET DEFAULT 2000;
   ```

2. Renaming a domain.

   ```sql
   ALTER DOMAIN D_BOOLEAN TO D_BOOL;
   ```

3. Deleting the default value and adding a constraint for the domain:

   ```sql
   ALTER DOMAIN D_DATE
   DROP DEFAULT
   ADD CONSTRAINT CHECK (VALUE >= date '01.01.2000');
   ```

4. Changing the CHECK constraint:

   ```sql
   ALTER DOMAIN D_DATE
   ```
5. Changing the data type to increase the permitted number of characters:

```sql
ALTER DOMAIN FIRSTNAME
    TYPE VARCHAR(50) CHARACTER SET UTF8;
```

6. Adding a NOT NULL constraint:

```sql
ALTER DOMAIN FIRSTNAME
    SET NOT NULL;
```

7. Removing a NOT NULL constraint:

```sql
ALTER DOMAIN FIRSTNAME
    DROP NOT NULL;
```

See also

CREATE DOMAIN, DROP DOMAIN

### 5.3.3. DROP DOMAIN

Drops an existing domain

**Available in**

DSQL, ESQL

**Syntax**

```sql
DROP DOMAIN domain_name
```

The DROP DOMAIN statement deletes a domain that exists in the database. It is not possible to delete a domain if it is referenced by any database table columns or used in any PSQL module. To delete a domain that is in use, all columns in all tables that refer to the domain have to be dropped and all references to the domain have to be removed from PSQL modules.

**Who Can Drop a Domain**

The DROP DOMAIN statement can be executed by:

- Administrators
The owner of the domain

Users with the DROP ANY DOMAIN privilege

**Example of DROP DOMAIN**

*Deleting the COUNTRYNAME domain*

```
DROP DOMAIN COUNTRYNAME;
```

*See also*

CREATE DOMAIN, ALTER DOMAIN

---

### 5.4. TABLE

As a relational DBMS, Firebird stores data in tables. A table is a flat, two-dimensional structure containing any number of rows. Table rows are often called *records*.

All rows in a table have the same structure and consist of columns. Table columns are often called *fields*. A table must have at least one column. Each column contains a single type of SQL data.

This section describes how to create, alter and drop tables in a database.

#### 5.4.1. CREATE TABLE

Creates a table

*Available in*

DSQL, ESQL

*Syntax*

```
CREATE [GLOBAL TEMPORARY] TABLE tablename
   [EXTERNAL [FILE] 'filespec']
   (<col_def> [, {<col_def> | <tconstraint>} ...])
   [{<table_attrs> | <gtt_table_attrs>}]

<col_def> ::= 
   <regular_col_def>
   | <computed_col_def>
   | <identity_col_def>

<regular_col_def> ::= 
   colname {<datatype> | domainname}
   [DEFAULT {<literal> | NULL | <context_var>}] 
   [<col_constraint> ...]
   [COLLATE collation_name]

<computed_col_def> ::= 
   colname [{<datatype> | domainname}]
```

---

Chapter 5. Data Definition (DDL) Statements

128
Chapter 5. Data Definition (DDL) Statements

{COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)

<identity_col_def> ::= colname {<datatype> | domainname} GENERATED {ALWAYS | BY DEFAULT} AS IDENTITY [((<identity_col_option>...)) [<col_constraint> ...]]

<identity_col_option> ::= START WITH start_value | INCREMENT [BY] inc_value

<datatype> ::= <scalar_datatype> | <blob_datatype> | <array_datatype>

<scalar_datatype> ::= !! See Scalar Data Types Syntax !!

<blob_datatype> ::= !! See BLOB Data Types Syntax !!

<array_datatype> ::= !! See Array Data Types Syntax !!

<col_constraint> ::= [CONSTRAINT constr_name]
{ PRIMARY KEY [using_index] | UNIQUE [using_index] | REFERENCES other_table [(colname)] [using_index] [ON DELETE {NO ACTION | CASCADE | SET DEFAULT | SET NULL}] [ON UPDATE {NO ACTION | CASCADE | SET DEFAULT | SET NULL}] | CHECK (<check_condition>) | NOT NULL }

<check_condition> ::= <val> <operator> <val>

<constraint> ::= [CONSTRAINT constr_name]
{ PRIMARY KEY (<col_list>) [using_index] | UNIQUE (<col_list>) [using_index] | FOREIGN KEY (<col_list>) REFERENCES other_table [(<col_list>)] [using_index] [ON DELETE {NO ACTION | CASCADE | SET DEFAULT | SET NULL}] [ON UPDATE {NO ACTION | CASCADE | SET DEFAULT | SET NULL}] | CHECK (<check_condition>) }

<col_list> ::= colname [, colname ...]

<using_index> ::= USING [ASC[ENDING] | DESC[ENDING]] INDEX indexname
<val> [NOT] BETWEEN <val> AND <val>
<val> [NOT] IN (<val> [, <val> ...] | <select_list>)
<val> IS [NOT] NULL
<val> IS [NOT] DISTINCT FROM <val>
<val> [NOT] CONTAINING <val>
<val> [NOT] STARTING [WITH] <val>
<val> [NOT] LIKE <val> [ESCAPE <val>]
<val> [NOT] SIMILAR TO <val> [ESCAPE <val>]
<val> <operator> {ALL | SOME | ANY} (<select_list>)
[NOT] EXISTS (<select_expr>)
[NOT] SINGULAR (<select_expr>)
( <check_condition>)
NOT <check_condition>
<check_condition> OR <check_condition>
<check_condition> AND <check_condition>

<operator> ::= 
  <> | != | ^= | ~= | = | < | > | <= | >=
  !< | ^< | ~< | !> | ^> | ~>.

<val> ::= 
  colname ['[array_idx [array_idx ...]]']
  | <literal>
  | <context_var>
  | <expression>
  | NULL
  | NEXT VALUE FOR genname
  | GEN_ID(genname, <val>)
  | CAST(<val> AS <cast_type>)
  | (<select_one>)
  | func([<val> [, <val> ...]])

<cast_type> ::= <domain_or_non_array_type> | <array_datatype>

<domain_or_non_array_type> ::= 
  !! See Scalar Data Types Syntax !!

<table_attrs> ::= <table_attr> [<table_attr> ...]

<table_attr> ::= 
  <sql_security>
  | {ENABLE | DISABLE} PUBLICATION

<sql_security> ::= SQL SECURITY {INVOKER | DEFINER}

<gtt_table_attrs> ::= <gtt_table_attr> [gtt_table_attr] ...

<gtt_table_attr> ::= 
  <sql_security>
  | ON COMMIT {DELETE | PRESERVE} ROWS
### Table 33. CREATE TABLE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tablename</td>
<td>Name (identifier) for the table. The maximum length is 63 characters and must be unique in the database.</td>
</tr>
<tr>
<td>filespec</td>
<td>File specification (only for external tables). Full file name and path, enclosed in single quotes, correct for the local file system and located on a storage device that is physically connected to Firebird’s host computer.</td>
</tr>
<tr>
<td>colname</td>
<td>Name (identifier) for a column in the table. The maximum length is 63 characters and must be unique in the table.</td>
</tr>
<tr>
<td>tconstraint</td>
<td>Table constraint</td>
</tr>
<tr>
<td>table_attrs</td>
<td>Attributes of a normal table</td>
</tr>
<tr>
<td>gtt_table_attrs</td>
<td>Attributes of a global temporary table</td>
</tr>
<tr>
<td>datatype</td>
<td>SQL data type</td>
</tr>
<tr>
<td>domain_name</td>
<td>Domain name</td>
</tr>
<tr>
<td>start_value</td>
<td>The initial value of the identity column</td>
</tr>
<tr>
<td>inc_value</td>
<td>The increment (or step) value of the identity column, default is 1; zero (0) is not allowed.</td>
</tr>
<tr>
<td>col_constraint</td>
<td>Column constraint</td>
</tr>
<tr>
<td>constr_name</td>
<td>The name (identifier) of a constraint. The maximum length is 63 characters.</td>
</tr>
<tr>
<td>other_table</td>
<td>The name of the table referenced by the foreign key constraint</td>
</tr>
<tr>
<td>other_col</td>
<td>The name of the column in other_table that is referenced by the foreign key</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is allowed in the given context</td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable whose data type is allowed in the given context</td>
</tr>
<tr>
<td>check_condition</td>
<td>The condition applied to a CHECK constraint, that will resolve as either true, false or NULL</td>
</tr>
<tr>
<td>collation</td>
<td>Collation</td>
</tr>
<tr>
<td>select_one</td>
<td>A scalar SELECT statement — selecting one column and returning only one row</td>
</tr>
<tr>
<td>select_list</td>
<td>A SELECT statement selecting one column and returning zero or more rows</td>
</tr>
<tr>
<td>select_expr</td>
<td>A SELECT statement selecting one or more columns and returning zero or more rows</td>
</tr>
<tr>
<td>expression</td>
<td>An expression resolving to a value that is allowed in the given context</td>
</tr>
<tr>
<td>genname</td>
<td>Sequence (generator) name</td>
</tr>
<tr>
<td>func</td>
<td>Internal function or UDF</td>
</tr>
</tbody>
</table>
The CREATE TABLE statement creates a new table. Its name must be unique among the names of all tables, views, and stored procedures in the database.

A table must contain at least one column that is not computed, and the names of columns must be unique in the table.

A column must have either an explicit SQL data type, the name of a domain whose attributes will be copied for the column, or be defined as COMPUTED BY an expression (a calculated field).

A table may have any number of table constraints, including none.

**Character Columns**

You can use the CHARACTER SET clause to specify the character set for the CHAR, VARCHAR and BLOB (text subtype) types. If the character set is not specified, the default character set of the database — at time of the creation of the column — will be used.

If the database has no default character set, the NONE character set is applied. Data in any encoding can be added to such a column, but it is not possible to add this data to a column with a different encoding. No transliteration is performed between the source and destination encodings, which may result in errors.

The optional COLLATE clause allows you to specify the collation for character data types, including BLOB SUB_TYPE TEXT. If no collation is specified, the default collation for the specified character set — at time of the creation of the column — is applied.

**Setting a DEFAULT Value**

The optional DEFAULT clause allows you to specify the default value for the table column. This value will be added to the column when an INSERT statement is executed and that column was omitted from the INSERT command or DEFAULT was used instead of a value expression. The default value will also be used in UPDATE when DEFAULT is used instead of a value expression.

The default value can be a literal of a compatible type, a context variable that is type-compatible with the data type of the column, or NULL, if the column allows it. If no default value is explicitly specified, NULL is implied.

An expression cannot be used as a default value.

**Domain-based Columns**

To define a column, you can use a previously defined domain. If the definition of a column is based on a domain, it may contain a new default value, additional CHECK constraints, and a COLLATE clause that will override the values specified in the domain definition. The definition of such a column may contain additional column constraints (for instance, NOT NULL), if the domain does not have it.

It is not possible to define a domain-based column that is nullable if the domain was defined with the NOT NULL attribute. If you want to have a domain that might be used for defining both nullable and non-nullable columns and variables, it is better practice defining the domain nullable and apply NOT NULL in the
Identity Columns (Autoincrement)

Identity columns are defined using the `GENERATED {ALWAYS | BY DEFAULT} AS IDENTITY` clause. The identity column is a column associated with an internal sequence. Its value is set automatically every time it is not specified in the `INSERT` statement, or when the column value is specified as `DEFAULT`.

**Rules**

- The data type of an identity column must be an exact number type with zero scale. Allowed types are `SMALLINT`, `INTEGER`, `BIGINT`, `NUMERIC(p[,0])` and `DECIMAL(p[,0])` with \( p \leq 18 \).
  - The `INT128` type and numeric types with a precision higher than 18 are not supported.
- An identity column cannot have a `DEFAULT` or `COMPUTED` value.
- An identity column can be altered to become a regular column.
- A regular column cannot be altered to become an identity column.
- Identity columns are implicitly `NOT NULL` (non-nullable), and cannot be made nullable.
- Uniqueness is not enforced automatically. A `UNIQUE` or `PRIMARY KEY` constraint is required to guarantee uniqueness.
- The use of other methods of generating key values for identity columns, e.g. by trigger-generator code or by allowing users to change or add them, is discouraged to avoid unexpected key violations.
- The `INCREMENT` value cannot be zero (0).

**GENERATED ALWAYS**

An identity column of type `GENERATED ALWAYS` will always generate a column value on insert. Explicitly inserting a value into a column of this type is not allowed, unless:

1. the specified value is `DEFAULT`; this generates the identity value as normal.
2. the `OVERRIDING SYSTEM VALUE` clause is specified in the `INSERT` statement; this allows a user value to be inserted;
3. the `OVERRIDING USER VALUE` clause is specified in the `INSERT` statement; this allows a user specified value to be ignored (though in general it makes more sense to not include the column in the `INSERT`).

**GENERATED BY DEFAULT**

An identity column of type `GENERATED BY DEFAULT` will generate a value on insert if no value — other than `DEFAULT` — is specified on insert. When the `OVERRIDING USER VALUE` clause is specified in the `INSERT` statement, the user-provided value is ignored, and an identity value is generated (as if the column was not included in the insert, or the value `DEFAULT` was specified).
**START WITH Option**

The optional `START WITH` clause allows you to specify an initial value other than 1. This value is the first value generated when using `NEXT VALUE FOR` sequence.

**INCREMENT Option**

The optional `INCREMENT` clause allows you to specify another non-zero step value than 1.

The SQL standard specifies that if `INCREMENT` is specified with a negative value, and `START WITH` is not specified, that the first value generated should be the maximum of the column type (e.g. $2^{31} - 1$ for `INTEGER`). Instead, Firebird will start at 1.

**Computed Columns**

Computed columns can be defined with the `COMPUTED [BY]` or `GENERATED ALWAYS AS` clause (the SQL standard alternative to `COMPUTED [BY]`). Specifying the data type is optional; if not specified, the appropriate type will be derived from the expression.

If the data type is explicitly specified for a calculated field, the calculation result is converted to the specified type. This means, for instance, that the result of a numeric expression could be converted to a string.

In a query that selects a computed column, the expression is evaluated for each row of the selected data.

Instead of a computed column, in some cases it makes sense to use a regular column whose value is calculated in triggers for adding and updating data. It may reduce the performance of inserting/updating records, but it will increase the performance of data selection.

**Defining an Array Column**

- If the column is to be an array, the base type can be any SQL data type except `BLOB` and `array`.
- The dimensions of the array are specified between square brackets.
- For each array dimension, one or two integer numbers define the lower and upper boundaries of its index range:
  - By default, arrays are 1-based. The lower boundary is implicit and only the upper boundary need be specified. A single number smaller than 1 defines the range `num...1` and a number greater than 1 defines the range `1...num`.
  - Two numbers separated by a colon (‘:’) and optional whitespace, the second greater than the first, can be used to define the range explicitly. One or both boundaries can be less than zero, as long as the upper boundary is greater than the lower.
- When the array has multiple dimensions, the range definitions for each dimension must be separated by commas and optional whitespace.
- Subscripts are validated only if an array actually exists. It means that no error messages regarding invalid subscripts will be returned if selecting a specific element returns nothing or if
an array field is NULL.

**Constraints**

Five types of constraints can be specified. They are:

- Primary key (PRIMARY KEY)
- Unique key (UNIQUE)
- Foreign key (REFERENCES)
- CHECK constraint (CHECK)
- NOT NULL constraint (NOT NULL)

Constraints can be specified at column level ("column constraints") or at table level ("table constraints"). Table-level constraints are required when keys (unique constraint, primary key, foreign key) consist of multiple columns and when a CHECK constraint involves other columns in the row besides the column being defined. The NOT NULL constraint can only be specified as a column constraint. Syntax for some types of constraint may differ slightly according to whether the constraint is defined at the column or table level.

- A column-level constraint is specified during a column definition, after all column attributes except COLLATION are specified, and can involve only the column specified in that definition
- A table-level constraints can only be specified after the definitions of the columns used in the constraint.
- Table-level constraints are a more flexible way to set constraints, since they can cater for constraints involving multiple columns
- You can mix column-level and table-level constraints in the same CREATE TABLE statement

The system automatically creates the corresponding index for a primary key (PRIMARY KEY), a unique key (UNIQUE), and a foreign key (REFERENCES for a column-level constraint, FOREIGN KEY REFERENCES for table-level).

**Names for Constraints and Their Indexes**

Constraints and their indexes are named automatically if no name was specified using the CONSTRAINT clause:

- The constraint name has the form INTEG\_n, where \(n\) represents one or more digits
- The index name has the form RDB\$PRIMARY\_n (for a primary key index), RDB\$FOREIGN\_n (for a foreign key index) or RDB\$\_n (for a unique key index).

**Named Constraints**

A constraint can be named explicitly if the CONSTRAINT clause is used for its definition. By default, the constraint index will have the same name as the constraint. If a different name is wanted for the constraint index, a USING clause can be included.
**The USING Clause**

The USING clause allows you to specify a user-defined name for the index that is created automatically and, optionally, to define the direction of the index—either ascending (the default) or descending.

**PRIMARY KEY**

The PRIMARY KEY constraint is built on one or more *key columns*, where each column has the NOT NULL constraint specified. The values across the key columns in any row must be unique. A table can have only one primary key.

- A single-column primary key can be defined as a column-level or a table-level constraint
- A multi-column primary key must be specified as a table-level constraint

**The UNIQUE Constraint**

The UNIQUE constraint defines the requirement of content uniqueness for the values in a key throughout the table. A table can contain any number of unique key constraints.

As with the primary key, the unique constraint can be multi-column. If so, it must be specified as a table-level constraint.

**NULL in Unique Keys**

Firebird’s SQL-compliant rules for UNIQUE constraints allow one or more NULLs in a column with a UNIQUE constraint. This makes it possible to define a UNIQUE constraint on a column that does not have the NOT NULL constraint.

For UNIQUE keys that span multiple columns, the logic is a little complicated:

- Multiple rows having null in all the columns of the key are allowed
- Multiple rows having keys with different combinations of nulls and non-null values are allowed
- Multiple rows having the same key columns null and the rest filled with non-null values are allowed, provided the non-null values differ in at least one column
- Multiple rows having the same key columns null and the rest filled with non-null values that are the same in every column will violate the constraint

The rules for uniqueness can be summarised thus:

In principle, all nulls are considered distinct. However, if two rows have exactly the same key columns filled with non-null values, the NULL columns are ignored and the uniqueness is determined on the non-null columns as though they constituted the entire key.

**Illustration**

```
RECREATE TABLE t( x int, y int, z int, unique(x,y,z));
INSERT INTO t values( NULL, 1, 1 );
```
FOREIGN KEY

A foreign key ensures that the participating column(s) can contain only values that also exist in the referenced column(s) in the master table. These referenced columns are often called target columns. They must be the primary key or a unique key in the target table. They need not have a NOT NULL constraint defined on them although, if they are the primary key, they will, of course, have that constraint.

The foreign key columns in the referencing table itself do not require a NOT NULL constraint.

A single-column foreign key can be defined in the column declaration, using the keyword REFERENCES:

```sql
...,
ARTIFACT_ID INTEGER REFERENCES COLLECTION (ARTIFACT_ID),
```

The column ARTIFACT_ID in the example references a column of the same name in the table COLLECTIONS.

Both single-column and multi-column foreign keys can be defined at the table level. For a multi-column foreign key, the table-level declaration is the only option.

```sql
...
CONSTRAINT FK_ARTSOURCE FOREIGN KEY(DEALER_ID, COUNTRY)
REFERENCES DEALER (DEALER_ID, COUNTRY),
```

Notice that the column names in the referenced ("master") table may differ from those in the foreign key.

If no target columns are specified, the foreign key automatically references the target table's primary key.

Foreign Key Actions

With the sub-clauses ON UPDATE and ON DELETE it is possible to specify an action to be taken on the affected foreign key column(s) when referenced values in the master table are changed:

**NO ACTION**

(the default) — Nothing is done

**CASCADE**

The change in the master table is propagated to the corresponding row(s) in the child table. If a
key value changes, the corresponding key in the child records changes to the new value; if the master row is deleted, the child records are deleted.

**SET DEFAULT**

The foreign key columns in the affected rows will be set to their default values as they were when the foreign key constraint was defined.

**SET NULL**

The foreign key columns in the affected rows will be set to NULL.

The specified action, or the default NO ACTION, could cause a foreign key column to become invalid. For example, it could get a value that is not present in the master table. Such condition will cause the operation on the master table to fail with an error message.

**Example**

```sql
...
CONSTRAINT FK_ORDERS_CUST
FOREIGN KEY (CUSTOMER) REFERENCES CUSTOMERS (ID)
ON UPDATE CASCADE ON DELETE SET NULL
```

**CHECK Constraint**

The CHECK constraint defines the condition the values inserted in this column or row must satisfy. A condition is a logical expression (also called a predicate) that can return the TRUE, FALSE and UNKNOWN values. A condition is considered satisfied if the predicate returns TRUE or value UNKNOWN (equivalent to NULL). If the predicate returns FALSE, the value will not be accepted. This condition is used for inserting a new row into the table (the INSERT statement) and for updating the existing value of the table column (the UPDATE statement) and also for statements where one of these actions may take place (UPDATE OR INSERT, MERGE).

A CHECK constraint on a domain-based column does not replace an existing CHECK condition on the domain, but becomes an addition to it. The Firebird engine has no way, during definition, to verify that the extra CHECK does not conflict with the existing one.

CHECK constraints — whether defined at table level or column level — refer to table columns by their names. The use of the keyword VALUE as a placeholder — as in domain CHECK constraints — is not valid in the context of defining constraints in a table.

**Example**

with two column-level constraints and one at table-level:

```sql
CREATE TABLE PLACES ( 
...
LAT DECIMAL(9, 6) CHECK (ABS(LAT) <= 90),
LON DECIMAL(9, 6) CHECK (ABS(LON) <= 180),
... 
```
**NOT NULL Constraint**

In Firebird, columns are nullable by default. The NOT NULL constraint specifies that the column cannot take NULL in place of a value.

A NOT NULL constraint can only be defined as a column constraint, not as a table constraint.

**SQL SECURITY Clause**

The SQL SECURITY clause specifies the security context for executing functions referenced in computed columns, and check constraints, and the default context used for triggers fired for this table. When SQL Security is not specified, the default value of the database is applied at runtime.

See also *SQL Security* in chapter *Security*.

**Replication Management**

When the database has been configured using `ALTER DATABASE INCLUDE ALL TO PUBLICATION`, new tables will automatically be added for publication, unless overridden using the `DISABLE PUBLICATION` clause.

If the database has not been configured for `INCLUDE ALL` (or has later been reconfigured using `ALTER DATABASE EXCLUDE ALL FROM PUBLICATION`), new tables will not automatically be added for publication. To include tables for publication, the `ENABLE PUBLICATION` clause must be used.

**Who Can Create a Table**

The CREATE TABLE statement can be executed by:

- **Administrators**
- Users with the CREATE TABLE privilege

The user executing the CREATE TABLE statement becomes the owner of the table.

**CREATE TABLE Examples**

1. Creating the COUNTRY table with the primary key specified as a column constraint.

   ```sql
   CREATE TABLE COUNTRY ( 
     COUNTRY COUNTRYNAME NOT NULL PRIMARY KEY, 
     CURRENCY VARCHAR(10) NOT NULL 
   );
   ```

2. Creating the STOCK table with the named primary key specified at the column level and the named unique key specified at the table level.
CREATE TABLE STOCK (  
    MODEL SMALLINT NOT NULL CONSTRAINT PK_STOCK PRIMARY KEY,  
    MODELNAME CHAR(10) NOT NULL,  
    ITEMID INTEGER NOT NULL,  
    CONSTRAINT MOD_UNIQUE UNIQUE (MODELNAME, ITEMID)  
);

3. Creating the JOB table with a primary key constraint spanning two columns, a foreign key constraint for the COUNTRY table and a table-level CHECK constraint. The table also contains an array of 5 elements.

CREATE TABLE JOB (  
    JOB_CODE JOBCODE NOT NULL,  
    JOB_GRADE JOBGRADE NOT NULL,  
    JOB_COUNTRY COUNTRYNAME,  
    JOB_TITLE VARCHAR(25) NOT NULL,  
    MIN_SALARY NUMERIC(18, 2) DEFAULT 0 NOT NULL,  
    MAX_SALARY NUMERIC(18, 2) NOT NULL,  
    JOB_REQUIREMENT BLOB SUB_TYPE 1,  
    LANGUAGE_REQ VARCHAR(15) [1:5],  
    PRIMARY KEY (JOB_CODE, JOB_GRADE),  
    FOREIGN KEY (JOB_COUNTRY) REFERENCES COUNTRY (COUNTRY) 
        ON UPDATE CASCADE  
        ON DELETE SET NULL,  
    CONSTRAINT CHK_SALARY CHECK (MIN_SALARY < MAX_SALARY)  
);

4. Creating the PROJECT table with primary, foreign and unique key constraints with custom index names specified with the USING clause.

CREATE TABLE PROJECT (  
    PROJ_ID PROJNO NOT NULL,  
    PROJ_NAME VARCHAR(20) NOT NULL UNIQUE USING DESC INDEX IDX_PROJNAME,  
    PROJ_DESC BLOB SUB_TYPE 1,  
    TEAM_LEADER EMPNO,  
    PRODUCT PRODTYPE,  
    CONSTRAINT PK_PROJECT PRIMARY KEY (PROJ_ID) USING INDEX IDX_PROJ_ID,  
    FOREIGN KEY (TEAM_LEADER) REFERENCES EMPLOYEE (EMP_NO)  
        USING INDEX IDX_LEADER  
);

5. Creating a table with an identity column

create table objects (  
    id integer generated by default as identity primary key,  
    name varchar(15)
insert into objects (name) values ('Table');
insert into objects (id, name) values (10, 'Computer');
insert into objects (name) values ('Book');

select * from objects order by id;

<table>
<thead>
<tr>
<th>ID</th>
<th>NAME</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Table</td>
</tr>
<tr>
<td>2</td>
<td>Book</td>
</tr>
<tr>
<td>10</td>
<td>Computer</td>
</tr>
</tbody>
</table>

6. Creating the `SALARY_HISTORY` table with two computed fields. The first one is declared according to the SQL standard, while the second one is declared according to the traditional declaration of computed fields in Firebird.

```sql
CREATE TABLE SALARY_HISTORY (
    EMP_NO         EMPNO NOT NULL,
    CHANGE_DATE    TIMESTAMP DEFAULT 'NOW' NOT NULL,
    UPDATER_ID     VARCHAR(20) NOT NULL,
    OLD_SALARY     SALARY NOT NULL,
    PERCENT_CHANGE DOUBLE PRECISION DEFAULT 0 NOT NULL,
    SALARY_CHANGE  GENERATED ALWAYS AS
        (OLD_SALARY * PERCENT_CHANGE / 100),
    NEW_SALARY     COMPUTED BY
        (OLD_SALARY + OLD_SALARY * PERCENT_CHANGE / 100)
);```

7. With `DEFINER` set for table `t`, user `US` needs only the `SELECT` privilege on `t`. If it were set for `INVOKER`, the user would also need the `EXECUTE` privilege on function `f`.

```sql
set term ^;
create function f() returns int
as
begin
    return 3;
end^
set term ;^;
create table t (i integer, c computed by (i + f())) SQL SECURITY DEFINER;
insert into t values (2);
grant select on table t to user us;

commit;

connect 'localhost:/tmp/7.fdb' user us password 'pas';
select * from t;
```
8. With `DEFINER` set for table `tr`, user `US` needs only the `INSERT` privilege on `tr`. If it were set for `INVOKER`, either the user or the trigger would also need the `INSERT` privilege on table `t`. The result would be the same if SQL SECURITY `DEFINER` were specified for trigger `tr_ins`:

```sql
create table tr (i integer) SQL SECURITY DEFINER;
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert
as
begin
    insert into t values (NEW.i);
end^
set term ;^
grant insert on table tr to user us;
commit;
connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);
```

**Global Temporary Tables (GTT)**

Global temporary tables have persistent metadata, but their contents are transaction-bound (the default) or connection-bound. Every transaction or connection has its own private instance of a GTT, isolated from all the others. Instances are only created if and when the GTT is referenced. They are destroyed when the transaction ends or on disconnect. The metadata of a GTT can be modified or removed using `ALTER TABLE` and `DROP TABLE`, respectively.

**Syntax**

```
CREATE GLOBAL TEMPORARY TABLE tablename
    (<column_def> [, {<column_def> | <table_constraint>} ...])
    [<gtt_table_attrs>]

<gtt_table_attrs> ::= <gtt_table_attr> [gtt_table_attr> ...]
<gtt_table_attr> ::= <sql_security>
    | ON COMMIT {DELETE | PRESERVE} ROWS
```

**Syntax notes**

- **ON COMMIT DELETE ROWS** creates a transaction-level GTT (the default), **ON COMMIT PRESERVE ROWS** a connection-level GTT
- The `EXTERNAL [FILE]` clause is not allowed in the definition of a global temporary table

GT Ts are writable in read-only transactions. The effect is as follows:
Read-only transaction in read-write database
Writable in both ON COMMIT PRESERVE ROWS and ON COMMIT DELETE ROWS

Read-only transaction in read-only database
Writable in ON COMMIT DELETE ROWS only

Restrictions on GTTs

GTTs can be “dressed up” with all the features of ordinary tables (keys, references, indexes, triggers and so on), but there are a few restrictions:

• GTTs and regular tables cannot reference one another
• A connection-bound (“PRESERVE ROWS”) GTT cannot reference a transaction-bound (“DELETE ROWS”) GTT
• Domain constraints cannot reference any GTT
• The destruction of a GTT instance at the end of its lifecycle does not cause any BEFORE/AFTER delete triggers to fire

In an existing database, it is not always easy to distinguish a regular table from a GTT, or a transaction-level GTT from a connection-level GTT. Use this query to find out what type of table you are looking at:

```sql
select t.rdb$type_name
from rdb$relations r
join rdb$types t on r.rdb$relation_type = t.rdb$type
where t.rdb$field_name = 'RDB$RELATION_TYPE'
and r.rdb$relation_name = 'TABLENAME'
```

For an overview of the types of all the relations in the database:

```sql
select r.rdb$relation_name, t.rdb$type_name
from rdb$relations r
join rdb$types t on r.rdb$relation_type = t.rdb$type
where t.rdb$field_name = 'RDB$RELATION_TYPE'
and coalesce (r.rdb$system_flag, 0) = 0
```

The RDB$TYPE_NAME field will show PERSISTENT for a regular table, VIEW for a view, GLOBAL_TEMPORARY_PRESERVE for a connection-bound GTT and GLOBAL_TEMPORARY_DELETE for a transaction_bound GTT.

Examples of Global Temporary Tables


```sql
CREATE GLOBAL TEMPORARY TABLE MYCONNGTT (ID INTEGER NOT NULL PRIMARY KEY,
ON COMMIT PRESERVE ROWS)
```
CREATE GLOBAL TEMPORARY TABLE MYCONNGTT (  
    ID    INTEGER NOT NULL PRIMARY KEY,  
    PARENT_ID INTEGER NOT NULL REFERENCES MYCONNGTT(ID),  
    TXT   VARCHAR(32),  
    TS    TIMESTAMP DEFAULT CURRENT_TIMESTAMP  
) ON COMMIT DELETE ROWS;

2. Creating a transaction-scoped global temporary table that uses a foreign key to reference a connection-scoped global temporary table. The ON COMMIT sub-clause is optional because DELETE ROWS is the default.

CREATE GLOBAL TEMPORARY TABLE MYTXGTT (  
    ID    INTEGER NOT NULL PRIMARY KEY,  
    PARENT_ID INTEGER NOT NULL REFERENCES MYCONNGTT(ID),  
    TXT   VARCHAR(32),  
    TS    TIMESTAMP DEFAULT CURRENT_TIMESTAMP  
) ON COMMIT PRESERVE ROWS;

External Tables

The optional EXTERNAL [FILE] clause specifies that the table is stored outside the database in an external text file of fixed-length records. The columns of a table stored in an external file can be of any type except BLOB or ARRAY, although for most purposes, only columns of CHAR types would be useful.

All you can do with a table stored in an external file is insert new rows (INSERT) and query the data (SELECT). Updating existing data (UPDATE) and deleting rows (DELETE) are not possible.

A file that is defined as an external table must be located on a storage device that is physically present on the machine where the Firebird server runs and, if the parameter ExternalFileAccess in the firebird.conf configuration file is Restrict, it must be in one of the directories listed there as the argument for Restrict. If the file does not exist yet, Firebird will create it on first access.

The ability to use external files for a table depends on the value set for the ExternalFileAccess parameter in firebird.conf:

- If it is set to None (the default), any attempt to access an external file will be denied.
- The Restrict setting is recommended, for restricting external file access to directories created explicitly for the purpose by the server administrator. For example:
  - `ExternalFileAccess = Restrict externalfiles` will restrict access to a directory named externalfiles directly beneath the Firebird root directory
  - `ExternalFileAccess = d:\databases\outfiles; e:\infiles` will restrict access to just those two directories on the Windows host server. Note that any path that is a network mapping will not work. Paths enclosed in single or double quotes will not work, either.
- If this parameter is set to Full, external files may be accessed anywhere on the host file system. This creates a security vulnerability and is not recommended.
External File Format

The “row” format of the external table is fixed length and binary. There are no field delimiters: both field and row boundaries are determined by maximum sizes, in bytes, of the field definitions. Keep this in mind, both when defining the structure of the external table and when designing an input file for an external table that is to import (or export) data from another application. The ubiquitous CSV format, for example, is of no use as an input file and cannot be generated directly into an external file.

The most useful data type for the columns of external tables is the fixed-length CHAR type, of suitable lengths for the data they are to carry. Date and number types are easily cast to and from strings whereas the native data types — binary data — will appear to external applications as unparsable “alphabetti”.

Of course, there are ways to manipulate typed data to generate output files from Firebird that can be read directly as input files to other applications, using stored procedures, with or without employing external tables. Such techniques are beyond the scope of a language reference. Here, we provide guidelines and tips for producing and working with simple text files, since the external table feature is often used as an easy way to produce or read transaction-independent logs that can be studied off-line in a text editor or auditing application.

Row Delimiters

Generally, external files are more useful if rows are separated by a delimiter, in the form of a “newline” sequence that is recognised by reader applications on the intended platform. For most contexts on Windows, it is the two-byte ‘CRLF’ sequence, carriage return (ASCII code decimal 13) and line feed (ASCII code decimal 10). On POSIX, LF on its own is usual. There are various ways to populate this delimiter column. In our example below, it is done by using a BEFORE INSERT trigger and the internal function ASCII_CHAR.

External Table Example

For our example, we will define an external log table that might be used by an exception handler in a stored procedure or trigger. The external table is chosen because the messages from any handled exceptions will be retained in the log, even if the transaction that launched the process is eventually rolled back because of another, unhandled exception. For demonstration purposes, it has two data columns, a timestamp and a message. The third column stores the row delimiter:

```sql
CREATE TABLE ext_log
EXTERNAL FILE 'd:\externals\log_me.txt' (  
    stamp CHAR (24),
    message CHAR(100),
    crlf CHAR(2) -- for a Windows context  
) ;
COMMIT;
```

Now, a trigger, to write the timestamp and the row delimiter each time a message is written to the file:
SET TERM ^;
CREATE TRIGGER bi_ext_log FOR ext_log
ACTIVE BEFORE INSERT
AS
BEGIN
  IF (new.stamp is NULL) then
    new.stamp = CAST (CURRENT_TIMESTAMP as CHAR(24));
    new.crlf = ASCII_CHAR(13) || ASCII_CHAR(10);
END ^
COMMIT ^
SET TERM ;^
<col_mod> ::=  
  TO newname  
  | POSITION newpos  
  | <regular_col_mod>  
  | <computed_col_mod>  
  | <identity_col_mod>  

<regular_col_mod> ::=  
  TYPE {<datatype> | domainname}  
  | SET DEFAULT {<literal> | NULL | <context_var>}  
  | DROP DEFAULT  
  | {SET | DROP} NOT NULL  

<computed_col_mod> ::=  
  [TYPE <datatype>] {COMPUTED [BY] | GENERATED ALWAYS AS} (<expression>)  

<identity_col_mod> ::=  
  SET GENERATED {ALWAYS | BY DEFAULT} [<identity_mod_option>...]  
  | <identity_mod_options>...  
  | DROP IDENTITY  

<identity_mod_options> ::=  
  RESTART [WITH restart_value]  
  | SET INCREMENT [BY] inc_value  

!! See CREATE TABLE syntax for further rules !!

Table 34. ALTER TABLE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tablename</td>
<td>Name (identifier) of the table</td>
</tr>
<tr>
<td>operation</td>
<td>One of the available operations altering the structure of the table</td>
</tr>
<tr>
<td>colname</td>
<td>Name (identifier) for a column in the table. The maximum length is 63 characters. Must be unique in the table.</td>
</tr>
<tr>
<td>domain_name</td>
<td>Domain name</td>
</tr>
<tr>
<td>newname</td>
<td>New name (identifier) for the column. The maximum length is 63 characters. Must be unique in the table.</td>
</tr>
<tr>
<td>newpos</td>
<td>The new column position (an integer between 1 and the number of columns in the table)</td>
</tr>
<tr>
<td>other_table</td>
<td>The name of the table referenced by the foreign key constraint</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is allowed in the given context</td>
</tr>
<tr>
<td>context_var</td>
<td>A context variable whose type is allowed in the given context</td>
</tr>
<tr>
<td>check_condition</td>
<td>The condition of a CHECK constraint that will be satisfied if it evaluates to TRUE or UNKNOWN/NULL</td>
</tr>
<tr>
<td>restart_value</td>
<td>The first value of the identity column after restart</td>
</tr>
<tr>
<td>Parameter</td>
<td>Description</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
</tr>
<tr>
<td>inc_value</td>
<td>The increment (or step) value of the identity column; zero (0) is not allowed.</td>
</tr>
</tbody>
</table>

The ALTER TABLE statement changes the structure of an existing table. With one ALTER TABLE statement it is possible to perform multiple operations, adding/dropping columns and constraints and also altering column specifications.

Multiple operations in an ALTER TABLE statement are separated with commas.

**Version Count Increments**

Some changes in the structure of a table increment the metadata change counter (“version count”) assigned to every table. The number of metadata changes is limited to 255 for each table, or 32,000 for each view. Once the counter reaches this limit, you will not be able to make any further changes to the structure of the table or view without resetting the counter.

**To reset the metadata change counter**

You need to back up and restore the database using the *gbak* utility.

**The ADD Clause**

With the ADD clause you can add a new column or a new table constraint. The syntax for defining the column and the syntax of defining the table constraint correspond with those described for CREATE TABLE statement.

**Effect on Version Count**

- Each time a new column is added, the metadata change counter is increased by one
- Adding a new table constraint does not increase the metadata change counter

**Points to Be Aware of**

1. Adding a column with a NOT NULL constraint without a DEFAULT value will fail if the table has existing rows. When adding a non-nullable column, it is recommended either to set a default value for it, or to create it as nullable, update the column in existing rows with a non-null value, and then add a NOT NULL constraint.

2. When a new CHECK constraint is added, existing data is not tested for compliance. Prior testing of existing data against the new CHECK expression is recommended.

3. Although adding an identity column is supported, this will only succeed if the table is empty. Adding an identity column will fail if the table has one or more rows.
The DROP Clause

The DROP colname clause deletes the specified column from the table. An attempt to drop a column will fail if anything references it. Consider the following items as sources of potential dependencies:

- column or table constraints
- indexes
- stored procedures, functions and triggers
- views

Effect on Version Count

- Each time a column is dropped, the table's metadata change counter is increased by one.

The DROP CONSTRAINT Clause

The DROP CONSTRAINT clause deletes the specified column-level or table-level constraint.

A PRIMARY KEY or UNIQUE key constraint cannot be deleted if it is referenced by a FOREIGN KEY constraint in another table. It will be necessary to drop that FOREIGN KEY constraint before attempting to drop the PRIMARY KEY or UNIQUE key constraint it references.

Effect on Version Count

- Deleting a column constraint or a table constraint does not increase the metadata change counter.

The ALTER [COLUMN] Clause

With the ALTER [COLUMN] clause, attributes of existing columns can be modified without the need to drop and re-add the column. Permitted modifications are:

- change the name (does not affect the metadata change counter)
- change the data type (increases the metadata change counter by one)
- change the column position in the column list of the table (does not affect the metadata change counter)
- delete the default column value (does not affect the metadata change counter)
- set a default column value or change the existing default (does not affect the metadata change counter)
- change the type and expression for a computed column (does not affect the metadata change counter)
- set the NOT NULL constraint (does not affect the metadata change counter)
- drop the NOT NULL constraint (does not affect the metadata change counter)
- change the type of an identity column, or change an identity column to a regular column
- restart an identity column
- change the increment of an identity column
Renaming a Column: the TO Clause

The TO keyword with a new identifier renames an existing column. The table must not have an existing column that has the same identifier.

It will not be possible to change the name of a column that is included in any constraint: primary key, unique key, foreign key, or CHECK constraints of the table.

Renaming a column will also be disallowed if the column is used in any stored PSQL module or view.

Changing the Data Type of a Column: the TYPE Clause

The keyword TYPE changes the data type of an existing column to another, allowable type. A type change that might result in data loss will be disallowed. As an example, the number of characters in the new type for a CHAR or VARCHAR column cannot be smaller than the existing specification for it.

If the column was declared as an array, no change to its type or its number of dimensions is permitted.

The data type of a column that is involved in a foreign key, primary key or unique constraint cannot be changed at all.

Changing the Position of a Column: the POSITION Clause

The POSITION keyword changes the position of an existing column in the notional “left-to-right” layout of the record.

Numbering of column positions starts at 1.

• If a position less than 1 is specified, an error message will be returned
• If a position number is greater than the number of columns in the table, its new position will be adjusted silently to match the number of columns.

The DROP DEFAULT and SET DEFAULT Clauses

The optional DROP DEFAULT clause deletes the current default value for the column.

• If the column is based on a domain with a default value, the default value will revert to the domain default
• An error will be raised if an attempt is made to delete the default value of a column which has no default value or whose default value is domain-based

The optional SET DEFAULT clause sets a default value for the column. If the column already has a default value, it will be replaced with the new one. The default value applied to a column always overrides one inherited from a domain.

The SET NOT NULL and DROP NOT NULL Clauses

The SET NOT NULL clause adds a NOT NULL constraint on an existing table column. Contrary to definition in CREATE TABLE, it is not possible to specify a constraint name.
The successful addition of the NOT NULL constraint is subject to a full data validation on the table, so ensure that the column has no nulls before attempting the change.

An explicit NOT NULL constraint on domain-based column overrides domain settings. In this scenario, changing the domain to be nullable does not extend to a table column.

Dropping the NOT NULL constraint from the column if its type is a domain that also has a NOT NULL constraint, has no observable effect until the NOT NULL constraint is dropped from the domain as well.

The **COMPUTED [BY] or GENERATED ALWAYS AS Clauses**

The data type and expression underlying a computed column can be modified using a COMPUTED [BY] or GENERATED ALWAYS AS clause in the ALTER TABLE ALTER [COLUMN] statement. Conversion of a regular column to a computed one and vice versa is not permitted.

**Changing Identity Columns**

For identity columns (SET GENERATED {ALWAYS | BY DEFAULT}) it is possible to modify several properties using the following clauses.

**Identity Type**

The SET GENERATED {ALWAYS | BY DEFAULT} changes an identity column from ALWAYS to BY DEFAULT and vice versa. It is not possible to use this to change a regular column to an identity column.

**RESTART**

The RESTART clause restarts the sequence used for generating identity values. If only the RESTART clause is specified, then the sequence resets to the initial value specified when the identity column was defined. If the optional WITH restart_value clause is specified, the sequence will restart with the specified value.

In Firebird 3.0, RESTART WITH restart_value would also change the configured initial value to restart_value. This was not compliant with the SQL standard, so since Firebird 4.0, RESTART WITH restart_value will only restart the sequence with the specified value. Subsequent RESTARTs (without WITH) will use the START WITH value specified when the identity column was defined.

It is currently not possible to change the configured start value.

**SET INCREMENT**

The SET INCREMENT clause changes the increment of the identity column.

**DROP IDENTITY**

The DROP IDENTITY clause will change an identity column to a regular column.
Changing SQL Security

Using the ALTER SQL SECURITY or DROP SQL SECURITY clauses, it is possible to change or drop the SQL Security property of a table. After dropping SQL Security, the default value of the database is applied at runtime.

If the SQL Security property is changed for a table, triggers that do not have an explicit SQL Security property will not see the effect of the change until the next time the trigger is loaded into the metadata cache.

Replication Management

To stop replicating a table, use the DISABLE PUBLICATION clause. To start replicating a table, use the ENABLE PUBLICATION clause.

The change in publication status takes effect at commit.

Attributes that Cannot Be Altered

The following alterations are not supported:

• Changing the collation of a character type column

Who Can Alter a Table?

The ALTER TABLE statement can be executed by:

• Administrators
• The owner of the table
• Users with the ALTER ANY TABLE privilege

Examples Using ALTER TABLE

1. Adding the CAPITAL column to the COUNTRY table.

```
ALTER TABLE COUNTRY
ADD CAPITAL VARCHAR(25);
```

2. Adding the CAPITAL column with the NOT NULL and UNIQUE constraint and deleting the CURRENCY column.

```
ALTER TABLE COUNTRY
ADD CAPITAL VARCHAR(25) NOT NULL UNIQUE,
DROP CURRENCY;
```
3. Adding the CHK_SALARY check constraint and a foreign key to the JOB table.

```
ALTER TABLE JOB
    ADD CONSTRAINT CHK_SALARY CHECK (MIN_SALARY < MAX_SALARY),
    ADD FOREIGN KEY (JOB_COUNTRY) REFERENCES COUNTRY (COUNTRY);
```

4. Setting default value for the MODEL field, changing the type of the ITEMID column and renaming the MODELNAME column.

```
ALTER TABLE STOCK
    ALTER COLUMN MODEL SET DEFAULT 1,
    ALTER COLUMN ITEMID TYPE BIGINT,
    ALTER COLUMN MODELNAME TO NAME;
```

5. Restarting the sequence of an identity column.

```
ALTER TABLE objects
    ALTER ID RESTART WITH 100;
```

6. Changing the computed columns NEW_SALARY and SALARY_CHANGE.

```
ALTER TABLE SALARY_HISTORY
    ALTER NEW_SALARY GENERATED ALWAYS AS
        (OLD_SALARY + OLD_SALARY * PERCENT_CHANGE / 100),
    ALTER SALARY_CHANGE COMPUTED BY
        (OLD_SALARY * PERCENT_CHANGE / 100);
```

See also

CREATE TABLE, DROP TABLE, CREATE DOMAIN

5.4.3. DROP TABLE

Drops a table

Available in
DSQL, ESQL

Syntax

```
DROP TABLE tablename
```

Table 35. DROP TABLE Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tablename</td>
<td>Name (identifier) of the table</td>
</tr>
</tbody>
</table>
The DROP TABLE statement drops (deletes) an existing table. If the table has dependencies, the DROP TABLE statement will fail with an error.

When a table is dropped, all its triggers and indexes will be deleted as well.

**Who Can Drop a Table?**

The DROP TABLE statement can be executed by:

- Administrators
- The owner of the table
- Users with the DROP ANY TABLE privilege

**Example of DROP TABLE**

* Dropping the **COUNTRY** table.

```sql
DROP TABLE COUNTRY;
```

See also

CREATE TABLE, ALTER TABLE, RECREATE TABLE

### 5.4.4. RECREATE TABLE

Drops a table if it exists, and creates a table

**Available in**

DSQL

**Syntax**

```sql
RECREATE [GLOBAL TEMPORARY] TABLE tablename
[EXTERNAL [FILE] 'filespec']

(<col_def> [, {<col_def> | <tconstraint>} ...])

[{{table_attrs} | <gtt_table_attrs>}]`

See the CREATE TABLE section for the full syntax of CREATE TABLE and descriptions of defining tables, columns and constraints.

RECREATE TABLE creates or recreates a table. If a table with this name already exists, the RECREATE TABLE statement will try to drop it and create a new one. Existing dependencies will prevent the statement from executing.

**Example of RECREATE TABLE**

* Creating or recreating the **COUNTRY** table.

```sql
RECREATE TABLE COUNTRY (  
  COUNTRY COUNTRYNAME NOT NULL PRIMARY KEY,
```
CURRENCY VARCHAR(10) NOT NULL;

See also
CREATE TABLE, DROP TABLE

5.5. INDEX

An index is a database object used for faster data retrieval from a table or for speeding up the sorting in a query. Indexes are also used to enforce the referential integrity constraints PRIMARY KEY, FOREIGN KEY and UNIQUE.

This section describes how to create indexes, activate and deactivate them, drop them and collect statistics (recalculate selectivity) for them.

5.5.1. CREATE INDEX

Creates an index

Available in
DSQL, ESQL

Syntax

CREATE [UNIQUE] [ASC[ENDING] | DESC[ENDING]]
INDEX indexname ON tablename
{(col [, col ...]) | COMPUTED BY (<expression>)}
[WHERE <search_condition>]

Table 36. CREATE INDEX Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexname</td>
<td>Index name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>tablename</td>
<td>The name of the table for which the index is to be built</td>
</tr>
<tr>
<td>col</td>
<td>Name of a column in the table. Columns of the types BLOB and ARRAY and computed fields cannot be used in an index.</td>
</tr>
<tr>
<td>expression</td>
<td>The expression that will compute the values for a computed index, also known as an “expression index”</td>
</tr>
<tr>
<td>search_condition</td>
<td>Conditional expression of a partial index, to filter the rows to include in the index.</td>
</tr>
</tbody>
</table>

The CREATE INDEX statement creates an index for a table that can be used to speed up searching, sorting and grouping. Indexes are created automatically in the process of defining constraints, such as primary key, foreign key or unique constraints.

An index can be built on the content of columns of any data type except for BLOB and arrays. The
name (identifier) of an index must be unique among all index names.

### Key Indexes

When a primary key, foreign key or unique constraint is added to a table or column, an index with the same name is created automatically, without an explicit directive from the designer. For example, the `PK_COUNTRY` index will be created automatically when you execute and commit the following statement:

```
ALTER TABLE COUNTRY ADD CONSTRAINT PK_COUNTRY
PRIMARY KEY (ID);
```

### Who Can Create an Index?

The `CREATE INDEX` statement can be executed by:

- **Administrators**
- The owner of the table
- Users with the `ALTER ANY TABLE` privilege

### Unique Indexes

Specifying the keyword `UNIQUE` in the index creation statement creates an index in which uniqueness will be enforced throughout the table. The index is referred to as a “unique index”. A unique index is not a constraint.

Unique indexes cannot contain duplicate key values (or duplicate key value combinations, in the case of compound, or multi-column, or multi-segment) indexes. Duplicated NULLs are permitted, in accordance with the SQL standard, in both single-segment and multi-segment indexes.

### Partial Indexes

Specifying the `WHERE` clause in the index creation statement creates a partial index (also known as filtered index). A partial index contains only rows that match the search condition of the `WHERE`.

A partial index definition may include the `UNIQUE` clause. In this case, every key in the index is required to be unique. This allows enforcing uniqueness for a subset of table rows.

A partial index is usable only in the following cases:

- The `WHERE` clause of the statement includes exactly the same boolean expression as the one defined for the index;
- The search condition defined for the index contains ORed boolean expressions and one of them is explicitly included in the `WHERE` clause of the statement;
- The search condition defined for the index specifies `IS NOT NULL` and the `WHERE` clause of the statement includes an expression on the same field that is known to exclude NULLs.
Index Direction

All indexes in Firebird are uni-directional. An index may be constructed from the lowest value to the highest (ascending order) or from the highest value to the lowest (descending order). The keywords ASCENDING and DESCENDING are used to specify the direction of the index. The default index order is ASCENDING. It is valid to define both an ascending and a descending index on the same column or key set.

A descending index can be useful on a column that will be subjected to searches on the high values (“newest”, maximum, etc.)

Firebird uses B-tree indexes, which are bidirectional. However, due to technical limitations, Firebird uses an index in one direction only.

See also Firebird for the Database Expert: Episode 3 - On disk consistency

Computed (Expression) Indexes

In creating an index, you can use the COMPUTED BY clause to specify an expression instead of one or more columns. Computed indexes are used in queries where the condition in a WHERE, ORDER BY or GROUP BY clause exactly matches the expression in the index definition. The expression in a computed index may involve several columns in the table.

Expression indexes can also be used as a workaround for indexing computed columns: use the name of the computed column as the expression.

Limits on Indexes

Certain limits apply to indexes.

The maximum length of a key in an index is limited to a quarter of the page size.

Maximum Indexes per Table

The number of indexes that can be accommodated for each table is limited. The actual maximum for a specific table depends on the page size and the number of columns in the indexes.

Table 37. Maximum Indexes per Table

<table>
<thead>
<tr>
<th>Page Size</th>
<th>Number of Indexes Depending on Column Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>2-Column</td>
</tr>
<tr>
<td>4096</td>
<td>203</td>
</tr>
<tr>
<td>8192</td>
<td>408</td>
</tr>
<tr>
<td>16384</td>
<td>818</td>
</tr>
<tr>
<td>32768</td>
<td>1637</td>
</tr>
</tbody>
</table>
Character Index Limits

The maximum indexed string length is 9 bytes less than the maximum key length. The maximum indexable string length depends on the page size, the character set, and the collation.

Table 38. Maximum indexable (VAR)CHAR length

<table>
<thead>
<tr>
<th>Page Size</th>
<th>1 byte/char</th>
<th>2 byte/char</th>
<th>3 byte/char</th>
<th>4 byte/char</th>
</tr>
</thead>
<tbody>
<tr>
<td>4096</td>
<td>1015</td>
<td>507</td>
<td>338</td>
<td>253</td>
</tr>
<tr>
<td>8192</td>
<td>2039</td>
<td>1019</td>
<td>679</td>
<td>509</td>
</tr>
<tr>
<td>16384</td>
<td>4087</td>
<td>2043</td>
<td>1362</td>
<td>1021</td>
</tr>
<tr>
<td>32768</td>
<td>8183</td>
<td>4091</td>
<td>2727</td>
<td>2045</td>
</tr>
</tbody>
</table>

Depending on the collation, the maximum size can be further reduced as case-insensitive and accent-insensitive collations require more bytes per character in an index. See also Character Indexes in Chapter Data Types and Subtypes.

Parallelized Index Creation

Since Firebird 5.0, index creation can be parallelized. Parallelization happens automatically if the current connection has two or more parallel workers—configured through ParallelWorkers in firebird.conf or isc_dpb_parallel_workers—and the server has parallel workers available.

Examples Using CREATE_INDEX

1. Creating an index for the UPDATER_ID column in the SALARY_HISTORY table

   ```sql
   CREATE INDEX IDX_UPDATER
   ON SALARY_HISTORY (UPDATER_ID);
   ```

2. Creating an index with keys sorted in the descending order for the CHANGE_DATE column in the SALARY_HISTORY table

   ```sql
   CREATE DESCENDING INDEX IDX_CHANGE
   ON SALARY_HISTORY (CHANGE_DATE);
   ```

3. Creating a multi-segment index for the ORDER_STATUS, PAID columns in the SALES table

   ```sql
   CREATE INDEX IDX_SALESTAT
   ON SALES (ORDER_STATUS, PAID);
   ```

4. Creating an index that does not permit duplicate values for the NAME column in the COUNTRY table

   ```sql
   CREATE UNIQUE INDEX UNQ_COUNTRY_NAME
   ```
5. Creating a computed index for the PERSONS table

```
CREATE INDEX IDX_NAME_UPPER ON PERSONS
    COMPUTED BY (UPPER (NAME));
```

An index like this can be used for a case-insensitive search:

```
SELECT *
FROM PERSONS
WHERE UPPER(NAME) STARTING WITH UPPER('Iv');
```

6. Creating a partial index and using its condition:

```
CREATE INDEX IT1_COL ON T1 (COL) WHERE COL < 100;
SELECT * FROM T1 WHERE COL < 100;
-- PLAN (T1 INDEX (IT1_COL))
```

7. Creating a partial index which excludes NULL

```
CREATE INDEX IT1_COL2 ON T1 (COL) WHERE COL IS NOT NULL;
SELECT * FROM T1 WHERE COL > 100;
PLAN (T1 INDEX IT1_COL2)
```

8. Creating a partial index with ORed conditions

```
CREATE INDEX IT1_COL3 ON T1 (COL) WHERE COL = 1 OR COL = 2;
SELECT * FROM T1 WHERE COL = 2;
-- PLAN (T1 INDEX IT1_COL3)
```

9. Using a partial index to enforce uniqueness for a subset of rows

```
create table OFFER (  
    OFFER_ID bigint generated always as identity primary key,  
    PRODUCT_ID bigint not null,  
    ARCHIVED boolean default false not null,  
    PRICE decimal(9,2) not null  
);  
create unique index IDX_OFFER_UNIQUE_PRODUCT
    on OFFER (PRODUCT_ID)
    where not ARCHIVED;
```
insert into OFFER (PRODUCT_ID, ARCHIVED, PRICE) values (1, false, 18.95);
insert into OFFER (PRODUCT_ID, ARCHIVED, PRICE) values (1, true, 17.95);
insert into OFFER (PRODUCT_ID, ARCHIVED, PRICE) values (1, true, 16.95);
-- Next fails due to second record for PRODUCT_ID=1 and ARCHIVED=false:
insert into OFFER (PRODUCT_ID, ARCHIVED, PRICE) values (1, false, 19.95);
-- Statement failed, SQLSTATE = 23000
-- attempt to store duplicate value (visible to active transactions) in unique
index "IDX_OFFER_UNIQUE_PRODUCT"
-- -Problematic key value is ("PRODUCT_ID" = 1)

See also
ALTER INDEX, DROP INDEX

5.5.2. ALTER INDEX
Activates or deactivates an index, and rebuilds an index

Available in
DSQL, ESQL

Syntax

```
ALTER INDEX indexname {ACTIVE | INACTIVE}
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexname</td>
<td>Index name</td>
</tr>
</tbody>
</table>

The ALTER INDEX statement activates or deactivates an index. There is no facility on this statement for altering any attributes of the index.

INACTIVE

With the INACTIVE option, the index is switched from the active to inactive state. The effect is similar to the DROP INDEX statement except that the index definition remains in the database. Altering a constraint index to the inactive state is not permitted.

An active index can be deactivated if there are no queries prepared using that index; otherwise, an “object in use” error is returned.

Activating an inactive index is also safe. However, if there are active transactions modifying the table, the transaction containing the ALTER INDEX statement will fail if it has the NOWAIT attribute. If the transaction is in WAIT mode, it will wait for completion of concurrent transactions.

On the other side of the coin, if our ALTER INDEX succeeds and starts to rebuild the index at COMMIT, other transactions modifying that table will fail or wait, according to their WAIT/NO WAIT attributes. The situation is the same for CREATE INDEX.

How is it Useful?
It might be useful to switch an index to the inactive state whilst inserting, updating or deleting a large batch of records in the table that owns the index.

**ACTIVE**

Rebuilds the index (even if already active), and marks it as active.

**How is it Useful?**

Even if the index is *active* when `ALTER INDEX ... ACTIVE` is executed, the index will be rebuilt. Rebuilding indexes can be a useful piece of housekeeping to do, occasionally, on the indexes of a large table in a database that has frequent inserts, updates or deletes but is infrequently restored.

**Who Can Alter an Index?**

The `ALTER INDEX` statement can be executed by:

- Administrators
- The owner of the table
- Users with the `ALTER ANY TABLE` privilege

**Use of `ALTER INDEX` on a Constraint Index**

Altering the index of a `PRIMARY KEY`, `FOREIGN KEY` or `UNIQUE` constraint to `INACTIVE` is not permitted. However, `ALTER INDEX ... ACTIVE` works just as well with constraint indexes as it does with others, as an index rebuilding tool.

**ALTER INDEX Examples**

1. Deactivating the `IDX_UPDATER` index

   ```sql
   ALTER INDEX IDX_UPDATER INACTIVE;
   ```

2. Switching the `IDX_UPDATER` index back to the active state and rebuilding it

   ```sql
   ALTER INDEX IDX_UPDATER ACTIVE;
   ```

**See also**

`CREATE INDEX, DROP INDEX, SET STATISTICS`

**5.5.3. DROP INDEX**

Drops an index

*Available in*

DSQL, ESQL
The `DROP INDEX` statement drops (deletes) the named index from the database.

A constraint index cannot be dropped using `DROP INDEX`. Constraint indexes are dropped during the process of executing the command `ALTER TABLE ... DROP CONSTRAINT ...`.

### Who Can Drop an Index?

The `DROP INDEX` statement can be executed by:

- Administrators
- The owner of the table
- Users with the `ALTER ANY TABLE` privilege

### DROP INDEX Example

**Dropping the IDX_UPDATER index**

```
DROP INDEX IDX_UPDATER;
```

**See also**

`CREATE INDEX`, `ALTER INDEX`

### 5.5.4. SET STATISTICS

Recalculates the selectivity of an index

**Available in**

DSQL, ESQL

### Syntax

```
SET STATISTICS INDEX indexname
```

**Table 41. SET STATISTICS Statement Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>indexname</td>
<td>Index name</td>
</tr>
</tbody>
</table>
The SET STATISTICS statement recalculates the selectivity of the specified index.

**Who Can Update Index Statistics?**

The SET STATISTICS statement can be executed by:

- Administrators
- The owner of the table
- Users with the ALTER ANY TABLE privilege

**Index Selectivity**

The selectivity of an index is the result of evaluating the number of rows that can be selected in a search on every index value. A unique index has the maximum selectivity because it is impossible to select more than one row for each value of an index key if it is used. Keeping the selectivity of an index up to date is important for the optimizer’s choices in seeking the most optimal query plan.

Index statistics in Firebird are not automatically recalculated in response to large batches of inserts, updates or deletions. It may be beneficial to recalculate the selectivity of an index after such operations because the selectivity tends to become outdated.

The statements `CREATE INDEX` and `ALTER INDEX ACTIVE` both store index statistics that correspond to the contents of the newly-[re]built index.

It can be performed under concurrent load without risk of corruption. However, under concurrent load, the newly calculated statistics could become outdated as soon as SET STATISTICS finishes.

**Example Using SET STATISTICS**

*Recalculating the selectivity of the index IDX_UPDATER*

```sql
SET STATISTICS INDEX IDX_UPDATER;
```

**See also**

CREATE INDEX, ALTER INDEX

## 5.6. VIEW

A view is a virtual table that is a stored and named SELECT query for retrieving data of any complexity. Data can be retrieved from one or more tables, from other views and also from selectable stored procedures.

Unlike regular tables in relational databases, a view is not an independent data set stored in the database. The result is dynamically created as a data set when the view is selected.

The metadata of a view are available to the process that generates the binary code for stored procedures and triggers, as though they were concrete tables storing persistent data.
Firebird does not support materialized views.

## 5.6.1. CREATE VIEW

Creates a view

**Available in**

DSQL

**Syntax**

```
CREATE VIEW viewname [full_column_list] AS <select_statement>
[WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>View name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>select_statement</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>full_column_list</td>
<td>The list of columns in the view</td>
</tr>
<tr>
<td>colname</td>
<td>View column name. Duplicate column names are not allowed.</td>
</tr>
</tbody>
</table>

The `CREATE VIEW` statement creates a new view. The identifier (name) of a view must be unique among the names of all views, tables, and stored procedures in the database.

The name of the new view can be followed by the list of column names that should be returned to the caller when the view is invoked. Names in the list do not have to be related to the names of the columns in the base tables from which they derive.

If the view column list is omitted, the system will use the column names and/or aliases from the `SELECT` statement. If duplicate names or non-aliased expression-derived columns make it impossible to obtain a valid list, creation of the view fails with an error.

The number of columns in the view's list must match the number of columns in the selection list of the underlying `SELECT` statement in the view definition.

### Additional Points

- If the full list of columns is specified, it makes no sense to specify aliases in the `SELECT` statement because the names in the column list will override them.
- The column list is optional if all the columns in the `SELECT` are explicitly named and are unique in the selection list.
Updatable Views

A view can be updatable or read-only. If a view is updatable, the data retrieved when this view is called can be changed by the DML statements INSERT, UPDATE, DELETE, UPDATE OR INSERT or MERGE. Changes made in an updatable view are applied to the underlying table(s).

A read-only view can be made updatable with the use of triggers. Once triggers have been defined on a view, changes posted to it will never be written automatically to the underlying table, even if the view was updatable to begin with. It is the responsibility of the programmer to ensure that the triggers update (or delete from, or insert into) the base tables as needed.

A view will be automatically updatable if all the following conditions are met:

- the SELECT statement queries only one table or one updatable view
- the SELECT statement does not call any stored procedures
- each base table (or base view) column not present in the view definition meets one of the following conditions:
  - it is nullable
  - it has a non-NULL default value
  - it has a trigger that supplies a permitted value
- the SELECT statement contains no fields derived from subqueries or other expressions
- the SELECT statement does not contain fields defined through aggregate functions (MIN, MAX, AVG, SUM, COUNT, LIST, etc.), statistical functions (CORR, COVAR_POP, COVAR_SAMP, etc.), linear regression functions (REGR_AVGX, REGR_AVGY, etc.) or any type of window function
- the SELECT statement contains no ORDER BY, GROUP BY or HAVING clause
- the SELECT statement does not include the keyword DISTINCT or row-restrictive keywords such as ROWS, FIRST, SKIP, OFFSET or FETCH

The RETURNING clause and updatable views

The RETURNING clause of a DML statement used on a view made updatable using triggers may not always report the correct values. For example, values of identity column, computed columns, default values, or other expressions performed by the trigger will not be automatically reflected in the RETURNING columns.

To report the right values in RETURNING, the trigger will need to explicitly assign those values to the columns of the NEW record.

WITH CHECK OPTION

The optional WITH CHECK OPTION clause requires an updatable view to check whether new or updated data meet the condition specified in the WHERE clause of the SELECT statement. Every attempt to insert a new record or to update an existing one is checked whether the new or updated record would meet the WHERE criteria. If they fail the check, the operation is not performed and an error is raised.

WITH CHECK OPTION can be specified only in a CREATE VIEW statement in which a WHERE clause is
present to restrict the output of the main SELECT statement. An error message is returned otherwise.

Please note:

If WITH CHECK OPTION is used, the engine checks the input against the WHERE clause before passing anything to the base relation. Therefore, if the check on the input fails, any default clauses or triggers on the base relation that might have been designed to correct the input will never come into action.

Furthermore, view fields omitted from the INSERT statement are passed as NULLs to the base relation, regardless of their presence or absence in the WHERE clause. As a result, base table defaults defined on such fields will not be applied. Triggers, on the other hand, will fire and work as expected.

For views that do not have WITH CHECK OPTION, fields omitted from the INSERT statement are not passed to the base relation at all, so any defaults will be applied.

Who Can Create a View?

The CREATE VIEW statement can be executed by:

- Administrators
- Users with the CREATE VIEW privilege

The creator of a view becomes its owner.

To create a view, a non-admin user also needs at least SELECT access to the underlying table(s) and/or view(s), and the EXECUTE privilege on any selectable stored procedures involved.

To enable insertions, updates and deletions through the view, the creator/owner must also possess the corresponding INSERT, UPDATE and DELETE rights on the underlying object(s).

Granting other users privileges on the view is only possible if the view owner has these privileges on the underlying objects WITH GRANT OPTION. This will always be the case if the view owner is also the owner of the underlying objects.

Examples of Creating Views

1. Creating view returning the JOB_CODE and JOB_TITLE columns only for those jobs where MAX_SALARY is less than $15,000.

   ```sql
   CREATE VIEW ENTRY_LEVEL_JOBS AS
   SELECT JOB_CODE, JOB_TITLE
   FROM JOB
   WHERE MAX_SALARY < 15000;
   ```

2. Creating a view returning the JOB_CODE and JOB_TITLE columns only for those jobs where MAX_SALARY is less than $15,000. Whenever a new record is inserted or an existing record is updated, the MAX_SALARY < 15000 condition will be checked. If the condition is not true, the
insert/update operation will be rejected.

```
CREATE VIEW ENTRY_LEVEL_JOBS AS
SELECT JOB_CODE, JOB_TITLE
FROM JOB
WHERE MAX_SALARY < 15000
WITH CHECK OPTION;
```

3. Creating a view with an explicit column list.

```
CREATE VIEW PRICE_WITH_MARKUP (  
   CODE_PRICE,
   COST,
   COST_WITH_MARKUP
) AS  
SELECT  
   CODE_PRICE,
   COST,
   COST * 1.1
FROM PRICE;
```

4. Creating a view with the help of aliases for fields in the SELECT statement (the same result as in Example 3).

```
CREATE VIEW PRICE_WITH_MARKUP AS  
SELECT  
   CODE_PRICE,
   COST,
   COST * 1.1 AS COST_WITH_MARKUP
FROM PRICE;
```

5. Creating a read-only view based on two tables and a stored procedure.

```
CREATE VIEW GOODS_PRICE AS  
SELECT  
   goods.name AS goodsname,
   price.cost AS cost,
   b.quantity AS quantity
FROM  
   goods
JOIN price ON goods.code_goods = price.code_goods
LEFT JOIN sp_get_balance(goods.code_goods) b ON 1 = 1;
```
5.6.2. ALTER VIEW

Alters a view

Available in
DSQL

Syntax

```sql
ALTER VIEW viewname [<full_column_list>]
   AS <select_statement>
   [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>Name of an existing view</td>
</tr>
<tr>
<td>select_statement</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>full_column_list</td>
<td>The list of columns in the view</td>
</tr>
<tr>
<td>colname</td>
<td>View column name. Duplicate column names are not allowed.</td>
</tr>
</tbody>
</table>

Use the ALTER VIEW statement for changing the definition of an existing view. Privileges for views remain intact and dependencies are not affected.

The syntax of the ALTER VIEW statement corresponds with that of CREATE VIEW.

Be careful when you change the number of columns in a view. Existing application code and PSQL modules that access the view may become invalid. For information on how to detect this kind of problem in stored procedures and trigger, see The RDB$VALID_BLR Field in the Appendix.

Who Can Alter a View?

The ALTER VIEW statement can be executed by:

- Administrators
- The owner of the view
- Users with the ALTER ANY VIEW privilege

Example using ALTER VIEW

Altering the view PRICE_WITH_MARKUP

```sql
ALTER VIEW PRICE_WITH_MARKUP (CODE_PRICE, COST,
```
COST_WITH_MARKUP
) AS
SELECT
  CODE_PRICE,
  COST,
  COST * 1.15
FROM PRICE;

See also
CREATE VIEW, CREATE OR ALTER VIEW, RECREATE VIEW

5.6.3. CREATE OR ALTER VIEW

Creates a view if it doesn’t exist, or alters a view

Available in
DSQL

Syntax

CREATE OR ALTER VIEW viewname [<full_column_list>]
  AS <select_statement>
  [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])

Table 44. CREATE OR ALTER VIEW Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>Name of a view which may or may not exist</td>
</tr>
<tr>
<td>select_statement</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>full_column_list</td>
<td>The list of columns in the view</td>
</tr>
<tr>
<td>colname</td>
<td>View column name. Duplicate column names are not allowed.</td>
</tr>
</tbody>
</table>

Use the CREATE OR ALTER VIEW statement for changing the definition of an existing view or creating it if it does not exist. Privileges for an existing view remain intact and dependencies are not affected.

The syntax of the CREATE OR ALTER VIEW statement corresponds with that of CREATE VIEW.

Example of CREATE OR ALTER VIEW

Creating the new view PRICE_WITH_MARKUP view or altering it if it already exists

CREATE OR ALTER VIEW PRICE_WITH_MARKUP (  CODE_PRICE,
  COST,
  COST_WITH_MARKUP
) AS
SELECT CODE_PRICE, COST, COST * 1.15 FROM PRICE;

See also
CREATE VIEW, ALTER VIEW, RECREATE VIEW

5.6.4. DROP VIEW

Drops a view

Available in
DSQL

Syntax

DROP VIEW viewname

Table 45. DROP VIEW Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>View name</td>
</tr>
</tbody>
</table>

The DROP VIEW statement drops (deletes) an existing view. The statement will fail if the view has dependencies.

Who Can Drop a View?

The DROP VIEW statement can be executed by:

- Administrators
- The owner of the view
- Users with the DROP ANY VIEW privilege

Example

Deleting the PRICE_WITH_MARKUP view

DROP VIEW PRICE_WITH_MARKUP;

See also
CREATE VIEW, RECREATE VIEW, CREATE OR ALTER VIEW
5.6.5. RECREATE VIEW

Drops a view if it exists, and creates a view

Available in
DSQL

Syntax

RECREATE VIEW viewname [<full_column_list>]  
    AS <select_statement>  
    [WITH CHECK OPTION]

<full_column_list> ::= (colname [, colname ...])

Table 46. RECREATE VIEW Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>viewname</td>
<td>View name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>select_statement</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>full_column_list</td>
<td>The list of columns in the view</td>
</tr>
<tr>
<td>colname</td>
<td>View column name. Duplicate column names are not allowed.</td>
</tr>
</tbody>
</table>

Creates or recreates a view. If there is a view with this name already, the engine will try to drop it before creating the new instance. If the existing view cannot be dropped, because of dependencies or insufficient rights, for example, RECREATE VIEW fails with an error.

Example of RECREATE VIEW

Creating the new view PRICE_WITH_MARKUP view or recreating it, if it already exists

RECREATE VIEW PRICE_WITH_MARKUP (  
    CODE_PRICE,  
    COST,  
    COST_WITH_MARKUP  
) AS  
SELECT  
    CODE_PRICE,  
    COST,  
    COST * 1.15  
FROM PRICE;

See also

CREATE VIEW, DROP VIEW, CREATE OR ALTER VIEW
5.7. TRIGGER

A trigger is a special type of stored procedure that is not called directly, instead it is executed when a specified event occurs. A DML trigger is specific to a single relation (table or view) and one phase in the timing of the event (BEFORE or AFTER). A DML trigger can be specified to execute for one specific event (insert, update, delete) or for a combination of those events.

Two other forms of trigger exist:

1. a “database trigger” can be specified to fire at the start or end of a user session (connection) or a user transaction.
2. a “DDL trigger” can be specified to fire before or after execution of one or more types of DDL statements.

5.7.1. CREATE TRIGGER

Creates a trigger

Available in
DSQL, ESQL

Syntax

```
CREATE TRIGGER trigname
{ <relation_trigger_legacy>
| <relation_trigger_sql>
| <database_trigger>
| <ddl_trigger> }
{<psql_trigger> | <external-module-body>}

<relation_trigger_legacy> ::= 
  FOR {tablename | viewname}
  [ACTIVE | INACTIVE]
  {BEFORE | AFTER} <mutation_list>
  [POSITION number]

<relation_trigger_sql> ::= 
  [ACTIVE | INACTIVE]
  {BEFORE | AFTER} <mutation_list>
  ON {tablename | viewname}
  [POSITION number]

<database_trigger> ::= 
  [ACTIVE | INACTIVE] ON <db_event>
  [POSITION number]

<ddl_trigger> ::= 
  [ACTIVE | INACTIVE]
  {BEFORE | AFTER} <ddl_event>
  [POSITION number]
```
<mutation_list> ::= 
  <mutation> [OR <mutation> [OR <mutation>]]

<mutation> ::= INSERT | UPDATE | DELETE

<db_event> ::= 
  CONNECT | DISCONNECT 
  | TRANSACTION {START | COMMIT | ROLLBACK}

<ddl_event> ::= 
  ANY DDL STATEMENT 
  | <ddl_event_item> [{OR <ddl_event_item>} ...]

<ddl_event_item> ::= 
  {CREATE | ALTER | DROP} TABLE 
  | {CREATE | ALTER | DROP} PROCEDURE 
  | {CREATE | ALTER | DROP} FUNCTION 
  | {CREATE | ALTER | DROP} TRIGGER 
  | {CREATE | ALTER | DROP} EXCEPTION 
  | {CREATE | ALTER | DROP} VIEW 
  | {CREATE | ALTER | DROP} DOMAIN 
  | {CREATE | ALTER | DROP} ROLE 
  | {CREATE | ALTER | DROP} SEQUENCE 
  | {CREATE | ALTER | DROP} USER 
  | {CREATE | ALTER | DROP} INDEX 
  | {CREATE | DROP} COLLATION 
  | ALTER CHARACTER SET 
  | {CREATE | ALTER | DROP} PACKAGE 
  | {CREATE | DROP} PACKAGE BODY 
  | {CREATE | ALTER | DROP} MAPPING

<psql_trigger> ::= 
  [SQL SECURITY {INVOKER | DEFINER}] 
  <psql-module-body>

<psql-module-body> ::= 
  !! See Syntax of Module Body !!

<external-module-body> ::= 
  !! See Syntax of Module Body !!

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>triggername</td>
<td>Trigger name. The maximum length is 63 characters. It must be unique among all trigger names in the database.</td>
</tr>
<tr>
<td>relation_trigger_legacy</td>
<td>Legacy style of trigger declaration for a relation trigger</td>
</tr>
<tr>
<td>relation_trigger_sql</td>
<td>Relation trigger declaration compliant with the SQL standard</td>
</tr>
</tbody>
</table>
The `CREATE TRIGGER` statement is used for creating a new trigger. A trigger can be created either for a `relation (table | view) event` (or a combination of relation events), for a `database event`, or for a `DDL event`.

`CREATE TRIGGER`, along with its associates `ALTER TRIGGER`, `CREATE OR ALTER TRIGGER` and `RECREATE TRIGGER`, is a `compound statement`, consisting of a header and a body. The header specifies the name of the trigger, the name of the relation (for a DML trigger), the phase of the trigger, the event(s) it applies to, and the position to determine an order between triggers.

The trigger body consists of optional declarations of local variables and named cursors followed by one or more statements, or blocks of statements, all enclosed in an outer block that begins with the keyword `BEGIN` and ends with the keyword `END`. Declarations and embedded statements are terminated with semicolons (`;`).

The name of the trigger must be unique among all trigger names.

**Statement Terminators**

Some SQL statement editors — specifically the `isql` utility that comes with Firebird, and possibly some third-party editors — employ an internal convention that requires all statements to be terminated with a semicolon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled `Switching the Terminator in isql`.

**SQL Security**

The `SQL SECURITY` clause specifies the security context for executing other routines or inserting into other tables.

By default, a trigger applies the SQL Security property defined on its table (or — if the table doesn’t have the SQL Security property set — the database default), but it can be overridden by specifying it explicitly.

If the SQL Security property is changed for the table, triggers that do not have an explicit SQL Security property will not see the effect of the change until the next time the trigger is loaded into the metadata cache.
See also *SQL Security* in chapter *Security*.

**The Trigger Body**

The trigger body is either a PSQL body, or an external UDR module body.

See **The Module Body** in the PSQL chapter for details.

**DML Triggers (on Tables or Views)**

DML — or “relation” — triggers are executed at the row (record) level, every time a row is changed. A trigger can be either ACTIVE or INACTIVE. Only active triggers are executed. Triggers are created ACTIVE by default.

**Who Can Create a DML Trigger?**

DML triggers can be created by:

- Administrators
- The owner of the table (or view)
- Users with — for a table — the ALTER ANY TABLE, or — for a view — ALTER ANY VIEW privilege

**Forms of Declaration**

Firebird supports two forms of declaration for relation triggers:

- The legacy syntax
- The SQL standard-compliant form (recommended)

A relation trigger specifies — among other things — a *phase* and one or more *events*.

**Phase**

Phase concerns the timing of the trigger with regard to the change-of-state event in the row of data:

- A **BEFORE** trigger is fired before the specified database operation (insert, update or delete) is carried out
- An **AFTER** trigger is fired after the database operation has been completed

**Row Events**

A relation trigger definition specifies at least one of the DML operations INSERT, UPDATE and DELETE, to indicate one or more events on which the trigger should fire. If multiple operations are specified, they must be separated by the keyword OR. No operation may occur more than once.

Within the statement block, the Boolean context variables INSERTING, UPDATING and DELETING can be used to test which operation is currently executing.
**Firing Order of Triggers**

The keyword `POSITION` allows an optional execution order ("firing order") to be specified for a series of triggers that have the same phase and event as their target. The default position is 0. If no positions are specified, or if several triggers have a single position number, the triggers will be executed in the alphabetical order of their names.

**Examples of CREATE TRIGGER for Tables and Views**

1. Creating a trigger in the “legacy” form, firing before the event of inserting a new record into the `CUSTOMER` table occurs.

   ```sql
   CREATE TRIGGER SET_CUST_NO FOR CUSTOMER
   ACTIVE BEFORE INSERT POSITION 0
   AS
   BEGIN
     IF (NEW.CUST_NO IS NULL) THEN
       NEW.CUST_NO = GEN_ID(CUST_NO_GEN, 1);
   END
   ```

2. Creating a trigger firing before the event of inserting a new record into the `CUSTOMER` table in the SQL standard-compliant form.

   ```sql
   CREATE TRIGGER set_cust_no
   ACTIVE BEFORE INSERT ON customer POSITION 0
   AS
   BEGIN
     IF (NEW.cust_no IS NULL) THEN
       NEW.cust_no = GEN_ID(cust_no_gen, 1);
   END
   ```

3. Creating a trigger that will file after either inserting, updating or deleting a record in the `CUSTOMER` table.

   ```sql
   CREATE TRIGGER TR_CUST_LOG
   ACTIVE AFTER INSERT OR UPDATE OR DELETE
   ON CUSTOMER POSITION 10
   AS
   BEGIN
     INSERT INTO CHANGE_LOG (LOG_ID,
                               ID_TABLE,
                               TABLE_NAME,
                               MUTATION)
     VALUES (NEXT VALUE FOR SEQ_CHANGE_LOG,
             OLD.CUST_NO,
             'CUSTOMER',
             CASE
               WHEN INSERTING THEN 'INSERT'
               WHEN UPDATING THEN 'UPDATE'
               WHEN DELETING THEN 'DELETE'
             END)
   END
   ```
4. With DEFiner set for trigger tr_ins, user US needs only the INSERT privilege on tr. If it were set for INVOKER, either the user or the trigger would also need the INSERT privilege on table t.

```sql
create table tr (i integer);
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert SQL SECURITY DEFINER
as
begin
    insert into t values (NEW.i);
end^
set term ;^
grant insert on table tr to user us;
commit;

connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);
```

The result would be the same if SQL SECURITY DEFINER were specified for table TR:

```sql
create table tr (i integer) SQL SECURITY DEFINER;
create table t (i integer);
set term ^;
create trigger tr_ins for tr after insert
as
begin
    insert into t values (NEW.i);
end^
set term ;^
grant insert on table tr to user us;
commit;

connect 'localhost:/tmp/29.fdb' user us password 'pas';
insert into tr values(2);
```

**Database Triggers**

Triggers can be defined to fire upon “database events”; a mixture of events that act across the scope of a session (connection), and events that act across the scope of an individual transaction:

- CONNECT
• DISCONNECT
• TRANSACTION START
• TRANSACTION COMMIT
• TRANSACTION ROLLBACK

**DDL Triggers** are a subtype of database triggers, covered in a separate section.

**Who Can Create a Database Trigger?**

Database triggers can be created by:

• Administrators
• Users with the ALTER DATABASE privilege

**Execution of Database Triggers and Exception Handling**

CONNECT and DISCONNECT triggers are executed in a transaction created specifically for this purpose. This transaction uses the default isolation level, i.e. snapshot (concurrency), write and wait. If all goes well, the transaction is committed. Uncaught exceptions cause the transaction to roll back, and

• for a CONNECT trigger, the connection is then broken and the exception is returned to the client
• for a DISCONNECT trigger, exceptions are not reported. The connection is broken as intended

TRANSACTION triggers are executed within the transaction whose start, commit or rollback evokes them. The action taken after an uncaught exception depends on the event:

• In a TRANSACTION START trigger, the exception is reported to the client and the transaction is rolled back
• In a TRANSACTION COMMIT trigger, the exception is reported, the trigger’s actions so far are undone and the commit is cancelled
• In a TRANSACTION ROLLBACK trigger, the exception is not reported and the transaction is rolled back as intended.

**Traps**

There is no direct way of knowing if a DISCONNECT or TRANSACTION ROLLBACK trigger caused an exception. It also follows that the connection to the database cannot happen if a CONNECT trigger causes an exception and a transaction cannot start if a TRANSACTION START trigger causes one, either. Both phenomena effectively lock you out of your database until you get in there with database triggers suppressed and fix the bad code.

**Suppressing Database Triggers**

Some Firebird command-line tools have been supplied with switches that an administrator can use to suppress the automatic firing of database triggers. So far, they are:

`gbak -nodbtriggers`
Two-phase Commit

In a two-phase commit scenario, TRANSACTION COMMIT triggers fire in the prepare phase, not at the commit.

Some Caveats

1. The use of the IN AUTONOMOUS TRANSACTION DO statement in the database event triggers related to transactions (TRANSACTION START, TRANSACTION ROLLBACK, TRANSACTION COMMIT) may cause the autonomous transaction to enter an infinite loop

2. The DISCONNECT and TRANSACTION ROLLBACK event triggers will not be executed when clients are disconnected via monitoring tables (DELETE FROM MON$ATTACHMENTS)

Examples of CREATE TRIGGER for “Database Triggers”

1. Creating a trigger for the event of connecting to the database that logs users logging into the system. The trigger is created as inactive.

```sql
CREATE TRIGGER tr_log_connect
INACTIVE ON CONNECT POSITION 0
AS
BEGIN
    INSERT INTO LOG_CONNECT (ID,
        USERNAME,
        ATIME)
    VALUES (NEXT VALUE FOR SEQ_LOG_CONNECT,
        CURRENT_USER,
        CURRENT_TIMESTAMP);
END
```

2. Creating a trigger for the event of connecting to the database that does not permit any users, except for SYSDBA, to log in during off hours.

```sql
CREATE EXCEPTION E_INCORRECT_WORKTIME 'The working day has not started yet.';

CREATE TRIGGER tr_limit_worktime ACTIVE
ON CONNECT POSITION 1
AS
BEGIN
    IF ((CURRENT_USER <> 'SYSDBA') AND
        NOT (CURRENT_TIME BETWEEN time '9:00' AND time '17:00')) THEN
        EXCEPTION E_INCORRECT_WORKTIME;
END
```
DDL Triggers

DDL triggers allow restrictions to be placed on users who attempt to create, alter or drop a DDL object. Their other purposes is to keep a metadata change log.

DDL triggers fire on specified metadata changes events in a specified phase. BEFORE triggers run before changes to system tables. AFTER triggers run after changes in system tables.

⚠️ The event type [BEFORE | AFTER] of a DDL trigger cannot be changed.

In a sense, DDL triggers are a sub-type of database triggers.

Who Can Create a DDL Trigger?

DDL triggers can be created by:

- Administrators
- Users with the ALTER DATABASE privilege

Suppressing DDL Triggers

A DDL trigger is a type of database trigger. See Suppressing Database Triggers how to suppress DDL — and database — triggers.

Examples of DDL Triggers

1. Here is how you might use a DDL trigger to enforce a consistent naming scheme, in this case, stored procedure names should begin with the prefix “SP_”:

   ```sql
   set auto on;
   create exception e_invalid_sp_name 'Invalid SP name (should start with SP_)';

   set term !;

   create trigger trig_ddl_sp before CREATE PROCEDURE
   as
   begin
     if (rdb$get_context('DDL_TRIGGER', 'OBJECT_NAME') not starting 'SP_') then
       exception e_invalid_sp_name;
   end!
   ```

   Test

   ```sql
   create procedure sp_test
   as
   begin
   end!
   create procedure test
   ```
2. Implement custom DDL security, in this case restricting the running of DDL commands to certain users:

```sql
create exception e_access_denied 'Access denied';

set term !;

create trigger trig_ddl before any ddl statement
as
begin
    if (current_user <> 'SUPER_USER') then
        exception e_access_denied;
    end!

Test

create procedure sp_test
as
begin
end!
```

Firebird has privileges for executing DDL statements, so writing a DDL trigger for this should be a last resort, if the same effect cannot be achieved using privileges.
3. Use a trigger to log DDL actions and attempts:

```sql
create sequence ddl_seq;

create table ddl_log (  
  id bigint not null primary key,  
  moment timestamp not null,  
  user_name varchar(63) not null,  
  event_type varchar(25) not null,  
  object_type varchar(25) not null,  
  ddl_event varchar(25) not null,  
  object_name varchar(63) not null,  
  sql_text blob sub_type text not null,  
  ok char(1) not null  
);

set term !;

create trigger trig_ddl_log_before before any ddl statement  
as  
declare id type of column ddl_log.id;  
begin  
  -- We do the changes in an AUTONOMOUS TRANSACTION, so if an exception happens  
  -- and the command didn't run, the log will survive.  
  in autonomous transaction do  
  begin  
    insert into ddl_log (id, moment, user_name, event_type, object_type,  
        ddl_event, object_name, sql_text, ok)  
    values (next value for ddl_seq, current_timestamp, current_user,  
            rdb$get_context('DDL_TRIGGER', 'EVENT_TYPE'),  
            rdb$get_context('DDL_TRIGGER', 'OBJECT_TYPE'),  
            rdb$get_context('DDL_TRIGGER', 'DDL_EVENT'),  
            rdb$get_context('DDL_TRIGGER', 'OBJECT_NAME'),  
            rdb$get_context('DDL_TRIGGER', 'SQL_TEXT'),  
            'N')  
    returning id into id;  
    rdb$set_context('USER_SESSION', 'trig_ddl_log_id', id);  
  end  
end!

The above trigger will fire for this DDL command. It's a good idea to use -nodbtriggers when working with them!

create trigger trig_ddl_log_after after any ddl statement  
as  
begin  
  -- Here we need an AUTONOMOUS TRANSACTION because the original transaction  
  -- will not see the record inserted on the BEFORE trigger autonomous  
  -- transaction if user transaction is not READ COMMITTED.
```
in autonomous transaction do
    update ddl_log set ok = 'Y'
    where id = rdb$get_context('USER_SESSION', 'trig_ddl_log_id');
end!

commit!

set term ;!

-- Delete the record about trig_ddl_log_after creation.
delete from ddl_log;
commit;

Test

-- This will be logged one time
-- (as T1 did not exist, RECREATE acts as CREATE) with OK = Y.
recreate table t1 (  
    n1 integer,
    n2 integer
);

-- This will fail as T1 already exists, so OK will be N.
create table t1 (  
    n1 integer,
    n2 integer
);

-- T2 does not exist. There will be no log.
drop table t2;

-- This will be logged twice
-- (as T1 exists, RECREATE acts as DROP and CREATE) with OK = Y.
recreate table t1 (  
    n integer
);

commit;

select id, ddl_event, object_name, sql_text, ok
    from ddl_log order by id;

    ID DDL_EVENT              OBJECT_NAME              SQL_TEXT OK
    === =============== =============== =============== ======
    2 CREATE TABLE            T1                         80:3 Y

SQL_TEXT:
recreate table t1 (
See also

ALTER TRIGGER, CREATE OR ALTER TRIGGER, RECREATE TRIGGER, DROP TRIGGER, DDL Triggers in Chapter

Procedural SQL (PSQL) Statements

5.7.2. ALTER TRIGGER

Alters a trigger

Available in

DSQL, ESQL

Syntax

```
ALTER TRIGGER trigname
[ACTIVE | INACTIVE]
[{{BEFORE | AFTER} <mutation_list>]
[POSITION number]
[{{<psql_trigger> | <external-module-body>}}]

<psql_trigger> ::= 
[<sql_security>]
[<psql-module-body>]
```
The `ALTER TRIGGER` statement only allows certain changes to the header and body of a trigger.

### Permitted Changes to Triggers

- Status (`ACTIVE` | `INACTIVE`)
- Phase (`BEFORE` | `AFTER`) (of DML triggers)
- Events (of DML triggers)
- Position in the firing order
- Modifications to code in the trigger body

If an element is not specified, it remains unchanged.

A DML trigger cannot be changed to a database or DDL trigger.

It is not possible to change the event(s) or phase of a database or DDL trigger.

### Reminders

The `BEFORE` keyword directs that the trigger be executed before the associated event occurs; the `AFTER` keyword directs that it be executed after the event.

More than one DML event—`INSERT`, `UPDATE`, `DELETE`—can be covered in a single trigger. The events should be separated with the keyword `OR`. No event should be mentioned more than once.

The keyword `POSITION` allows an optional execution order (“firing order”) to be specified for a series of triggers that have the same phase and event as their target. The default position is 0. If no positions are specified, or if several triggers have a single position number, the triggers will be executed in the alphabetical order of their names.

### Who Can Alter a Trigger?

DML triggers can be altered by:

- **Administrators**
- The owner of the table (or view)
- Users with — for a table — the `ALTER ANY TABLE`, or — for a view — `ALTER ANY VIEW` privilege

Database and DDL triggers can be altered by:

- **Administrators**
Users with the ALTER DATABASE privilege

**Examples using ALTER TRIGGER**

1. Deactivating the set_cust_no trigger (switching it to the inactive status).
   
   ```sql
   ALTER TRIGGER set_cust_no INACTIVE;
   ```

2. Changing the firing order position of the set_cust_no trigger.
   
   ```sql
   ALTER TRIGGER set_cust_no POSITION 14;
   ```

3. Switching the TR_CUST_LOG trigger to the inactive status and modifying the list of events.
   
   ```sql
   ALTER TRIGGER TR_CUST_LOG
   INACTIVE AFTER INSERT OR UPDATE;
   ```

4. Switching the tr_log_connect trigger to the active status, changing its position and body.
   
   ```sql
   ALTER TRIGGER tr_log_connect
   ACTIVE POSITION 1
   AS
   BEGIN
   INSERT INTO LOG_CONNECT (ID, 
   USERNAME, 
   ROLENAME, 
   ATIME)
   VALUES (NEXT VALUE FOR SEQ_LOG_CONNECT, 
   CURRENT_USER, 
   CURRENT_ROLE, 
   CURRENT_TIMESTAMP);
   END
   ```

*See also*
- `CREATE TRIGGER`
- `CREATE OR ALTER TRIGGER`
- `RECREATE TRIGGER`
- `DROP TRIGGER`

**5.7.3. CREATE OR ALTER TRIGGER**

Creates a trigger if it doesn’t exist, or alters a trigger

*Available in*
- `DSQL`

*Syntax*

```
CREATE OR ALTER TRIGGER triname
```
The **CREATE OR ALTER TRIGGER** statement creates a new trigger if it does not exist; otherwise it alters and recompiles it with the privileges intact and dependencies unaffected.

**Example of CREATE OR ALTER TRIGGER**

Creating a new trigger if it does not exist or altering it if it does exist

```sql
CREATE OR ALTER TRIGGER set_cust_no
ACTIVE BEFORE INSERT ON customer POSITION 0
AS
BEGIN
  IF (NEW.cust_no IS NULL) THEN
    NEW.cust_no = GEN_ID(cust_no_gen, 1);
END
```

See also

**CREATE TRIGGER, ALTER TRIGGER, RECREATE TRIGGER**

### 5.7.4. DROP TRIGGER

Drops a trigger

**Available in**

DSQL, ESQl

**Syntax**

```
DROP TRIGGER triname
```

**Table 48. DROP TRIGGER Statement Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>triname</td>
<td>Trigger name</td>
</tr>
</tbody>
</table>

The **DROP TRIGGER** statement drops (deletes) an existing trigger.

**Who Can Drop a Trigger?**

DML triggers can be dropped by:

- **Administrators**
• The owner of the table (or view)
• Users with — for a table — the ALTER ANY TABLE, or — for a view — ALTER ANY VIEW privilege

Database and DDL triggers can be dropped by:

• **Administrators**
• Users with the ALTER DATABASE privilege

**Example of DROP TRIGGER**

*Deleting the set_cust_no trigger*

```sql
DROP TRIGGER set_cust_no;
```

**See also**

`CREATE TRIGGER, RECREATE TRIGGER`

**5.7.5. RECREATE TRIGGER**

Drops a trigger if it exists, and creates a trigger

*Available in*

DSQL

*Syntax*

```sql
RECREATE TRIGGER trigname
{ <relation_trigger_legacy>
 | <relation_trigger_sql>
 | <database_trigger>
 | <ddl_trigger> }
{<psql_trigger> | <external-module-body>}

!! See syntax of `CREATE TRIGGER` for further rules !!
```

The **RECREATE TRIGGER** statement creates a new trigger if no trigger with the specified name exists; otherwise the **RECREATE TRIGGER** statement tries to drop the existing trigger and create a new one. The operation will fail on COMMIT if the trigger is in use.

⚠️ Be aware that dependency errors are not detected until the COMMIT phase of this operation.

**Example of RECREATE TRIGGER**

Creating or recreating the set_cust_no trigger.

```sql
RECREATE TRIGGER set_cust_no
```
ACTIVE BEFORE INSERT ON customer POSITION 0
AS
BEGIN
  IF (NEW.cust_no IS NULL) THEN
    NEW.cust_no = GEN_ID(cust_no_gen, 1);
END

See also
CREATE TRIGGER, DROP TRIGGER, CREATE OR ALTER TRIGGER

5.8. PROCEDURE

A stored procedure is a software module that can be called from a client, another procedure, function, executable block or trigger. Stored procedures are written in procedural SQL (PSQL) or defined using a UDR (User-Defined Routine). Most SQL statements are available in PSQL as well, sometimes with limitations or extensions. Notable limitations are the prohibition on DDL and transaction control statements in PSQL.

Stored procedures can have many input and output parameters.

5.8.1. CREATE PROCEDURE

Creates a stored procedure

Available in
DSQL, ESQL

Syntax

```
CREATE PROCEDURE procname [ ( [ <in_params> ] ) ]
  [RETURNS (<out_params>)]
  {<psql_procedure> | <external-module-body>}

<in_params> ::= <inparam> [, <inparam> ...]

<inparam> ::= <param_decl> [= | DEFAULT] <value>

<out_params> ::= <outparam> [, <outparam> ...]

<outparam> ::= <param_decl>

[value] ::= {<literal> | NULL | <context_var>}

<param_decl> ::= paramname <domain_or_non_array_type> [NOT NULL]
  [COLLATE collation]

<type> ::= 
  <datatype>
  | [TYPE OF] domain
```
Table 49. CREATE PROCEDURE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>proname</td>
<td>Stored procedure name. The maximum length is 63 characters. Must be unique among all table, view and procedure names in the database</td>
</tr>
<tr>
<td>inparam</td>
<td>Input parameter description</td>
</tr>
<tr>
<td>outparam</td>
<td>Output parameter description</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is assignment-compatible with the data type of the parameter</td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable whose type is compatible with the data type of the parameter</td>
</tr>
<tr>
<td>paramname</td>
<td>The name of an input or output parameter of the procedure. The maximum length is 63 characters. The name of the parameter must be unique among input and output parameters of the procedure and its local variables</td>
</tr>
<tr>
<td>collation</td>
<td>Collation</td>
</tr>
</tbody>
</table>

The CREATE PROCEDURE statement creates a new stored procedure. The name of the procedure must be unique among the names of all stored procedures, tables, and views in the database.

CREATE PROCEDURE is a compound statement, consisting of a header and a body. The header specifies the name of the procedure and declares input parameters and the output parameters, if any, that are to be returned by the procedure.

The procedure body consists of declarations for any local variables, named cursors, and subroutines that will be used by the procedure, followed by one or more statements, or blocks of statements, all enclosed in an outer block that begins with the keyword BEGIN and ends with the keyword END. Declarations and embedded statements are terminated with semicolons (';').

**Statement Terminators**

Some SQL statement editors — specifically the isql utility that comes with Firebird, and possibly
some third-party editors—employ an internal convention that requires all statements to be
terminated with a semicolon. This creates a conflict with PSQL syntax when coding in these
environments. If you are unacquainted with this problem and its solution, please study the details
in the PSQL chapter in the section entitled Switching the Terminator in isql.

Parameters

Each parameter has a data type. The NOT NULL constraint can also be specified for any parameter, to
prevent NULL being passed or assigned to it.

A collation can be specified for string-type parameters, using the COLLATE clause.

Input Parameters

Input parameters are presented as a parenthesized list following the name of the function. They
are passed by value into the procedure, so any changes inside the procedure has no effect on the
parameters in the caller. Input parameters may have default values. Parameters with default
values specified must be added at the end of the list of parameters.

Output Parameters

The optional RETURNS clause is for specifying a parenthesised list of output parameters for the
stored procedure.

SQL Security

The SQL SECURITY clause specifies the security context for executing other routines or inserting into
other tables. When SQL Security is not specified, the default value of the database is applied at
runtime.

The SQL SECURITY clause can only be specified for PSQL procedures, and is not valid for procedures
defined in a package.

See also SQL Security in chapter Security.

Variable, Cursor and Subroutine Declarations

The optional declarations section, located at the start of the body of the procedure definition,
defines variables (including cursors) and subroutines local to the procedure. Local variable
declarations follow the same rules as parameters regarding specification of the data type. See
details in the PSQL chapter for DECLARE VARIABLE, DECLARE CURSOR, DECLARE FUNCTION, and DECLARE
PROCEDURE.

External UDR Procedures

A stored procedure can also be located in an external module. In this case, instead of a procedure
body, the CREATE PROCEDURE specifies the location of the procedure in the external module using the
EXTERNAL clause. The optional NAME clause specifies the name of the external module, the name of the
procedure inside the module, and — optionally — user-defined information. The required ENGINE
clause specifies the name of the UDR engine that handles communication between Firebird and the
external module. The optional AS clause accepts a string literal “body”, which can be used by the
engine or module for various purposes.
Who Can Create a Procedure

The CREATE PROCEDURE statement can be executed by:

- Administrators
- Users with the CREATE PROCEDURE privilege

The user executing the CREATE PROCEDURE statement becomes the owner of the table.

Examples

1. Creating a stored procedure that inserts a record into the BREED table and returns the code of the inserted record:

   ```sql
   CREATE PROCEDURE ADD_BREED (  
     NAME D_BREEDNAME, /* Domain attributes are inherited */  
     NAME_EN TYPE OF D_BREEDNAME, /* Only the domain type is inherited */  
     SHORTNAME TYPE OF COLUMN BREED.SHORTNAME,  
     /* The table column type is inherited */  
     REMARK VARCHAR(120) CHARACTER SET WIN1251 COLLATE PXW_CYRL,  
     CODE_ANIMAL INT NOT NULL DEFAULT 1  
   )  
   RETURNS (  
     CODE_BREED INT  
   )  
   AS  
   BEGIN  
   INSERT INTO BREED (  
     CODE_ANIMAL, NAME, NAME_EN, SHORTNAME, REMARK)  
   VALUES (  
     :CODE_ANIMAL, :NAME, :NAME_EN, :SHORTNAME, :REMARK)  
   RETURNING CODE_BREED INTO CODE_BREED;  
   END
   ```

2. Creating a selectable stored procedure that generates data for mailing labels (from employee.fdb):

   ```sql
   CREATE PROCEDURE mail_label (cust_no INTEGER)  
   RETURNS (line1 CHAR(40), line2 CHAR(40), line3 CHAR(40),  
             line4 CHAR(40), line5 CHAR(40), line6 CHAR(40))  
   AS  
   DECLARE VARIABLE customer VARCHAR(25);  
   DECLARE VARIABLE first_name VARCHAR(15);  
   DECLARE VARIABLE last_name VARCHAR(20);  
   DECLARE VARIABLE addr1 VARCHAR(30);  
   DECLARE VARIABLE addr2 VARCHAR(30);  
   DECLARE VARIABLE city VARCHAR(25);  
   DECLARE VARIABLE state VARCHAR(15);  
   DECLARE VARIABLE country VARCHAR(15);  
   ```
DECLARE VARIABLE postcode VARCHAR(12);
DECLARE VARIABLE cnt INTEGER;
BEGIN

line1 = '';
line2 = '';
line3 = '';
line4 = '';
line5 = '';
line6 = '';

SELECT customer, contact_first, contact_last, address_line1,
    address_line2, city, state_province, country, postal_code
FROM CUSTOMER
WHERE cust_no = :cust_no
INTO :customer, :first_name, :last_name, :addr1, :addr2,
    :city, :state, :country, :postcode;

IF (customer IS NOT NULL) THEN
    line1 = customer;
END IF;
IF (first_name IS NOT NULL) THEN
    line2 = first_name || ' ' || last_name;
ELSE
    line2 = last_name;
END IF;
IF (addr1 IS NOT NULL) THEN
    line3 = addr1;
END IF;
IF (addr2 IS NOT NULL) THEN
    line4 = addr2;
END IF;

IF (country = 'USA') THEN
    BEGIN
        IF (city IS NOT NULL) THEN
            line5 = city || ', ' || state || '  ' || postcode;
        ELSE
            line5 = state || '  ' || postcode;
        END IF;
    END IF;
ELSE
    BEGIN
        IF (city IS NOT NULL) THEN
            line5 = city || ', ' || state;
        ELSE
            line5 = state;
        END IF;
        line6 = country || '    ' || postcode;
    END IF;

SUSPEND; -- the statement that sends an output row to the buffer
        -- and makes the procedure "selectable"
END

3. With DEFINER set for procedure p, user US needs only the EXECUTE privilege on p. If it were set for INVOKER, either the user or the procedure would also need the INSERT privilege on table t.
set term ^;
create procedure p (i integer) SQL SECURITY DEFINER
as
begin
insert into t values (:i);
end^
set term ;^

grant execute on procedure p to user us;
commit;

connect 'localhost:/tmp/17.fdb' user us password 'pas';
execute procedure p(1);

See also
CREATE OR ALTER PROCEDURE, ALTER PROCEDURE, RECREATE PROCEDURE, DROP PROCEDURE

5.8.2. ALTER PROCEDURE
Alters a stored procedure

Available in
DSQL, ESQL

Syntax

```
ALTER PROCEDURE procname [ ( [ <in_params> ] ) ]
[RETURNS (<out_params>)]
{<psql_procedure> | <external-module-body>}
```

!! See syntax of CREATE PROCEDURE for further rules !!

The ALTER PROCEDURE statement allows the following changes to a stored procedure definition:

- the set and characteristics of input and output parameters
- local variables
- code in the body of the stored procedure

After ALTER PROCEDURE executes, existing privileges remain intact and dependencies are not affected.

Altering a procedure without specifying the SQL SECURITY clause will remove the SQL Security property if currently set for this procedure. This means the behaviour will revert to the database default.

Take care about changing the number and type of input and output parameters in stored procedures. Existing application code and procedures and triggers that call it could become invalid because the new description of the parameters is
Who Can Alter a Procedure

The ALTER PROCEDURE statement can be executed by:

- Administrators
- The owner of the stored procedure
- Users with the ALTER ANY PROCEDURE privilege

**ALTER PROCEDURE Example**

*Altering the GET_EMP_PROJ stored procedure.*

```sql
ALTER PROCEDURE GET_EMP_PROJ (    
    EMP_NO SMALLINT) 
RETURNS (    
    PROJ_ID VARCHAR(20)) 
AS 
BEGIN 
    FOR SELECT 
        PROJ_ID 
    FROM 
        EMPLOYEE_PROJECT 
    WHERE 
        EMP_NO = :emp_no 
    INTO :proj_id 
    DO 
        SUSPEND; 
END
```

See also
CREATE PROCEDURE, CREATE OR ALTER PROCEDURE, RECREATE PROCEDURE, DROP PROCEDURE

5.8.3. CREATE OR ALTER PROCEDURE

Creates a stored procedure if it does not exist, or alters a stored procedure

Available in
DSQL

Syntax

```sql
CREATE OR ALTER PROCEDURE procname [ ( [ <in_params> ] ] ) 
[RETURNS (<out_params>)] 
{<psql_procedure> | <external-module-body>}
```
The **CREATE OR ALTER PROCEDURE** statement creates a new stored procedure or alters an existing one. If the stored procedure does not exist, it will be created by invoking a **CREATE PROCEDURE** statement transparently. If the procedure already exists, it will be altered and compiled without affecting its existing privileges and dependencies.

### CREATE OR ALTER PROCEDURE Example

Creating or altering the **GET_EMP_PROJ** procedure.

```sql
CREATE OR ALTER PROCEDURE GET_EMP_PROJ (
    EMP_NO SMALLINT)
RETURNS (  
    PROJ_ID VARCHAR(20))
AS
BEGIN
    FOR SELECT  
        PROJ_ID   
    FROM  
        EMPLOYEE_PROJECT  
    WHERE  
        EMP_NO = :emp_no  
    INTO :proj_id  
    DO  
    SUSPEND;
END
```

See also

**CREATE PROCEDURE, ALTER PROCEDURE, RECREATE PROCEDURE**

### 5.8.4. DROP PROCEDURE

Drops a stored procedure

**Available in**

DSQL, ESQL

**Syntax**

```
DROP PROCEDURE procname
```

**Table 50. DROP PROCEDURE Statement Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>procname</td>
<td>Name of an existing stored procedure</td>
</tr>
</tbody>
</table>

The **DROP PROCEDURE** statement deletes an existing stored procedure. If the stored procedure has any
dependencies, the attempt to delete it will fail and raise an error.

**Who Can Drop a Procedure**

The `DROP PROCEDURE` statement can be executed by:

- Administrators
- The owner of the stored procedure
- Users with the `DROP ANY PROCEDURE` privilege

**DROP PROCEDURE Example**

*Deleting the GET_EMP_PROJ stored procedure.*

```
DROP PROCEDURE GET_EMP_PROJ;
```

**See also**

`CREATE PROCEDURE`, `RECREATE PROCEDURE`

### 5.8.5. RECREATE PROCEDURE

Drops a stored procedure if it exists, and creates a stored procedure

**Available in**

DSQL

**Syntax**

```
RECREATE PROCEDURE procname [ ( [ <in_params> ] ) ]
[RETURNS (<out_params>)]
{<psql_procedure> | <external-module-body>}
```

!! See syntax of `CREATE PROCEDURE` for further rules !!

The `RECREATE PROCEDURE` statement creates a new stored procedure or recreates an existing one. If a procedure with this name already exists, the engine will try to drop it and create a new one. Recreating an existing procedure will fail at the `COMMIT` request if the procedure has dependencies.

Be aware that dependency errors are not detected until the `COMMIT` phase of this operation.

After a procedure is successfully recreated, privileges to execute the stored procedure, and the privileges of the stored procedure itself are dropped.

**RECREATE PROCEDURE Example**
Creating the new GET_EMP_PROJ stored procedure or recreating the existing GET_EMP_PROJ stored procedure.

```
RECREATE PROCEDURE GET_EMP_PROJ (
    EMP_NO SMALLINT
) RETURNS (    
    PROJ_ID VARCHAR(20)
) AS     
BEGIN     
    FOR SELECT
        PROJ_ID
    FROM
        EMPLOYEE_PROJECT
    WHERE
        EMP_NO = :emp_no
    INTO :proj_id
    DO
        SUSPEND;
    END
```

See also
CREATE PROCEDURE, DROP PROCEDURE, CREATE OR ALTER PROCEDURE

5.9. FUNCTION

A stored function is a user-defined function stored in the metadata of a database, and running on the server. Stored functions can be called by stored procedures, stored functions (including the function itself), triggers and DSQL. When a stored function calls itself, such a stored function is called a recursive function.

Unlike stored procedures, stored functions always return a single scalar value. To return a value from a stored functions, use the RETURN statement, which immediately ends the function.

See also
EXTERNAL FUNCTION

5.9.1. CREATE FUNCTION

Creates a stored function

Available in
DSQL

Syntax

```
CREATE FUNCTION funcname [ ( [ <in_params> ] ) ]
    RETURNS <domain_or_non_array_type> [COLLATE collation]    
    [DETERMINISTIC]
    {<psql_function> | <external-module-body>}
```
<in_params> ::= <inparam> [, <inparam> ... ]

<inparam> ::= <param-decl> [ { = | DEFAULT } <value> ]

<value> ::= { <literal> | NULL | <context-var> }

<param-decl> ::= paramname <domain_or_non_array_type> [NOT NULL] [COLLATE collation]

<domain_or_non_array_type> ::= !! See Scalar Data Types Syntax !!

<psql_function> ::= [SQL SECURITY {INVOKER | DEFINER}] <psql-module-body>

<psql-module-body> ::= !! See Syntax of Module Body !!

<external-module-body> ::= !! See Syntax of Module Body !!

Table 51. CREATE FUNCTION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Stored function name. The maximum length is 63 characters. Must be unique among all function names in the database.</td>
</tr>
<tr>
<td>inparam</td>
<td>Input parameter description</td>
</tr>
<tr>
<td>collation</td>
<td>Collation</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is assignment-compatible with the data type of the parameter</td>
</tr>
<tr>
<td>context-var</td>
<td>Any context variable whose type is compatible with the data type of the parameter</td>
</tr>
<tr>
<td>paramname</td>
<td>The name of an input parameter of the function. The maximum length is 63 characters. The name of the parameter must be unique among input parameters of the function and its local variables.</td>
</tr>
</tbody>
</table>

The CREATE FUNCTION statement creates a new stored function. The stored function name must be unique among the names of all stored and external (legacy) functions, excluding sub-functions or functions in packages. For sub-functions or functions in packages, the name must be unique within its module (package, stored procedure, stored function, trigger).

It is advisable to not reuse function names between global stored functions and stored functions in packages, although this is legal. At the moment, it is not possible to call a function or procedure from the global namespace from inside a package, if that package defines a function or procedure with the same name. In that situation, the function or procedure of the package will be called.
CREATE FUNCTION is a compound statement with a header and a body. The header defines the name of the stored function, and declares input parameters and return type.

The function body consists of optional declarations of local variables, named cursors, and subroutines (sub-functions and sub-procedures), and one or more statements or statement blocks, enclosed in an outer block that starts with the keyword BEGIN and ends with the keyword END. Declarations and statements inside the function body must be terminated with a semicolon (‘;’).

**Statement Terminators**

Some SQL statement editors—specifically the *isql* utility that comes with Firebird, and possibly some third-party editors—employ an internal convention that requires all statements to be terminated with a semicolon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled *Switching the Terminator in isql*.

**Parameters**

Each parameter has a data type.

A collation can be specified for string-type parameters, using the COLLATE clause.

**Input Parameters**

Input parameters are presented as a parenthesized list following the name of the function. They are passed by value into the function, so any changes inside the function has no effect on the parameters in the caller. The NOT NULL constraint can also be specified for any input parameter, to prevent NULL being passed or assigned to it. Input parameters may have default values. Parameters with default values specified must be added at the end of the list of parameters.

**Output Parameter**

The RETURNS clause specifies the return type of the stored function. If a function returns a string value, then it is possible to specify the collation using the COLLATE clause. As a return type, you can specify a data type, a domain, the type of a domain (using TYPE OF), or the type of a column of a table or view (using TYPE OF COLUMN).

**Deterministic functions**

The optional DETERMINISTIC clause indicates that the function is deterministic. Deterministic functions always return the same result for the same set of inputs. Non-deterministic functions can return different results for each invocation, even for the same set of inputs. If a function is specified as deterministic, then such a function might not be called again if it has already been called once with the given set of inputs, and instead takes the result from a metadata cache.

Current versions of Firebird do not cache results of deterministic functions.

Specifying the DETERMINISTIC clause is comparable to a “promise” that the function will return the same thing for equal inputs. At the moment, a deterministic function is considered an invariant, and works like other invariants. That is, they are computed and cached at the current execution level of a given statement.
This is easily demonstrated with an example:

```sql
CREATE FUNCTION FN_T
RETURNS DOUBLE PRECISION DETERMINISTIC
AS
BEGIN
    RETURN rand();
END;

-- the function will be evaluated twice and will return 2 different values
SELECT fn_t() FROM rdb$database
UNION ALL
SELECT fn_t() FROM rdb$database;

-- the function will be evaluated once and will return 2 identical values
WITH t (n) AS (
    SELECT 1 FROM rdb$database
    UNION ALL
    SELECT 2 FROM rdb$database
)
SELECT n, fn_t() FROM t;
```

**SQL Security**

The SQL SECURITY clause specifies the security context for executing other routines or inserting into other tables. When SQL Security is not specified, the default value of the database is applied at runtime.

The SQL SECURITY clause can only be specified for PSQL functions, and is not valid for functions defined in a package.

See also *SQL Security* in chapter *Security*.

**Variable, Cursor and Subroutine Declarations**

The optional declarations section, located at the start of the body of the function definition, defines variables (including cursors) and subroutines local to the function. Local variable declarations follow the same rules as parameters regarding specification of the data type. See details in the PSQL chapter for DECLARE VARIABLE, DECLARE CURSOR, DECLARE FUNCTION, and DECLARE PROCEDURE.

**Function Body**

The header section is followed by the function body, consisting of one or more PSQL statements enclosed between the outer keywords BEGIN and END. Multiple BEGIN … END blocks of terminated statements may be embedded inside the procedure body.
**External UDR Functions**

A stored function can also be located in an external module. In this case, instead of a function body, the `CREATE FUNCTION` specifies the location of the function in the external module using the `EXTERNAL` clause. The optional `NAME` clause specifies the name of the external module, the name of the function inside the module, and — optionally — user-defined information. The required `ENGINE` clause specifies the name of the UDR engine that handles communication between Firebird and the external module. The optional `AS` clause accepts a string literal “body”, which can be used by the engine or module for various purposes.

> External UDR (User Defined Routine) functions created using `CREATE FUNCTION … EXTERNAL …` should not be confused with legacy UDFs (User Defined Functions) declared using `DECLARE EXTERNAL FUNCTION`. UDFs are deprecated, and a legacy from previous Firebird functions. Their capabilities are significantly inferior to the capabilities to the new type of external UDR functions.

**Who Can Create a Function**

The `CREATE FUNCTION` statement can be executed by:

- **Administrators**
- **Users with the CREATE FUNCTION privilege**

The user who created the stored function becomes its owner.

**CREATE FUNCTION Examples**

1. Creating a stored function

   ```sql
   CREATE FUNCTION ADD_INT (A INT, B INT DEFAULT 0) 
   RETURNS INT 
   AS 
   BEGIN 
   RETURN A + B; 
   END 
   ```

   Calling in a select:

   ```sql
   SELECT ADD_INT(2, 3) AS R FROM RDB$DATABASE 
   ```

   Call inside PSQL code, the second optional parameter is not specified:

   ```sql
   MY_VAR = ADD_INT(A); 
   ```

2. Creating a deterministic stored function
CREATE FUNCTION FN_E() 
RETURNS DOUBLE PRECISION DETERMINISTIC 
AS 
BEGIN 
RETURN EXP(1); 
END

3. Creating a stored function with table column type parameters

Returns the name of a type by field name and value

CREATE FUNCTION GET_MNEMONIC ( 
    AFIELD_NAME TYPE OF COLUMN RDB$TYPES.RDB$FIELD_NAME, 
    ATYPE TYPE OF COLUMN RDB$TYPES.RDB$TYPE) 
RETURNS TYPE OF COLUMN RDB$TYPES.RDB$TYPE_NAME 
AS 
BEGIN 
RETURN (SELECT RDB$TYPE_NAME 
            FROM RDB$TYPES 
            WHERE RDB$FIELD_NAME = :AFIELD_NAME 
            AND RDB$TYPE = :ATYPE); 
END

4. Creating an external stored function

Create a function located in an external module (UDR). Function implementation is located in the external module udrcpp_example. The name of the function inside the module is wait_event.

CREATE FUNCTION wait_event ( 
    event_name varchar (31) CHARACTER SET ascii 
) RETURNS INTEGER 
EXTERNAL NAME 'udrcpp_example!Wait_event' 
ENGINE udr

5. Creating a stored function containing a sub-function

Creating a function to convert a number to hexadecimal format.

CREATE FUNCTION INT_TO_HEX ( 
    ANumber BIGINT, 
    AByte_Per_Number SMALLINT = 8) 
RETURNS CHAR (66) 
AS 
DECLARE VARIABLE xMod SMALLINT ; 
DECLARE VARIABLE xResult VARCHAR (64); 
DECLARE FUNCTION TO_HEX (ANum SMALLINT ) RETURNS CHAR 
AS
BEGIN
RETURN CASE ANum
WHEN 0 THEN '0'
WHEN 1 THEN '1'
WHEN 2 THEN '2'
WHEN 3 THEN '3'
WHEN 4 THEN '4'
WHEN 5 THEN '5'
WHEN 6 THEN '6'
WHEN 7 THEN '7'
WHEN 8 THEN '8'
WHEN 9 THEN '9'
WHEN 10 THEN 'A'
WHEN 11 THEN 'B'
WHEN 12 THEN 'C'
WHEN 13 THEN 'D'
WHEN 14 THEN 'E'
WHEN 15 THEN 'F'
ELSE NULL
END;
END
BEGIN
xMod = MOD (ANumber, 16);
ANumber = ANumber / 16;
xResult = TO_HEX (xMod);
WHILE (ANUMBER> 0) DO
BEGIN
xMod = MOD (ANumber, 16);
ANumber = ANumber / 16;
xResult = TO_HEX (xMod) || xResult;
END
RETURN '0x' || LPAD (xResult, AByte_Per_Number * 2, '0' );
END

6. With DEFINER set for function f, user US needs only the EXECUTE privilege on f. If it were set for
INVOKER, the user would also need the INSERT privilege on table t.

set term ^;
create function f (i integer) returns int SQL SECURITY DEFINER
as
begin
insert into t values (:i);
return i + 1;
end^ set term ;^
grant execute on function f to user us;
commit;
connect 'localhost:/tmp/59.fdb' user us password 'pas';
select f(3) from rdb$database;

See also
CREATE OR ALTER FUNCTION, ALTER FUNCTION, RECREATE FUNCTION, DROP FUNCTION, DECLARE EXTERNAL FUNCTION

5.9.2. ALTER FUNCTION

Alters a stored function

Available in
DSQL

Syntax

ALTER FUNCTION funcname
  [ ( [ <in_params> ] ) ]
RETURNS <domain_or_non_array_type> [COLLATE collation] [DETERMINISTIC]
{<psql_function> | <external-module-body>}

!! See syntax of CREATE FUNCTION for further rules !!

The ALTER FUNCTION statement allows the following changes to a stored function definition:

- the set and characteristics of input and output type
- local variables, named cursors, and subroutines
- code in the body of the stored procedure

For external functions (UDR), you can change the entry point and engine name. For legacy external functions declared using DECLARE EXTERNAL FUNCTION—also known as UDFs—it is not possible to convert to PSQL and vice versa.

After ALTER FUNCTION executes, existing privileges remain intact and dependencies are not affected.

Altering a function without specifying the SQL SECURITY clause will remove the SQL Security property if currently set for this function. This means the behaviour will revert to the database default.

Take care about changing the number and type of input parameters and the output type of a stored function. Existing application code and procedures, functions and triggers that call it could become invalid because the new description of the parameters is incompatible with the old calling format. For information on how to troubleshoot such a situation, see the article The RDB$VALID_BLR Field in the Appendix.
Who Can Alter a Function

The ALTER FUNCTION statement can be executed by:

- Administrators
- Owner of the stored function
- Users with the ALTER ANY FUNCTION privilege

Examples of ALTER FUNCTION

Altering a stored function

```sql
ALTER FUNCTION ADD_INT(A INT, B INT, C INT)
RETURNS INT
AS
BEGIN
  RETURN A + B + C;
END
```

See also

CREATE FUNCTION, CREATE OR ALTER FUNCTION, RECREATE FUNCTION, DROP FUNCTION

5.9.3. CREATE OR ALTER FUNCTION

Creates a stored function if it does not exist, or alters a stored function

Available in

DSQL

Syntax

```sql
CREATE OR ALTER FUNCTION funcname
  [ ( [ <in_params> ] ) ]
RETURNS <domain_or_non_array_type> [COLLATE collation]
[DETERMINISTIC]
{<psql_function> | <external-module-body>}

!! See syntax of CREATE FUNCTION for further rules !!
```

The CREATE OR ALTER FUNCTION statement creates a new stored function or alters an existing one. If the stored function does not exist, it will be created by invoking a CREATE FUNCTION statement transparently. If the function already exists, it will be altered and compiled (through ALTER FUNCTION) without affecting its existing privileges and dependencies.

Examples of CREATE OR ALTER FUNCTION

Create a new or alter an existing stored function

```sql
CREATE OR ALTER FUNCTION ADD_INT(A INT, B INT DEFAULT 0)
```
RETURNS INT
AS
BEGIN
    RETURN A + B;
END

See also
CREATE FUNCTION, ALTER FUNCTION, DROP FUNCTION

5.9.4. DROP FUNCTION
Drops a stored function

Available in
DSQL

Syntax

DROP FUNCTION funcname

Table 52. DROP FUNCTION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Stored function name. The maximum length is 63 characters. Must be unique among all function names in the database.</td>
</tr>
</tbody>
</table>

The DROP FUNCTION statement deletes an existing stored function. If the stored function has any dependencies, the attempt to delete it will fail, and raise an error.

Who Can Drop a Function
The DROP FUNCTION statement can be executed by:

• Administrators
• Owner of the stored function
• Users with the DROP ANY FUNCTION privilege

Examples of DROP FUNCTION

DROP FUNCTION ADD_INT;

See also
CREATE FUNCTION, CREATE OR ALTER FUNCTION, RECREATE FUNCTION
5.9.5. RECREATE FUNCTION

Drops a stored function if it exists, and creates a stored function

Available in

DSQL

Syntax

```
RECREATE FUNCTION funcname
  [ ( [ <in_params> ] ) ]
RETURNS <domain_or_non_array_type> [COLLATE collation]
[DETERMINISTIC]
{<psql_function> | <external-module-body>}
```

!! See syntax of CREATE FUNCTION for further rules !!

The RECREATE FUNCTION statement creates a new stored function or recreates an existing one. If there is a function with this name already, the engine will try to drop it and then create a new one. Recreating an existing function will fail at COMMIT if the function has dependencies.

Be aware that dependency errors are not detected until the COMMIT phase of this operation.

After a procedure is successfully recreated, existing privileges to execute the stored function and the privileges of the stored function itself are dropped.

Examples of RECREATE FUNCTION

Creating or recreating a stored function

```
RECREATE FUNCTION ADD_INT(A INT, B INT DEFAULT 0)
RETURNS INT
AS
BEGIN
  RETURN A + B;
EN
```

See also

CREATE FUNCTION, DROP FUNCTION

5.10. EXTERNAL FUNCTION

External functions (UDFs) have been aggressively deprecated in Firebird 4.0:

- The default setting for the configuration parameter UdfAccess is None. To use UDFs now requires an explicit configuration of Restrict path-list
- The UDF libraries (ib_udf, fbudf) are no longer distributed in the installation
• Most of the functions in the libraries previously distributed in the shared (dynamic) libraries ib_udf and fbudf have already been replaced with built-in functions. A few remaining UDFs have been replaced with either compatible routines in a new library of UDRs named udf_compat or converted to stored functions.

Refer to Deprecation of External Functions (UDFs) in the Compatibility chapter of the Firebird 4.0 Release notes for details and instructions about upgrading to use the safe functions.

• Replacement of UDFs with UDRs or stored functions is strongly recommended

External functions, also known as “User-Defined Functions” (UDFs) are programs written in an external programming language and stored in dynamically loaded libraries. Once declared in a database, they become available in dynamic and procedural statements as though they were implemented in the SQL language.

External functions extend the possibilities for processing data with SQL considerably. To make a function available to a database, it is declared using the statement DECLARE EXTERNAL FUNCTION.

The library containing a function is loaded when any function included in it is called.

External functions declared as DECLARE EXTERNAL FUNCTION are a legacy from previous versions of Firebird. Their capabilities are inferior to the capabilities of the new type of external functions, UDR (User-Defined Routine). Such functions are declared as CREATE FUNCTION … EXTERNAL …. See CREATE FUNCTION for details.

External functions may be contained in more than one library — or “module”, as it is referred to in the syntax.

UDFs are fundamentally insecure. We recommend avoiding their use whenever possible, and disabling UDFs in your database configuration (UdfAccess = None in firebird.conf; this is the default since Firebird 4). If you do need to call native code from your database, use a UDR external engine instead.

See also
FUNCTION

5.10.1. DECLARE EXTERNAL FUNCTION

Declares a user-defined function (UDF) in the current database

Available in
DSQL, ESQL
Syntax

```
DECLARE EXTERNAL FUNCTION funcname
    [{ <arg_desc_list> | ( <arg_desc_list> ) }]
RETURNS { <return_value> | ( <return_value> ) }
ENTRY_POINT 'entry_point' MODULE_NAME 'library_name'
```

Table 53. DECLARE EXTERNAL FUNCTION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Function name in the database. The maximum length is 63 characters. It should be unique among all internal and external function names in the database and need not be the same name as the name exported from the UDF library via ENTRY_POINT.</td>
</tr>
<tr>
<td>entry_point</td>
<td>The exported name of the function</td>
</tr>
<tr>
<td>library_name</td>
<td>The name of the module (MODULE_NAME) from which the function is exported. This will be the name of the file, without the “.dll” or “.so” file extension.</td>
</tr>
<tr>
<td>length</td>
<td>The maximum length of a null-terminated string, specified in bytes</td>
</tr>
<tr>
<td>charset</td>
<td>Character set of the CSTRING</td>
</tr>
<tr>
<td>param_num</td>
<td>The number of the input parameter, numbered from 1 in the list of input parameters in the declaration, describing the data type that will be returned by the function</td>
</tr>
</tbody>
</table>

The DECLARE EXTERNAL FUNCTION statement makes a user-defined function available in the database. UDF declarations must be made in each database that is going to use them. There is no need to declare UDFs that will never be used.

The name of the external function must be unique among all function names. It may be different
from the exported name of the function, as specified in the ENTRY_POINT argument.

**DECLARE EXTERNAL FUNCTION Input Parameters**

The input parameters of the function follow the name of the function and are separated with commas. Each parameter has an SQL data type specified for it. Arrays cannot be used as function parameters. In addition to the SQL types, the CSTRING type is available for specifying a null-terminated string with a maximum length of LENGTH bytes. There are several mechanisms for passing a parameter from the Firebird engine to an external function, each of these mechanisms will be discussed below.

By default, input parameters are passed *by reference*. There is no separate clause to explicitly indicate that parameters are passed by reference.

When passing a NULL value by reference, it is converted to the equivalent of zero, for example, a number ‘0’ or an empty string (“’”). If the keyword NULL is specified after a parameter, then with passing a NULL values, the null pointer will be passed to the external function.

---

Declaring a function with the NULL keyword does not guarantee that the function will correctly handle a NULL input parameter. Any function must be written or rewritten to correctly handle NULL values. Always use the function declaration as provided by its developer.

---

If **BY DESCRIPTOR** is specified, then the input parameter is passed by descriptor. In this case, the UDF parameter will receive a pointer to an internal structure known as a descriptor. The descriptor contains information about the data type, subtype, precision, character set and collation, scale, a pointer to the data itself and some flags, including the NULL indicator. This declaration only works if the external function is written using a handle.

---

When passing a function parameter by descriptor, the passed value is not cast to the declared data type.

---

The **BY SCALAR_ARRAY** clause is used when passing arrays as input parameters. Unlike other types, you cannot return an array from a UDF.

**Clauses and Keywords**

**RETURNS clause**

(Required) specifies the output parameter returned by the function. A function is scalar, it returns one value (output parameter). The output parameter can be of any SQL type (except an array or an array element) or a null-terminated string (CSTRING). The output parameter can be passed by reference (the default), by descriptor or by value. If the **BY DESCRIPTOR** clause is specified, the output parameter is passed by descriptor. If the **BY VALUE** clause is specified, the output parameter is passed by value.

**PARAMETER keyword**

specifies that the function returns the value from the parameter under number *param_num*. It is necessary if you need to return a value of data type BLOB.
**FREE_IT keyword**

means that the memory allocated for storing the return value will be freed after the function is executed. It is used only if the memory was allocated dynamically in the UDF. In such a UDF, the memory must be allocated with the help of the `ib_util_malloc` function from the `ib_util` module, a requirement for compatibility with the functions used in Firebird code and in the code of the shipped UDF modules, for allocating and freeing memory.

**ENTRY_POINT clause**

specifies the name of the entry point (the name of the imported function), as exported from the module.

**MODULE_NAME clause**

defines the name of the module where the exported function is located. The link to the module should not be the full path and extension of the file, if that can be avoided. If the module is located in the default location (in the `../UDF` subdirectory of the Firebird server root) or in a location explicitly configured in `firebird.conf`, it makes it easier to move the database between different platforms. The `UDFAccess` parameter in the `firebird.conf` file allows access restrictions to external functions modules to be configured.

Any user connected to the database can declare an external function (UDF).

**Who Can Create an External Function**

The `DECLARE EXTERNAL FUNCTION` statement can be executed by:

- Administrators
- Users with the `CREATE FUNCTION` privilege

The user who created the function becomes its owner.

**Examples using DECLARE EXTERNAL FUNCTION**

1. Declaring the `addDay` external function located in the `fbudf` module. The input and output parameters are passed by reference.

   ```sql
   DECLARE EXTERNAL FUNCTION addDay
       TIMESTAMP, INT
       RETURNS TIMESTAMP
       ENTRY_POINT 'addDay' MODULE_NAME 'fbudf';
   ```

2. Declaring the `invl` external function located in the `fbudf` module. The input and output parameters are passed by descriptor.

   ```sql
   DECLARE EXTERNAL FUNCTION invl
       INT BY DESCRIPTOR, INT BY DESCRIPTOR
       RETURNS INT BY DESCRIPTOR
       ENTRY_POINT 'idNvl' MODULE_NAME 'fbudf';
   ```
3. Declaring the `isLeapYear` external function located in the `fbudf` module. The input parameter is passed by reference, while the output parameter is passed by value.

```sql
DECLARE EXTERNAL FUNCTION isLeapYear
TIMESTAMP
RETURNS INT BY VALUE
ENTRY_POINT 'isLeapYear' MODULE_NAME 'fbudf';
```

4. Declaring the `i64Truncate` external function located in the `fbudf` module. The input and output parameters are passed by descriptor. The second parameter of the function is used as the return value.

```sql
DECLARE EXTERNAL FUNCTION i64Truncate
NUMERIC(18) BY DESCRIPTOR, NUMERIC(18) BY DESCRIPTOR
RETURNS PARAMETER 2
ENTRY_POINT 'fbtruncate' MODULE_NAME 'fbudf';
```

*See also*

`ALTER EXTERNAL FUNCTION`, `DROP EXTERNAL FUNCTION`, `CREATE FUNCTION`

### 5.10.2. ALTER EXTERNAL FUNCTION

Alters the entry point and/or the module name of a user-defined function (UDF)

*Available in*

DSQL

**Syntax**

```sql
ALTER EXTERNAL FUNCTION funcname
[ENTRY_POINT 'new_entry_point']
[MODULE_NAME 'new_library_name']
```

**Table 54. ALTER EXTERNAL FUNCTION Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Function name in the database</td>
</tr>
<tr>
<td>new_entry_point</td>
<td>The new exported name of the function</td>
</tr>
<tr>
<td>new_library_name</td>
<td>The new name of the module (MODULE_NAME from which the function is exported). This will be the name of the file, without the “.dll” or “.so” file extension.</td>
</tr>
</tbody>
</table>

The `ALTER EXTERNAL FUNCTION` statement changes the entry point and/or the module name for a user-defined function (UDF). Existing dependencies remain intact after the statement containing the change(s) is executed.
The **ENTRY_POINT clause**

is for specifying the new entry point (the name of the function as exported from the module).

The **MODULE_NAME clause**

is for specifying the new name of the module where the exported function is located.

Any user connected to the database can change the entry point and the module name.

**Who Can Alter an External Function**

The `ALTER EXTERNAL FUNCTION` statement can be executed by:

- Administrators
- Owner of the external function
- Users with the `ALTER ANY FUNCTION` privilege

**Examples using ALTER EXTERNAL FUNCTION**

*Changing the entry point for an external function*

```sql
ALTER EXTERNAL FUNCTION invl ENTRY_POINT 'intNvl';
```

*Changing the module name for an external function*

```sql
ALTER EXTERNAL FUNCTION invl MODULE_NAME 'fbudf2';
```

**See also**

`DECLARE EXTERNAL FUNCTION, DROP EXTERNAL FUNCTION`

### 5.10.3. DROP EXTERNAL FUNCTION

Drops a user-defined function (UDF) from the current database

**Available in**

DSQL, ESQL

**Syntax**

```sql
DROP EXTERNAL FUNCTION funcname
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>funcname</td>
<td>Function name in the database</td>
</tr>
</tbody>
</table>

The `DROP EXTERNAL FUNCTION` statement deletes the declaration of a user-defined function from the database. If there are any dependencies on the external function, the statement will fail and raise
an error.

Any user connected to the database can delete the declaration of an internal function.

**Who Can Drop an External Function**

The `DROP EXTERNAL FUNCTION` statement can be executed by:

- **Administrators**
- Owner of the external function
- Users with the `DROP ANY FUNCTION` privilege

**Example using DROP EXTERNAL FUNCTION**

Deleting the declaration of the `addDay` function.

```sql
DROP EXTERNAL FUNCTION addDay;
```

See also

DECLARE EXTERNAL FUNCTION

5.11. PACKAGE

A package is a group of procedures and functions managed as one entity.

5.11.1. CREATE PACKAGE

Creates a package header

*Available in*

DSQL

**Syntax**

```sql
CREATE PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END

<package_item> ::= 
  <function_decl>;
  | <procedure_decl>;

<function_decl> ::= 
  FUNCTION funcname [ ( [ <in_params> ] ) ]
  RETURNS <domain_or_non_array_type> [COLLATE collation]
  [DETERMINISTIC]
```
<procedure_decl> ::= PROCEDURE procname [ ( [ <in_params> ] ) ] [RETURNS (<out_params>)]

<in_params> ::= <inparam> [, <inparam> ... ]

<inparam> ::= <param_decl> [ { = | DEFAULT } <value> ]

<out_params> ::= <outparam> [, <outparam> ...]

<outparam> ::= <param_decl>

<value> ::= { literal | NULL | context_var }

<param-decl> ::= paramname <domain_or_non_array_type> [NOT NULL] [COLLATE collation]

<domain_or_non_array_type> ::= !! See Scalar Data Types Syntax !!

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>package_name</td>
<td>Package name. The maximum length is 63 characters. The package name must be unique among all package names.</td>
</tr>
<tr>
<td>function_decl</td>
<td>Function declaration</td>
</tr>
<tr>
<td>procedure_decl</td>
<td>Procedure declaration</td>
</tr>
<tr>
<td>func_name</td>
<td>Function name. The maximum length is 63 characters. The function name must be unique within the package.</td>
</tr>
<tr>
<td>proc_name</td>
<td>Procedure name. The maximum length is 63 characters. The function name must be unique within the package.</td>
</tr>
<tr>
<td>collation</td>
<td>Collation</td>
</tr>
<tr>
<td>inparam</td>
<td>Input parameter declaration</td>
</tr>
<tr>
<td>outparam</td>
<td>Output parameter declaration</td>
</tr>
<tr>
<td>literal</td>
<td>A literal value that is assignment-compatible with the data type of the parameter</td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable that is assignment-compatible with the data type of the parameter</td>
</tr>
<tr>
<td>paramname</td>
<td>The name of an input parameter of a procedure or function, or an output parameter of a procedure. The maximum length is 63 characters. The name of the parameter must be unique among input and output parameters of the procedure or function.</td>
</tr>
</tbody>
</table>

The CREATE PACKAGE statement creates a new package header. Routines (procedures and functions)
declared in the package header are available outside the package using the full identifier
(package_name.proc_name or package_name.func_name). Routines defined only in the package
body — but not in the package header — are not visible outside the package.

Package procedure and function names may shadow global routines

If a package header or package body declares a procedure or function with the
same name as a stored procedure or function in the global namespace, it is not
possible to call that global procedure or function from the package body. In this
case, the procedure or function of the package will always be called.

For this reason, it is recommended that the names of stored procedures and
functions in packages do not overlap with names of stored procedures and
functions in the global namespace.

Statement Terminators

Some SQL statement editors — specifically the isql utility that comes with Firebird, and possibly
some third-party editors — employ an internal convention that requires all statements to be
terminated with a semicolon. This creates a conflict with PSQL syntax when coding in these
environments. If you are unacquainted with this problem and its solution, please study the details
in the PSQL chapter in the section entitled Switching the Terminator in isql.

SQL Security

The SQL SECURITY clause specifies the security context for executing other routines or inserting into
other tables from functions or procedures defined in this package. When SQL Security is not
specified, the default value of the database is applied at runtime.

The SQL SECURITY clause can only be specified for the package, not for individual procedures and
functions of the package.

See also SQL Security in chapter Security.

Procedure and Function Parameters

For details on stored procedure parameters, see Parameters in CREATE PROCEDURE.

For details on function parameters, see Parameters in CREATE FUNCTION.

Who Can Create a Package

The CREATE PACKAGE statement can be executed by:

• Administrators

• Users with the CREATE PACKAGE privilege

The user who created the package header becomes its owner.
Examples of `CREATE PACKAGE`

1. Create a package header

```sql
CREATE PACKAGE APP_VAR
AS
BEGIN
    FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
    FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
    PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
                             ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

1. With `DEFINER` set for package `pk`, user `US` needs only the `EXECUTE` privilege on `pk`. If it were set for `INVOKER`, either the user or the package would also need the `INSERT` privilege on table `t`.

```sql
create table t (i integer);
set term ^;
create package pk SQL SECURITY DEFINER
as
    begin
        function f(i integer) returns int;
    end^

create package body pk
as
    begin
        function f(i integer) returns int
            as
                begin
                    insert into t values (:i);
                    return i + 1;
                end
    end^
set term ;^
grant execute on package pk to user us;
commit;
connect 'localhost:/tmp/69.fdb' user us password 'pas';
select pk.f(3) from rdb$database;
```

*See also*

`CREATE PACKAGE BODY`, `RECREATE PACKAGE BODY`, `ALTER PACKAGE`, `DROP PACKAGE`, `RECREATE PACKAGE`

5.11.2. ALTER PACKAGE

Alters a package header
Available in
DSQL

Syntax

```
ALTER PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END
```

!! See syntax of CREATE PACKAGE for further rules!!

The **ALTER PACKAGE** statement modifies the package header. It can be used to change the number and definition of procedures and functions, including their input and output parameters. However, the source and compiled form of the package body is retained, though the body might be incompatible after the change to the package header. The validity of a package body for the defined header is stored in the column `RDB$PACKAGES.RDB$VALID_BODY_FLAG`.

Alternating a package without specifying the **SQL SECURITY** clause will remove the SQL Security property if currently set for this package. This means the behaviour will revert to the database default.

**Who Can Alter a Package**

The **ALTER PACKAGE** statement can be executed by:

- Administrators
- The owner of the package
- Users with the **ALTER ANY PACKAGE** privilege

**Examples of ALTER PACKAGE**

**Modifying a package header**

```
ALTER PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
                            ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

See also

CREATE PACKAGE, DROP PACKAGE, RECREATE PACKAGE BODY
5.11.3. CREATE OR ALTER PACKAGE

Creates a package header if it does not exist, or alters a package header

*Available in*
DSQL

**Syntax**

```
CREATE OR ALTER PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
  [ <package_item> ... ]
END

!! See syntax of CREATE PACKAGE for further rules!!
```

The `CREATE OR ALTER PACKAGE` statement creates a new package or modifies an existing package header. If the package header does not exist, it will be created using `CREATE PACKAGE`. If it already exists, then it will be modified using `ALTER PACKAGE` while retaining existing privileges and dependencies.

**Examples of CREATE OR ALTER PACKAGE**

*Creating a new or modifying an existing package header*

```
CREATE OR ALTER PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
          ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

*See also*
CREATE PACKAGE, ALTER PACKAGE, RECREATE PACKAGE, RECREATE PACKAGE BODY

5.11.4. DROP PACKAGE

Drops a package header

*Available in*
DSQL
Syntax

```sql
DROP PACKAGE package_name
```

### Table 57. DROP PACKAGE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>package_name</td>
<td>Package name</td>
</tr>
</tbody>
</table>

The `DROP PACKAGE` statement deletes an existing package header. If a package body exists, it will be dropped together with the package header. If there are still dependencies on the package, an error will be raised.

**Who Can Drop a Package**

The `DROP PACKAGE` statement can be executed by:

- Administrators
- The owner of the package
- Users with the `DROP ANY PACKAGE` privilege

**Examples of DROP PACKAGE**

**Dropping a package header**

```sql
DROP PACKAGE APP_VAR
```

See also

`CREATE PACKAGE`, `DROP PACKAGE BODY`

**5.11.5. RECREATE PACKAGE**

Drops a package header if it exists, and creates a package header

*Available in*

DSQL

Syntax

```sql
RECREATE PACKAGE package_name
[SQL SECURITY {INVOKER | DEFINER}]
AS
BEGIN
[ <package_item> ... ]
END
```

!! See syntax of `CREATE PACKAGE` for further rules!!
The `RECREATE PACKAGE` statement creates a new package or recreates an existing package header. If a package header with the same name already exists, then this statement will first drop it and then create a new package header. It is not possible to recreate the package header if there are still dependencies on the existing package, or if the body of the package exists. Existing privileges of the package itself are not preserved, nor are privileges to execute the procedures or functions of the package.

**Examples of RECREATE PACKAGE**

*Creating a new or recreating an existing package header*

```
RECREATE PACKAGE APP_VAR
AS
BEGIN
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC;
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC;
  PROCEDURE SET_DATERANGE(ADATEBEGIN DATE,
                           ADATEEND DATE DEFAULT CURRENT_DATE);
END
```

**See also**

CREATE PACKAGE, DROP PACKAGE, CREATE PACKAGE BODY, RECREATE PACKAGE BODY

## 5.12. PACKAGE BODY

### 5.12.1. CREATE PACKAGE BODY

Creates a package body

*Available in*

DSQL

*Syntax*

```
CREATE PACKAGE BODY name
AS
BEGIN
  [ <package_item> ... ]
  [ <package_body_item> ... ]
END

<package_item> ::=  
  !! See CREATE PACKAGE syntax !!

<package_body_item> ::=  
  <function_impl> |  
  <procedure_impl>

<function_impl> ::=  
```


FUNCTION funcname [ ( [ <in_params> ] ) ]
RETURNS <domain_or_non_array_type> [COLLATE collation]
[DETERMINISTIC]
<module-body>

<procedure_impl> ::= 
PROCEDURE procname [ ( [ <in_params> ] ) ] 
[RETURNS (<out_params>)]
<module-body>

<module-body> ::= 
!! See Syntax of Module Body !!

<in_params> ::= 
!! See CREATE PACKAGE syntax !!
!! See also Rules below !!

<out_params> ::= 
!! See CREATE PACKAGE syntax !!

<domain_or_non_array_type> ::= 
!! See Scalar Data Types Syntax !!

Table 58. CREATE PACKAGE BODY Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>package_name</td>
<td>Package name. The maximum length is 63 characters. The package name must be unique among all package names.</td>
</tr>
<tr>
<td>function_impl</td>
<td>Function implementation. Essentially a CREATE FUNCTION statement without CREATE.</td>
</tr>
<tr>
<td>procedure_impl</td>
<td>Procedure implementation. Essentially a CREATE PROCEDURE statement without CREATE.</td>
</tr>
<tr>
<td>func_name</td>
<td>Function name. The maximum length is 63 characters. The function name must be unique within the package.</td>
</tr>
<tr>
<td>collation</td>
<td>Collation</td>
</tr>
<tr>
<td>proc_name</td>
<td>Procedure name. The maximum length is 63 characters. The function name must be unique within the package.</td>
</tr>
</tbody>
</table>

The CREATE PACKAGE BODY statement creates a new package body. The package body can only be created after the package header has been created. If there is no package header with name package_name, an error is raised.

All procedures and functions declared in the package header must be implemented in the package body. Additional procedures and functions may be defined and implemented in the package body only. Procedure and functions defined in the package body, but not defined in the package header, are not visible outside the package body.
The names of procedures and functions defined in the package body must be unique among the names of procedures and functions defined in the package header and implemented in the package body.

**Package procedure and function names may shadow global routines**

If a package header or package body declares a procedure or function with the same name as a stored procedure or function in the global namespace, it is not possible to call that global procedure or function from the package body. In this case, the procedure or function of the package will always be called.

For this reason, it is recommended that the names of stored procedures and functions in packages do not overlap with names of stored procedures and functions in the global namespace.

**Rules**

- In the package body, all procedures and functions must be implemented with the same signature as declared in the header and at the beginning of the package body.
- The default values for procedure or function parameters cannot be overridden (as specified in the package header or in `<package_item>`). This means default values can only be defined in `<package_body_item>` for procedures or functions that have not been defined in the package header or earlier in the package body.

**Who Can Create a Package Body**

The `CREATE PACKAGE BODY` statement can be executed by:

- **Administrators**
- The owner of the package
- Users with the `ALTER ANY PACKAGE` privilege

**Examples of CREATE PACKAGE BODY**

*Creating the package body*

```sql
CREATE PACKAGE BODY APP_VAR
AS
BEGIN
  -- Returns the start date of the period
  FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC AS
  BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEBEGIN');
  END
  -- Returns the end date of the period
  FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC
```
AS
BEGIN
    RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEEND');
END
-- Sets the date range of the working period
PROCEDURE SET_DATERANGE(ADATEBEGIN DATE, ADATEEND DATE) AS
BEGIN
    RDB$SET_CONTEXT('USER_SESSION', 'DATEBEGIN', ADATEBEGIN);
    RDB$SET_CONTEXT('USER_SESSION', 'DATEEND', ADATEEND);
END
END

See also
DROP PACKAGE BODY, RECREATE PACKAGE BODY, CREATE PACKAGE

5.12.2. DROP PACKAGE BODY

Drops a package body

Available in
DSQL

Syntax

DROP PACKAGE package_name

Table 59. DROP PACKAGE BODY Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>package_name</td>
<td>Package name</td>
</tr>
</tbody>
</table>

The DROP PACKAGE BODY statement deletes the package body.

Who Can Drop a Package Body

The DROP PACKAGE BODY statement can be executed by:

- Administrators
- The owner of the package
- Users with the ALTER ANY PACKAGE privilege

Examples of DROP PACKAGE BODY

Dropping the package body

DROP PACKAGE BODY APP_VAR;
5.12.3. RECREATE PACKAGE BODY

Drops a package body if it exists, and creates a package body

Available in

DSQL

Syntax

```
RECREATE PACKAGE BODY name
AS
BEGIN
    [ <package_item> ... ]
    [ <package_body_item> ... ]
END
```

!! See syntax of CREATE PACKAGE BODY for further rules !!

The RECREATE PACKAGE BODY statement creates a new or recreates an existing package body. If a package body with the same name already exists, the statement will try to drop it and then create a new package body. After recreating the package body, privileges of the package and its routines are preserved.

See CREATE PACKAGE BODY for more details.

Examples of RECREATE PACKAGE BODY

Recreating the package body

```
RECREATE PACKAGE BODY APP_VAR
AS
BEGIN
    -- Returns the start date of the period
    FUNCTION GET_DATEBEGIN() RETURNS DATE DETERMINISTIC
    AS
    BEGIN
        RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEBEGIN');
    END
    -- Returns the end date of the period
    FUNCTION GET_DATEEND() RETURNS DATE DETERMINISTIC
    AS
    BEGIN
        RETURN RDB$GET_CONTEXT('USER_SESSION', 'DATEEND');
    END
    -- Sets the date range of the working period
    PROCEDURE SET_DATERANGE(ADATEBEGIN DATE, ADATEEND DATE)
    AS
```
5.13. FILTER

A BLOB FILTER is a database object that is a special type of external function, with the sole purpose of taking a BLOB object in one format and converting it to a BLOB object in another format. The formats of the BLOB objects are specified with user-defined BLOB subtypes.

External functions for converting BLOB types are stored in dynamic libraries and loaded when necessary.

For more details on BLOB subtypes, see Binary Data Types.

5.13.1. DECLARE FILTER

Declares a BLOB filter in the current database

Available in
DSQL, ESQL

Syntax

```
DECLARE FILTER filtername
    INPUT_TYPE <sub_type> OUTPUT_TYPE <sub_type>
    ENTRY_POINT 'function_name' MODULE_NAME 'library_name'
```

| <sub_type> ::= number | <mnemonic> |
| <mnemonic> ::= |

| BINARY | TEXT | BLR | ACL | RANGES |
| SUMMARY | FORMAT | TRANSACTION_DESCRIPTION |
| EXTERNAL_FILE_DESCRIPTION | user_defined |

Table 60. DECLARE FILTER Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filtername</td>
<td>Filter name in the database. The maximum length is 63 characters. It need not be the same name as the name exported from the filter library via ENTRY_POINT.</td>
</tr>
<tr>
<td>sub_type</td>
<td>BLOB subtype</td>
</tr>
</tbody>
</table>
### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>BLOB subtype number (must be negative)</td>
</tr>
<tr>
<td>mnemonic</td>
<td>BLOB subtype mnemonic name</td>
</tr>
<tr>
<td>function_name</td>
<td>The exported name (entry point) of the function</td>
</tr>
<tr>
<td>library_name</td>
<td>The name of the module where the filter is located</td>
</tr>
<tr>
<td>user_defined</td>
<td>User-defined BLOB subtype mnemonic name</td>
</tr>
</tbody>
</table>

The DECLARE FILTER statement makes a BLOB filter available to the database. The name of the BLOB filter must be unique among the names of BLOB filters.

#### Specifying the Subtypes

The subtypes can be specified as the subtype number or as the subtype mnemonic name. Custom subtypes must be represented by negative numbers (from -1 to -32,768), or their user-defined name from the RDB$TYPES table. An attempt to declare more than one BLOB filter with the same combination of the input and output types will fail with an error.

**INPUT_TYPE**
- clause defining the BLOB subtype of the object to be converted

**OUTPUT_TYPE**
- clause defining the BLOB subtype of the object to be created.

Mnemonic names can be defined for custom BLOB subtypes and inserted manually into the system table RDB$TYPES system table:

```sql
INSERT INTO RDB$TYPES (RDB$FIELD_NAME, RDB$TYPE, RDB$TYPE_NAME)
VALUES ('RDB$FIELD_SUB_TYPE', -33, 'MIDI');
```

After the transaction is committed, the mnemonic names can be used in declarations when you create new filters.

The value of the column RDB$FIELD_NAME must always be 'RDB$FIELD_SUB_TYPE'. If a mnemonic names was defined in upper case, they can be used case-insensitively and without quotation marks when a filter is declared, following the rules for other object names.

**Warning**
In general, the system tables are not writable by users. However, inserting custom types into RDB$TYPES is still possible if the user is an administrator, or has the system privilege CREATE_USER_TYPES.

**Parameters**

Chapter 5. Data Definition (DDL) Statements

228
ENTRY_POINT

clause defining the name of the entry point (the name of the imported function) in the module.

MODULE_NAME

The clause defining the name of the module where the exported function is located. By default, modules must be located in the UDF folder of the root directory on the server. The UDFAccess parameter in firebird.conf allows editing of access restrictions to filter libraries.

Any user connected to the database can declare a BLOB filter.

Who Can Create a BLOB Filter?

The DECLARE FILTER statement can be executed by:

- Administrators
- Users with the CREATE FILTER privilege

The user executing the DECLARE FILTER statement becomes the owner of the filter.

Examples of DECLARE FILTER

1. Creating a BLOB filter using subtype numbers.

   DECLARE FILTER DESC_FILTER
   INPUT_TYPE 1
   OUTPUT_TYPE -4
   ENTRY_POINT 'desc_filter'
   MODULE_NAME 'FILTERLIB';

2. Creating a BLOB filter using subtype mnemonic names.

   DECLARE FILTER FUNNEL
   INPUT_TYPE blr OUTPUT_TYPE text
   ENTRY_POINT 'blr2asc' MODULE_NAME 'myfilterlib';

See also

DROP FILTER

5.13.2. DROP FILTER

Drops a BLOB filter declaration from the current database

Available in

DSQL, ESQL
Syntax

```
DROP FILTER filtername
```

### Table 61. DROP FILTER Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>filtername</td>
<td>Filter name in the database</td>
</tr>
</tbody>
</table>

The `DROP FILTER` statement removes the declaration of a BLOB filter from the database. Removing a BLOB filter from a database makes it unavailable for use from that database. The dynamic library where the conversion function is located remains intact and the removal from one database does not affect other databases in which the same BLOB filter is still declared.

**Who Can Drop a BLOB Filter?**

The `DROP FILTER` statement can be executed by:

- Administrators
- The owner of the filter
- Users with the `DROP ANY FILTER` privilege

**DROP FILTER Example**

Dropping a BLOB filter.

```
DROP FILTER DESC_FILTER;
```

**See also**

`DECLARE FILTER`

### 5.14. SEQUENCE (GENERATOR)

A sequence — or generator — is a database object used to get unique number values to fill a series. “Sequence” is the SQL-compliant term for the same thing which — in Firebird — has traditionally been known as “generator”. Firebird has syntax for both terms.

Sequences are always stored as 64-bit integers, regardless of the SQL dialect of the database.

If a client is connected using Dialect 1, the server handles sequence values as 32-bit integers. Passing a sequence value to a 32-bit field or variable will not cause errors as long as the current value of the sequence does not exceed the limits of a 32-bit number. However, as soon as the sequence value exceeds this limit, a database in Dialect 3 will produce an error. A database in Dialect 1 will truncate (overflow) the value, which could compromise the uniqueness of the series.

This section describes how to create, alter, set and drop sequences.
5.14.1. CREATE SEQUENCE

Creates a SEQUENCE (GENERATOR)

Available in
DSQL, ESQL

Syntax

```
CREATE {SEQUENCE | GENERATOR} seq_name
[START WITH start_value]
[INCREMENT [BY] increment]
```

Table 62. CREATE SEQUENCE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>start_value</td>
<td>Initial value of the sequence. Default is 1.</td>
</tr>
<tr>
<td>increment</td>
<td>Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0. Default is 1.</td>
</tr>
</tbody>
</table>

The statements CREATE SEQUENCE and CREATE GENERATOR are synonymous—both create a new sequence. Either can be used, but CREATE SEQUENCE is recommended as that is the syntax defined in the SQL standard.

When a sequence is created, its current value is set so that the next value obtained from NEXT VALUE FOR seq_name is equal to start_value. In other words, the current value of the sequence is set to (start_value - increment). By default, the start_value is 1 (one).

The optional INCREMENT [BY] clause allows you to specify an increment for the NEXT VALUE FOR seq_name expression. By default, the increment is 1 (one). The increment cannot be set to 0 (zero). The GEN_ID(seq_name, <step>) function can be called instead, to “step” the series by a different integer number. The increment specified through INCREMENT [BY] is not used for GEN_ID.

Non-standard behaviour for negative increments

The SQL standard specifies that sequences with a negative increment should start at the maximum value of the sequence ($2^{31} - 1$) and count down. Firebird does not do that, and instead starts at 1.

This may change in a future Firebird version.

Who Can Create a Sequence?

The CREATE SEQUENCE (CREATE GENERATOR) statement can be executed by:

- **Administrators**
- **Users with the CREATE SEQUENCE (CREATE GENERATOR) privilege**
The user executing the `CREATE SEQUENCE (CREATE GENERATOR)` statement becomes its owner.

### Examples of CREATE SEQUENCE

1. Creating the `EMP_NO_GEN` sequence using `CREATE SEQUENCE`.

   ```
   CREATE SEQUENCE EMP_NO_GEN;
   ```

2. Creating the `EMP_NO_GEN` sequence using `CREATE GENERATOR`.

   ```
   CREATE GENERATOR EMP_NO_GEN;
   ```

3. Creating the `EMP_NO_GEN` sequence with an initial value of 5 and an increment of 1.

   ```
   CREATE SEQUENCE EMP_NO_GEN START WITH 5;
   ```

4. Creating the `EMP_NO_GEN` sequence with an initial value of 1 and an increment of 10.

   ```
   CREATE SEQUENCE EMP_NO_GEN INCREMENT BY 10;
   ```

5. Creating the `EMP_NO_GEN` sequence with an initial value of 5 and an increment of 10.

   ```
   CREATE SEQUENCE EMP_NO_GEN START WITH 5 INCREMENT BY 10;
   ```

See also

`ALTER SEQUENCE`, `CREATE OR ALTER SEQUENCE`, `DROP SEQUENCE`, `RECREATE SEQUENCE`, `SET GENERATOR`, `NEXT VALUE FOR`, `GEN_ID()` function

### 5.14.2. ALTER SEQUENCE

Sets the next value of a sequence, or changes its increment

*Available in*

DSQL

#### Syntax

```
ALTER {SEQUENCE | GENERATOR} seq_name
   [RESTART [WITH newvalue]]
   [INCREMENT [BY] increment]
```

*Table 63. ALTER SEQUENCE Statement Parameters*
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name</td>
</tr>
<tr>
<td>newvalue</td>
<td>New sequence (generator) value. A 64-bit integer from $-2^{63}$ to $2^{63}-1$.</td>
</tr>
<tr>
<td>increment</td>
<td>Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0.</td>
</tr>
</tbody>
</table>

The **ALTER SEQUENCE** statement sets the current value of a sequence to the specified value and/or changes the increment of the sequence.

The **RESTART WITH** newvalue clause allows you to set the next value generated by NEXT VALUE FOR seq_name. To achieve this, the current value of the sequence is set to (newvalue - increment) with increment either as specified in the statement, or stored in the metadata of the sequence. The **RESTART** clause (without **WITH**) restarts the sequence with the initial value stored in the metadata of the sequence.

Contrary to Firebird 3.0, since Firebird 4.0 **RESTART WITH newvalue** only restarts the sequence with the specified value, and does not store newvalue as the new initial value of the sequence. A subsequent **ALTER SEQUENCE Restart** will use the initial value specified when the sequence was created, and not the newvalue of this statement. This behaviour is specified in the SQL standard.

It is currently not possible to change the initial value stored in the metadata.

Incorrect use of the **ALTER SEQUENCE** statement (changing the current value of the sequence or generator) is likely to break the logical integrity of data, or result in primary key or unique constraint violations.

**INCREMENT [BY]** allows you to change the sequence increment for the **NEXT VALUE FOR** expression.

Changing the increment value takes effect for all queries that run after the transaction commits. Procedures that are called for the first time after changing the commit, will use the new value if they use NEXT VALUE FOR. Procedures that were already used (and cached in the metadata cache) will continue to use the old increment. You may need to close all connections to the database for the metadata cache to clear, and the new increment to be used. Procedures using **NEXT VALUE FOR** do not need to be recompiled to see the new increment. Procedures using **GEN_ID(gen, expression)** are not affected when the increment is changed.

**Who Can Alter a Sequence?**

The **ALTER SEQUENCE (ALTER GENERATOR)** statement can be executed by:

- Administrators
- The owner of the sequence
- Users with the **ALTER ANY SEQUENCE (ALTER ANY GENERATOR)** privilege
Examples of ALTER SEQUENCE

1. Setting the value of the EMP_NO_GEN sequence so the next value is 145.

   ```sql
   ALTER SEQUENCE EMP_NO_GEN RESTART WITH 145;
   ```

2. Resetting the base value of the sequence EMP_NO_GEN to the initial value stored in the metadata.

   ```sql
   ALTER SEQUENCE EMP_NO_GEN RESTART;
   ```

3. Changing the increment of sequence EMP_NO_GEN to 10.

   ```sql
   ALTER SEQUENCE EMP_NO_GEN INCREMENT BY 10;
   ```

See also

- SET GENERATOR
- CREATE SEQUENCE
- CREATE OR ALTER SEQUENCE
- DROP SEQUENCE
- RECREATE SEQUENCE
- NEXT VALUE FOR
- GEN_ID() function

5.14.3. CREATE OR ALTER SEQUENCE

Creates a sequence if it doesn’t exist, or alters a sequence

Available in

DSQL, ESQL

Syntax

```
CREATE OR ALTER {SEQUENCE | GENERATOR} seq_name
{RESTART | START WITH start_value}
[INCREMENT [BY] increment]
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>start_value</td>
<td>Initial value of the sequence. Default is 1.</td>
</tr>
<tr>
<td>increment</td>
<td>Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0. Default is 1.</td>
</tr>
</tbody>
</table>

If the sequence does not exist, it will be created. An existing sequence will be changed:

- If RESTART is specified, the sequence will restart with the initial value stored in the metadata.
- If the START WITH clause is specified, the sequence is restarted with start_value, but the start_value is not stored. In other words, it behaves as RESTART WITH in ALTER SEQUENCE.
If the INCREMENT [BY] clause is specified, increment is stored as the increment in the metadata, and used for subsequent calls to NEXT VALUE FOR.

**Example of CREATE OR ALTER SEQUENCE**

Create a new or modify an existing sequence EMP_NO_GEN

```sql
CREATE OR ALTER SEQUENCE EMP_NO_GEN
    START WITH 10
    INCREMENT BY 1
```

See also

CREATE SEQUENCE, ALTER SEQUENCE, DROP SEQUENCE, RECREATE SEQUENCE, SET GENERATOR, NEXT VALUE FOR, GEN_ID() function

### 5.14.4. DROP SEQUENCE

Drops a SEQUENCE (GENERATOR)

*Available in*

DSQL, ESQL

**Syntax**

```
DROP {SEQUENCE | GENERATOR} seq_name
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name. The maximum length is 63 characters</td>
</tr>
</tbody>
</table>

The statements DROP SEQUENCE and DROP GENERATOR statements are equivalent: both drop (delete) an existing sequence (generator). Either is valid but DROP SEQUENCE, being defined in the SQL standard, is recommended.

The statements will fail if the sequence (generator) has dependencies.

**Who Can Drop a Sequence?**

The DROP SEQUENCE (DROP GENERATOR) statement can be executed by:

- **Administrators**
- The owner of the sequence
- Users with the DROP ANY SEQUENCE (DROP ANY GENERATOR) privilege

**Example of DROP SEQUENCE**
Dropping the EMP_NO_GEN series:

```
DROP SEQUENCE EMP_NO_GEN;
```

See also

CREATE SEQUENCE, CREATE OR ALTER SEQUENCE, RECREATE SEQUENCE

### 5.14.5. RECREATE SEQUENCE

Drops a sequence if it exists, and creates a sequence (generator)

Available in

DSQL, ESQL

Syntax

```
RECREATE {SEQUENCE | GENERATOR} seq_name
  [START WITH start_value]
  [INCREMENT [BY] increment]
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Sequence (generator) name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>start_value</td>
<td>Initial value of the sequence</td>
</tr>
<tr>
<td>increment</td>
<td>Increment of the sequence (when using NEXT VALUE FOR seq_name); cannot be 0</td>
</tr>
</tbody>
</table>

See CREATE SEQUENCE for the full syntax of CREATE SEQUENCE and descriptions of defining a sequences and its options.

RECREATE SEQUENCE creates or recreates a sequence. If a sequence with this name already exists, the RECREATE SEQUENCE statement will try to drop it and create a new one. Existing dependencies will prevent the statement from executing.

**Example of RECREATE SEQUENCE**

Recreating sequence EMP_NO_GEN

```
RECREATE SEQUENCE EMP_NO_GEN
  START WITH 10
  INCREMENT BY 2;
```

See also

CREATE SEQUENCE, ALTER SEQUENCE, CREATE OR ALTER SEQUENCE, DROP SEQUENCE, SET GENERATOR, NEXT VALUE FOR, GEN_ID() function
5.14.6. SET GENERATOR

Sets the current value of a sequence (generator)

Available in
DSQL, ESQL

Syntax

```
SET GENERATOR seq_name TO new_val
```

Table 67. SET GENERATOR Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>seq_name</td>
<td>Generator (sequence) name</td>
</tr>
<tr>
<td>new_val</td>
<td>New sequence (generator) value. A 64-bit integer from $-2^{63}$ to $2^{63}-1$.</td>
</tr>
</tbody>
</table>

The SET GENERATOR statement sets the current value of a sequence or generator to the specified value.

Although SET GENERATOR is considered outdated, it is retained for backward compatibility. Use of the standards-compliant ALTER SEQUENCE is recommended.

Who Can Use a SET GENERATOR?

The SET GENERATOR statement can be executed by:

- Administrators
- The owner of the sequence (generator)
- Users with the ALTER ANY SEQUENCE (ALTER ANY GENERATOR) privilege

Example of SET GENERATOR

Setting the value of the EMP_NO_GEN sequence to 145:

```
SET GENERATOR EMP_NO_GEN TO 145;
```

Similar effects can be achieved with ALTER SEQUENCE:

```
ALTER SEQUENCE EMP_NO_GEN
RESTART WITH 145 + increment;
```

Here, the value of `increment` is the current increment of the sequence. We need add it as ALTER SEQUENCE calculates the current value to set based on the next value it should produce.
See also

ALTER SEQUENCE, CREATE SEQUENCE, CREATE OR ALTER SEQUENCE, DROP SEQUENCE, NEXT VALUE FOR, GEN_ID() function

5.15. EXCEPTION

This section describes how to create, modify and delete custom exceptions for use in error handlers in PSQL modules.

5.15.1. CREATE EXCEPTION

Creates a custom exception for use in PSQL modules

Available in
DSQL, ESQL

Syntax

```sql
CREATE EXCEPTION exception_name '<message>'

<message> ::= <message-part> [<message-part> ...]

<message-part> ::= 
    <text> 
    | @<slot>

<slot> ::= one of 1..9
```

Table 68. CREATE EXCEPTION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exception_name</td>
<td>Exception name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>message</td>
<td>Default error message. The maximum length is 1,021 characters</td>
</tr>
<tr>
<td>text</td>
<td>Text of any character</td>
</tr>
<tr>
<td>slot</td>
<td>Slot number of a parameter. Numbering starts at 1. Maximum slot number is 9.</td>
</tr>
</tbody>
</table>

The statement CREATE EXCEPTION creates a new exception for use in PSQL modules. If an exception with the same name exists, the statement will raise an error.

The exception name is an identifier, see Identifiers for more information.

The default message is stored in character set NONE, i.e. in characters of any single-byte character set. The text can be overridden in the PSQL code when the exception is thrown.

The error message may contain “parameter slots” that can be filled when raising the exception.

⚠️ If the message contains a parameter slot number that is greater than 9, the second
and subsequent digits will be treated as literal text. For example @10 will be interpreted as slot 1 followed by a literal ‘0’.

Custom exceptions are stored in the system table RDB$EXCEPTIONS.

**Who Can Create an Exception**

The CREATE EXCEPTION statement can be executed by:

- **Administrators**
- Users with the CREATE EXCEPTION privilege

The user executing the CREATE EXCEPTION statement becomes the owner of the exception.

**CREATE EXCEPTION Examples**

*Creating an exception named E_LARGE_VALUE*

```sql
CREATE EXCEPTION E_LARGE_VALUE
 'The value is out of range';
```

*Creating a parameterized exception E_INVALID_VALUE*

```sql
CREATE EXCEPTION E_INVALID_VALUE
 'Invalid value @1 for field @2';
```

**See also**

ALTER EXCEPTION, CREATE OR ALTER EXCEPTION, DROP EXCEPTION, RECREATE EXCEPTION

**5.15.2. ALTER EXCEPTION**

Alters the default message of a custom exception

Available in

DSQL, ESQL

**Syntax**

```sql
ALTER EXCEPTION exception_name '<message>'
```

!! See syntax of CREATE EXCEPTION for further rules !!

**Who Can Alter an Exception**

The ALTER EXCEPTION statement can be executed by:

- **Administrators**
The owner of the exception

Users with the ALTER ANY EXCEPTION privilege

**ALTER EXCEPTION Examples**

*Changing the default message for the exception E_LARGE_VALUE*

```
ALTER EXCEPTION E_LARGE_VALUE
 'The value exceeds the prescribed limit of 32,765 bytes';
```

*See also*

CREATE EXCEPTION, CREATE OR ALTER EXCEPTION, DROP EXCEPTION, RECREATE EXCEPTION

### 5.15.3. CREATE OR ALTER EXCEPTION

Creates a custom exception if it doesn’t exist, or alters a custom exception

*Available in*

DSQL

*Syntax*

```
CREATE OR ALTER EXCEPTION exception_name '<message>'
```

!! See syntax of CREATE EXCEPTION for further rules !!

The statement CREATE OR ALTER EXCEPTION is used to create the specified exception if it does not exist, or to modify the text of the error message returned from it if it exists already. If an existing exception is altered by this statement, any existing dependencies will remain intact.

**CREATE OR ALTER EXCEPTION Example**

*Changing the message for the exception E_LARGE_VALUE*

```
CREATE OR ALTER EXCEPTION E_LARGE_VALUE
 'The value is higher than the permitted range 0 to 32,765';
```

*See also*

CREATE EXCEPTION, ALTER EXCEPTION, RECREATE EXCEPTION

### 5.15.4. DROP EXCEPTION

Drops a custom exception

*Available in*

DSQL, ESQL
Syntax

```
DROP EXCEPTION exception_name
```

Table 69. DROP EXCEPTION Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exception_name</td>
<td>Exception name</td>
</tr>
</tbody>
</table>

The statement DROP EXCEPTION is used to delete an exception. Any dependencies on the exception will cause the statement to fail, and the exception will not be deleted.

**Who Can Drop an Exception**

The DROP EXCEPTION statement can be executed by:

- Administrators
- The owner of the exception
- Users with the DROP ANY EXCEPTION privilege

**DROP EXCEPTION Examples**

Dropping exception E_LARGE_VALUE

```
DROP EXCEPTION E_LARGE_VALUE;
```

See also

CREATE EXCEPTION, RECREATE EXCEPTION

**5.15.5. RECREATE EXCEPTION**

Drops a custom exception if it exists, and creates a custom exception

Available in

DSQL

Syntax

```
RECREATE EXCEPTION exception_name '<message>'
```

!! See syntax of CREATE EXCEPTION for further rules !!

The statement RECREATE EXCEPTION creates a new exception for use in PSQL modules. If an exception with the same name exists already, the RECREATE EXCEPTION statement will try to drop it and create a new one. If there are any dependencies on the existing exception, the attempted deletion fails and RECREATE EXCEPTION is not executed.
RECREATE EXCEPTION Example

Recreating the E_LARGE_VALUE exception

RECREATE EXCEPTION E_LARGE_VALUE
  'The value exceeds its limit';

See also
CREATE EXCEPTION, DROP EXCEPTION, CREATE OR ALTER EXCEPTION

5.16. COLLATION

In SQL, text strings are sortable objects. This means that they obey ordering rules, such as alphabetical order. Comparison operations can be applied to such text strings (for example, “less than” or “greater than”), where the comparison must apply a certain sort order or collation. For example, the expression "'a' < 'b'" means that "'a'" precedes "'b'" in the collation. The expression "'c' > 'b'" means that "'c'" follows "'b'" in the collation. Text strings of more than one character are sorted using sequential character comparisons: first the first characters of the two strings are compared, then the second characters, and so on, until a difference is found between the two strings. This difference defines the sort order.

A COLLATION is the schema object that defines a collation (or sort order).

5.16.1. CREATE COLLATION

Defines a new collation for a character set

Available in
DSQL

Syntax

CREATE COLLATION collname
  FOR charset
  [FROM {basecoll | EXTERNAL ('extname')}]
  [NO PAD | PAD SPACE]
  [CASE [IN]SENSITIVE]
  [ACCENT [IN]SENSITIVE]
  ['<specific-attributes>']

<specific-attributes> ::= <attribute> [; <attribute> ...]

<attribute> ::= attrname=attrvalue

Table 70. CREATE COLLATION Statement Parameters
The CREATE COLLATION statement does not “create” anything, its purpose is to make a collation known to a database. The collation must already be present on the system, typically in a library file, and must be properly registered in a .conf file in the int1 subdirectory of the Firebird installation.

The collation may alternatively be based on one that is already present in the database.

How the Engine Detects the Collation

The optional FROM clause specifies the base collation that is used to derive a new collation. This collation must already be present in the database. If the keyword EXTERNAL is specified, then Firebird will scan the .conf files in $fbroot/int1/, where extname must exactly match the name in the configuration file (case-sensitive).

If no FROM clause is present, Firebird will scan the .conf file(s) in the int1 subdirectory for a collation with the collation name specified in CREATE COLLATION. In other words, omitting the FROM basecoll clause is equivalent to specifying FROM EXTERNAL ("collname").

The — single-quoted — extname is case-sensitive and must correspond exactly with the collation name in the .conf file. The collname, charset and basecoll parameters are case-insensitive unless enclosed in double-quotes.

When creating a collation, you can specify whether trailing spaces are included in the comparison. If the NO PAD clause is specified, trailing spaces are taken into account in the comparison. If the PAD SPACE clause is specified, trailing spaces are ignored in the comparison.

The optional CASE clause allows you to specify whether the comparison is case-sensitive or case-insensitive.

The optional ACCENT clause allows you to specify whether the comparison is accent-sensitive or accent-insensitive (e.g. if ‘é’ and ‘ë’ are considered equal or unequal).

Specific Attributes

The CREATE COLLATION statement can also include specific attributes to configure the collation. The available specific attributes are listed in the table below. Not all specific attributes apply to every collation. If the attribute is not applicable to the collation, but is specified when creating it, it will not cause an error.

Specific attribute names are case-sensitive.

In the table, “1 bpc” indicates that an attribute is valid for collations of character sets using 1 byte.
per character (so-called narrow character sets), and “UNI” for “Unicode collations”.

### Table 71. Specific Collation Attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Values</th>
<th>Valid for</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>DISABLE-COMPRESSIONS</td>
<td>0, 1</td>
<td>1 bpc, UNI</td>
<td>Disables compressions (a.k.a. contractions). Compressions cause certain character sequences to be sorted as atomic units, e.g. Spanish c+h as a single character ch</td>
</tr>
<tr>
<td>DISABLE-EXPANSIONS</td>
<td>0, 1</td>
<td>1 bpc</td>
<td>Disables expansions. Expansions cause certain characters (e.g. ligatures or umlauted vowels) to be treated as character sequences and sorted accordingly</td>
</tr>
<tr>
<td>ICU-VERSION</td>
<td>default or M.m</td>
<td>UNI</td>
<td>Specifies the ICU library version to use. Valid values are the ones defined in the applicable &lt;intl_module&gt; element in intl/fbintl.conf. Format: either the string literal “default” or a major+minor version number like “3.0” (both unquoted).</td>
</tr>
<tr>
<td>LOCALE</td>
<td>xx_YY</td>
<td>UNI</td>
<td>Specifies the collation locale. Requires complete version of ICU libraries. Format: a locale string like “du_NL” (unquoted)</td>
</tr>
<tr>
<td>MULTI-LEVEL</td>
<td>0, 1</td>
<td>1 bpc</td>
<td>Uses more than one ordering level</td>
</tr>
<tr>
<td>NUMERIC-SORT</td>
<td>0, 1</td>
<td>UNI</td>
<td>Treats contiguous groups of decimal digits in the string as atomic units and sorts them numerically. (This is also known as natural sorting)</td>
</tr>
<tr>
<td>SPECIALS-FIRST</td>
<td>0, 1</td>
<td>1 bpc</td>
<td>Orders special characters (spaces, symbols etc.) before alphanumeric characters</td>
</tr>
</tbody>
</table>

If you want to add a new character set with its default collation into your database, declare and run the stored procedure `sp_register_character_set(name, max_bytes_per_character)`, found in `misc/intl.sql` under the Firebird installation directory.

In order for this to work, the character set must be present on the system and registered in a .conf file in the `intl` subdirectory.

**Who Can Create a Collation**

The `CREATE COLLATION` statement can be executed by:
• Administrators
• Users with the CREATE COLLATION privilege

The user executing the CREATE COLLATION statement becomes the owner of the collation.

**Examples using CREATE COLLATION**

1. Creating a collation using the name found in the fbintl.conf file (case-sensitive)

   CREATE COLLATION ISO8859_1_UNICODE FOR ISO8859_1;

2. Creating a collation using a special (user-defined) name (the “external” name must match the name in the fbintl.conf file)

   CREATE COLLATION LAT_UNI
   FOR ISO8859_1
   FROM EXTERNAL ('ISO8859_1_UNICODE');

3. Creating a case-insensitive collation based on one already existing in the database

   CREATE COLLATION ES_ES_NOPAD_CI
   FOR ISO8859_1
   FROM ES_ES
   NO PAD
   CASE INSENSITIVE;

4. Creating a case-insensitive collation based on one already existing in the database with specific attributes

   CREATE COLLATION ES_ES_CI_COMPR
   FOR ISO8859_1
   FROM ES_ES
   CASE INSENSITIVE
   'DISABLE-COMPRESSIONS=0';

5. Creating a case-insensitive collation by the value of numbers (the so-called natural collation)

   CREATE COLLATION nums_coll FOR UTF8
   FROM UNICODE
   CASE INSENSITIVE 'NUMERIC-SORT=1';

   CREATE DOMAIN dm_nums AS varchar(20)
   CHARACTER SET UTF8 COLLATE nums_coll; -- original (manufacturer) numbers
CREATE TABLE wares(id int primary key, articul dm_nums ...);

See also
DROP COLLATION

5.16.2. DROP COLLATION

Drops a collation from the database

Available in
DSQL

Syntax

DROP COLLATION collname

Table 72. DROP COLLATION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>collname</td>
<td>The name of the collation</td>
</tr>
</tbody>
</table>

The DROP COLLATION statement removes the specified collation from the database, if it exists. An error will be raised if the specified collation is not present.

If you want to remove an entire character set with all its collations from the database, declare and execute the stored procedure `sp_unregister_character_set(name)` from the `misc/intl.sql` subdirectory of the Firebird installation.

Who Can Drop a Collation

The DROP COLLATION statement can be executed by:

- Administrators
- The owner of the collation
- Users with the DROP ANY COLLATION privilege

Example using DROP COLLATION

Deleting the ES_ES_NOPAD_CI collation.

DROP COLLATION ES_ES_NOPAD_CI;

See also
CREATE COLLATION
5.17. CHARACTER SET

5.17.1. ALTER CHARACTER SET

Sets the default collation of a character set

Available in
DSQL

Syntax

```
ALTER CHARACTER SET charset
    SET DEFAULT COLLATION collation
```

Table 73. ALTER CHARACTER SET Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>charset</td>
<td>Character set identifier</td>
</tr>
<tr>
<td>collation</td>
<td>The name of the collation</td>
</tr>
</tbody>
</table>

This will affect the future usage of the character set, except for cases where the COLLATE clause is explicitly overridden. In that case, the collation of existing domains, columns and PSQL variables will remain intact after the change to the default collation of the underlying character set.

If you change the default collation for the database character set (the one defined when the database was created), it will change the default collation for the database.

If you change the default collation for the character set that was specified during the connection, string constants will be interpreted according to the new collation value, except in those cases where the character set and/or the collation have been overridden.

Who Can Alter a Character Set

The ALTER CHARACTER SET statement can be executed by:

- Administrators
- Users with the ALTER ANY CHARACTER SET privilege

ALTER CHARACTER SET Example

Setting the default UNICODE_CI_AI collation for the UTF8 encoding

```
ALTER CHARACTER SET UTF8
    SET DEFAULT COLLATION UNICODE_CI_AI;
```
5.18. Comments

Database objects and a database itself may be annotated with comments. It is a convenient mechanism for documenting the development and maintenance of a database. Comments created with `COMMENT ON` will survive a `gbak` backup and restore.

5.18.1. `COMMENT ON`

Adds a comment to a metadata object

Available in

DSQL

Syntax

```
COMMENT ON <object> IS {'sometext' | NULL}
```

```
<object> ::= 
    {DATABASE | SCHEMA} 
  | <basic-type> objectname 
  | USER username [USING PLUGIN pluginname] 
  | COLUMN relationname.fieldname 
  | [{PROCEDURE | FUNCTION}] PARAMETER 
      [packagename.]routinename.paramname 
  | {PROCEDURE | [EXTERNAL] FUNCTION} 
      [package_name.]routinename 
  | [GLOBAL] MAPPING mappingname 
```

```
<basic-type> ::= 
    CHARACTER SET | COLLATION | DOMAIN 
  | EXCEPTION | FILTER | GENERATOR 
  | INDEX | PACKAGE | ROLE 
  | SEQUENCE | TABLE | TRIGGER 
  | VIEW 
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sometext</td>
<td>Comment text</td>
</tr>
<tr>
<td>basic-type</td>
<td>Metadata object type</td>
</tr>
<tr>
<td>objectname</td>
<td>Metadata object name</td>
</tr>
<tr>
<td>username</td>
<td>Username</td>
</tr>
<tr>
<td>pluginname</td>
<td>User manager plugin name</td>
</tr>
<tr>
<td>relationname</td>
<td>Name of table or view</td>
</tr>
<tr>
<td>fieldname</td>
<td>Name of the column</td>
</tr>
<tr>
<td>package_name</td>
<td>Name of the package</td>
</tr>
</tbody>
</table>
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>routinename</td>
<td>Name of stored procedure or function</td>
</tr>
<tr>
<td>paramname</td>
<td>Name of a stored procedure or function parameter</td>
</tr>
<tr>
<td>mappingname</td>
<td>Name of a mapping</td>
</tr>
</tbody>
</table>

The `COMMENT ON` statement adds comments for database objects (metadata). Comments are saved to the `RDB$DESCRIPTION` column of the corresponding system tables. Client applications can view comments from these fields.

1. If you add an empty comment (""), it will be saved as NULL in the database.
2. By default, the `COMMENT ON USER` statement will create comments on users managed by the default user manager (the first plugin listed in the `UserManager` config option). The `USING PLUGIN` can be used to comment on a user managed by a different user manager.
3. Comments on users are not stored for the Legacy_UserManager.
4. Comments on users are stored in the security database.
5. Comments on global mappings are stored in the security database.
6. `SCHEMA` is currently a synonym for `DATABASE`; this may change in a future version, so we recommend to always use `DATABASE`.

Comments on users are visible to that user through the `SEC$USERS` virtual table.

### Who Can Add a Comment

The `COMMENT ON` statement can be executed by:

- **Administrators**
- The owner of the object that is commented on
- Users with the `ALTER ANY` `object_type` privilege, where `object_type` is the type of object commented on (e.g. `PROCEDURE`)

### Examples using `COMMENT ON`

1. Adding a comment for the current database

   ```sql
   COMMENT ON DATABASE IS 'It is a test (''my.fdb'') database';
   ```

2. Adding a comment for the `METALS` table

   ```sql
   COMMENT ON TABLE METALS IS 'Metal directory';
   ```

3. Adding a comment for the `ISALLOY` field in the `METALS` table

   ```sql
   ```
4. Adding a comment for a parameter

```sql
COMMENT ON PARAMETER ADD_EMP_PROJ.EMP_NO IS 'Employee ID';
```

5. Adding a comment for a package, its procedures and functions, and their parameters

```sql
COMMENT ON PACKAGE APP_VAR IS 'Application Variables';

COMMENT ON FUNCTION APP_VAR.GET_DATEBEGIN IS 'Returns the start date of the period';

COMMENT ON PROCEDURE APP_VAR.SET_DATERANGE IS 'Set date range';

COMMENT ON PROCEDURE PARAMETER APP_VAR.SET_DATERANGE.ADATEBEGIN IS 'Start Date';
```
Chapter 6. Data Manipulation (DML)

Statements

DML—data manipulation language—is the subset of SQL that is used by applications and procedural modules to extract and change data. Extraction, for the purpose of reading data, both raw and manipulated, is achieved with the SELECT statement. INSERT is for adding new data and DELETE is for erasing data that is no longer required. UPDATE, MERGE and UPDATE OR INSERT all modify data in various ways.

6.1. SELECT

“Queries” or retrieves data from the database

Global syntax

```sql
[WITH [RECURSIVE] <cte> [, <cte> ...]]
SELECT
  [FIRST <limit-expression>] [SKIP <limit-expression>]
  [[ALL | DISTINCT]] <select-list>
FROM <table-reference> [, <table-reference> ...]
[WHERE <search-condition>]
[GROUP BY <value-expression> [, <value-expression> ...]]
[HAVING <search-condition>]
[WINDOW <window_definition> [, <window_definition> ...]]
[PLAN <plan-expression>]
[UNION [{DISTINCT | ALL}] <query-term>]
[ORDER BY <sort-specification> [, <sort-specification> ...]]
[ROWS <value-expression> [TO <value-expression>]
  [OFFSET <offset-fetch-expression> {ROW | ROWS}]
  [FETCH {FIRST | NEXT}
    {<offset-fetch-expression>} {ROW | ROWS} ONLY]
]
[FOR UPDATE [OF <column-name-list>]]
[WITH LOCK [SKIP LOCKED]]
[OPTIMIZE FOR {FIRST | ALL} ROWS]
[INTO <variable-list>]

<variable-list> ::= <variable> [, <variable> ...]

<variable> ::= varname | ':' varname
```

The above syntax is not the full SELECT syntax. For documentation reasons it is simplified, and we attempt to build out the syntax in later sections. The full SELECT syntax can be found below, in Full SELECT Syntax.

The SELECT statement retrieves data from the database and hands them to the application or the enclosing SQL statement. Data is returned in zero or more rows, each containing one or more
columns or fields. The total of rows returned is the result set of the statement.

The only mandatory parts of the SELECT statement are:

- The SELECT keyword, followed by a select list. This part specifies what you want to retrieve.
- The FROM keyword, followed by a selectable object. This tells the engine where you want to get it from.

In its most basic form, SELECT retrieves a number of columns from a single table or view, like this:

```
select id, name, address
from contacts
```

Or, to retrieve all the columns:

```
select * from sales
```

In practice, a SELECT statement is usually executed with a WHERE clause, which limits the rows returned. The result set may be sorted by an ORDER BY clause, and FIRST … SKIP, OFFSET … FETCH or ROWS may further limit the number of returned rows, and can—for example—be used for pagination.

The column list may contain all kinds of expressions, not only column names, and the source need not be a table or view: it may also be a derived table, a common table expression (CTE) or a selectable stored procedure. Multiple sources may be combined in a JOIN, and multiple result sets may be combined in a UNION.

The following sections discuss the available SELECT subclauses and their usage in detail.

### 6.1.1. FIRST, SKIP

Retrieves a slice of rows from an ordered set

**Syntax**

```
SELECT
  [FIRST <limit-expression>] [SKIP <limit-expression>]
  FROM ...
...
```

<limit-expression> ::=<integer-literal>
  | <query-parameter>
  | (<value-expression>)

Table 75. Arguments for the FIRST and SKIP Clauses
FIRST and SKIP are non-standard syntax

FIRST and SKIP are Firebird-specific clauses. Use the SQL-standard OFFSET, FETCH syntax wherever possible.

FIRST \( m \) limits the output of a query to the first \( m \) rows. SKIP \( n \) will skip the first \( n \) rows of the result set before returning rows.

FIRST and SKIP are both optional. When used together as in “FIRST \( m \) SKIP \( n \)”, the \( n \) topmost rows of the result set are discarded, and the first \( m \) rows of the rest of the set are returned.

Characteristics of FIRST and SKIP

• Any argument to FIRST and SKIP that is not an integer literal or an SQL parameter must be enclosed in parentheses. This implies that a subquery expression must be enclosed in two pairs of parentheses.

• SKIP 0 is allowed but pointless.

• FIRST 0 is also allowed and returns an empty set.

• Negative SKIP and/or FIRST values result in an error.

• If a SKIP lands past the end of the result set, an empty set is returned.

• If the number of rows in the result set (or the remainder left after a SKIP) is less than the value of the \( m \) argument supplied for FIRST, that smaller number of rows is returned. These are valid results, not error conditions.

Examples of FIRST/SKIP

1. The following query will return the first 10 names from the People table:

```sql
select first 10 id, name from People
order by name asc
```

2. The following query will return everything but the first 10 names:

```sql
select skip 10 id, name from People
order by name asc
```

3. And this one returns the last 10 rows. Notice the double parentheses:

```sql
select skip ((select count(*) - 10 from People))
```
4. This query returns rows 81 to 100 of the People table:

```
select first 20 skip 80 id, name from People
order by name asc
```

See also
OFFSET, FETCH, ROWS

6.1.2. The SELECT Columns List

The columns list contains one or more comma-separated value expressions. Each expression provides a value for one output column. Alternatively, * (“star” or “all”) can be used to stand for all the columns of all relations in the FROM clause.

Syntax

```
SELECT [...]
[ALL | DISTINCT] <select-list>
[...]
FROM ...

<select_list> ::= * | <select-sublist> [, <select-sublist> ...]

<select-sublist> ::= table-alias.*
| <value-expression> [[AS] column-alias]

<value-expression> ::= [table-alias.]col_name
| [table-alias.]selectable_SP_outparm
| <literal>
| <context-variable>
| <function-call>
| <single-value-subselect>
| <CASE-construct>
| any other expression returning a single value of a Firebird data type or NULL

<function-call> ::=<normal-function>
| <aggregate-function>
| <window-function>

<normal-function> ::= !! See Built-in Scalar Functions !!
```
Table 76. Arguments for the SELECT Columns List

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table-alias</td>
<td>Name of relation (view, stored procedure, derived table), or its alias</td>
</tr>
<tr>
<td>col_name</td>
<td>Name of a table or view column, or its alias</td>
</tr>
<tr>
<td>selectable_SP_outparm</td>
<td>Declared name of an output parameter of a selectable stored procedure</td>
</tr>
<tr>
<td>literal</td>
<td>A literal</td>
</tr>
<tr>
<td>context-variable</td>
<td>Context variable</td>
</tr>
<tr>
<td>function-call</td>
<td>Scalar, aggregate, or window function expression</td>
</tr>
<tr>
<td>single-value-subselect</td>
<td>A subquery returning one scalar value (singleton)</td>
</tr>
<tr>
<td>CASE-construct</td>
<td>CASE construct setting conditions for a return value</td>
</tr>
</tbody>
</table>

It is always valid to qualify a column name (or “*”) with the name or alias of the table, view or selectable SP to which it belongs, followed by a dot (‘.’). For example, `relationname.columnname`, `relationname.*`, `alias.columnname`, `alias.*`. Qualifying is required if the column name occurs in more than one relation taking part in a join. Qualifying “*” is required if it is not the only item in the column list.

Aliases hide the original relation name: once a table, view or procedure has been aliased, only the alias can be used as its qualifier throughout the query. The relation name itself becomes unavailable.

The column list may optionally be preceded by one of the keywords DISTINCT or ALL:

- **DISTINCT** filters out any duplicate rows. That is, if two or more rows have the same values in every corresponding column, only one of them is included in the result set
- **ALL** is the default: it returns all rows, including duplicates. **ALL** is rarely used; it is allowed for compliance with the SQL standard.

A **COLLATE** clause of a value-expression will not change the appearance of the column as such. However, if the specified collation changes the case or accent sensitivity of the column, it may influence:

- The ordering, if an **ORDER BY** clause is also present, and it involves that column
- Grouping, if the column is part of a **GROUP BY** clause
- The rows retrieved (and hence the total number of rows in the result set), if **DISTINCT** is used
**Examples of SELECT queries with different types of column lists**

A simple SELECT using only column names:

```sql
select cust_id, cust_name, phone
from customers
where city = 'London'
```

A query featuring a concatenation expression and a function call in the columns list:

```sql
select 'Mr./Mrs. ' || lastname, street, zip, upper(city)
from contacts
where date_last_purchase(id) = current_date
```

A query with two subselects:

```sql
select p.fullname,
(select name from classes c where c.id = p.class) as class,
(select name from mentors m where m.id = p.mentor) as mentor
from pupils p
```

The following query accomplishes the same as the previous one using joins instead of subselects:

```sql
select p.fullname,
c.name as class,
m.name as mentor
join classes c on c.id = p.class
from pupils p
join mentors m on m.id = p.mentor
```

This query uses a CASE construct to determine the correct title, e.g. when sending mail to a person:

```sql
select case upper(sex)
    when 'F' then 'Mrs.'
    when 'M' then 'Mr.'
    else ''
end as title,
lastname,
address
from employees
```

Query using a window function, ranks employees by salary.

```sql
SELECT
id,
```
salary, 
name, 
DENSE_RANK() OVER (ORDER BY salary) AS EMP_RANK
FROM employees
ORDER BY salary;

Querying a selectable stored procedure:

select * from interesting_transactions(2010, 3, 'S')
order by amount

Selecting from columns of a derived table. A derived table is a parenthesized SELECT statement whose result set is used in an enclosing query as if it were a regular table or view. The derived table is shown in bold here:

select fieldcount, 
count(relation) as num_tables 
from (select r.rdb$relation_name as relation, 
count(*) as fieldcount 
from rdb$relations r 
join rdb$relation_fields rf 
on rf.rdb$relation_name = r.rdb$relation_name 
group by relation) 
group by fieldcount

Asking the time through a context variable (CURRENT_TIME):

select current_time from rdb$database

For those not familiar with RDB$DATABASE: this is a system table that is present in all Firebird databases and is guaranteed to contain exactly one row. Although it wasn't created for this purpose, it has become standard practice among Firebird programmers to select from this table if you want to select “from nothing”, i.e. if you need data that are not bound to a table or view, but can be derived from the expressions in the output columns alone. Another example is:

select power(12, 2) as twelve_squared, power(12, 3) as twelve_cubed
from rdb$database

Finally, an example where you select some meaningful information from RDB$DATABASE itself:

select rdb$character_set_name from rdb$database

As you may have guessed, this will give you the default character set of the database.
6.1.3. The **FROM** clause

The **FROM** clause specifies the source(s) from which the data are to be retrieved. In its simplest form, this is a single table or view. However, the source can also be a selectable stored procedure, a derived table, or a common table expression. Multiple sources can be combined using various types of joins.

This section focuses on single-source selects. **Joins** are discussed in a following section.

**Syntax**

```
SELECT ...
    FROM <table-reference> [, <table-reference> ...]
    [ ... ]

<table-reference> ::= <table-primary> | <joined-table>

<table-primary> ::=<table-or-query-name> [[AS] correlation-name]
    | [LATERAL] <derived-table> [<correlation-or-recognition>]
    | <parenthesized-joined-table>

<table-or-query-name> ::= 
    table-name
    | query-name
    | [package-name.]procedure-name [(<procedure-args>)]

<procedure-args> ::= <value-expression [, <value-expression> ...]}

<derived-table> ::= (query-expression)

<correlation-or-recognition> ::= 
    [AS] correlation-name [(<column-name-list>)]

<column-name-list> ::= column-name [, column-name ...]
```

**Table 77. Arguments for the FROM Clause**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table-name</td>
<td>Name of a table or view</td>
</tr>
<tr>
<td>query-name</td>
<td>Name of a CTE</td>
</tr>
<tr>
<td>package-name</td>
<td>Name of a package</td>
</tr>
<tr>
<td>procedure-name</td>
<td>Name of a selectable stored procedure</td>
</tr>
<tr>
<td>procedure-args</td>
<td>Selectable stored procedure arguments</td>
</tr>
</tbody>
</table>
### Argument Description

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>derived-table</td>
<td>Derived table query expression</td>
</tr>
<tr>
<td>correlation-name</td>
<td>The alias of a data source (table, view, procedure, CTE, derived table)</td>
</tr>
<tr>
<td>column-name</td>
<td>Name or alias for a column in a relation, CTE or derived table</td>
</tr>
</tbody>
</table>

## Selecting FROM a table or view

When selecting from a single table or view, the `FROM` clause requires nothing more than the name. An alias may be useful or even necessary if there are subqueries that refer to the main select statement (as they often do — subqueries like this are called *correlated subqueries*).

### Examples

```
select id, name, sex, age from actors
where state = 'Ohio'
```

```
select * from birds
where type = 'flightless'
order by family, genus, species
```

```
select firstname,
   middlename,
   lastname,
   date_of_birth,
   (select name from schools s where p.school = s.id) schoolname
from pupils p
where year_started = '2012'
order by schoolname, date_of_birth
```

### Never mix column names with column aliases!

If you specify an alias for a table or a view, you must always use this alias in place of the table name whenever you query the columns of the relation (and wherever else you make a reference to columns, such as `ORDER BY`, `GROUP BY` and `WHERE` clauses).

**Correct use:**

```
SELECT PEARS
FROM FRUIT;
```

```
SELECT FRUIT.PEARS
FROM FRUIT;
```

```
SELECT PEARS
```
FROM FRUIT F;
SELECT F.PEARS
FROM FRUIT F;

Incorrect use:
SELECT FRUIT.PEARS
FROM FRUIT F;

Selecting FROM a stored procedure

A selectable stored procedure is a procedure that:

• contains at least one output parameter, and
• utilizes the SUSPEND keyword so the caller can fetch the output rows one by one, like selecting from a table or view.

The output parameters of a selectable stored procedure correspond to the columns of a regular table.

Selecting from a stored procedure without input parameters is like selecting from a table or view:

select * from suspicious_transactions
where assignee = 'John'

Any required input parameters must be specified after the procedure name, enclosed in parentheses:

select name, az, alt from visible_stars('Brugge', current_date, '22:30')
where alt >= 20
order by az, alt

Values for optional parameters (that is, parameters for which default values have been defined) may be omitted or provided. However, if you provide them only partly, the parameters you omit must all be at the tail end.

Supposing that the procedure visible_stars from the previous example has two optional parameters: min_magn numeric(3,1) and spectral_class varchar(12), the following queries are all valid:

select name, az, alt
from visible_stars('Brugge', current_date, '22:30');

select name, az, alt
from visible_stars('Brugge', current_date, '22:30', 4.0);

select name, az, alt
from visible_stars('Brugge', current_date, '22:30', 4.0, 'G');

But this one isn’t, because there’s a “hole” in the parameter list:

select name, az, alt
from visible_stars('Brugge', current_date, '22:30', 'G');

An alias for a selectable stored procedure is specified after the parameter list:

select number,
    (select name from contestants c where c.number = gw.number)
from get_winners('#34517', 'AMS') gw

If you refer to an output parameter (“column”) by qualifying it with the full procedure name, the
procedure alias should be omitted:

select number,
    (select name from contestants c where c.number = get_winners.number)
from get_winners('#34517', 'AMS')

See also

Stored Procedures, CREATE  PROCEDURE

Selecting FROM a derived table

A derived table is a valid SELECT statement enclosed in parentheses, optionally followed by a table
alias and/or column aliases. The result set of the statement acts as a virtual table which the
enclosing statement can query.

Syntax

(<query-expression>) [<correlation-or-recognition>]

<correlation-or-recognition> ::=  
    [AS] correlation-name [(<column-name-list>)]

<column-name-list> ::=  column-name [, column-name ...]

The SQL standard requires the <correlation-or-recognition>, and not providing one
makes it hard to reference the derived table or its columns. For maximum
compatibility and portability, we recommend always specifying an alias (correlation-name).

The result set returned by this “SELECT … FROM (SELECT FROM …)” style of statement is a virtual table that can be queried within the enclosing statement, as if it were a regular table or view.

**LATERAL Derived Tables**

The keyword LATERAL marks a table as a lateral derived table. Lateral derived tables can reference tables (including other derived tables) that occur earlier in the FROM clause. See [Joins with LATERAL Derived Tables](#) for more information.

**Example using a derived table**

The derived table in the query below returns the list of table names in the database, and the number of columns in each table. A “drill-down” query on the derived table returns the counts of fields and the counts of tables having each field count:

```sql
SELECT
    FIELD_COUNT,
    COUNT(RELATION) AS NUM_TABLES
FROM (SELECT
    R.RDB$RELATION_NAME RELATION,
    COUNT(*) AS FIELD_COUNT
FROM RDB$RELATIONS R
JOIN RDB$RELATION_FIELDS RF
ON RF.RDB$RELATION_NAME = R.RDB$RELATION_NAME
GROUP BY RELATION)
GROUP BY FIELD_COUNT
```

A trivial example demonstrating how the alias of a derived table and the list of column aliases (both optional) can be used:

```sql
SELECT
    DBINFO.DESCR, DBINFO.DEF_CHARSET
FROM (SELECT *
    FROM RDB$DATABASE) DBINFO
(DESCR, REL_ID, SEC_CLASS, DEF_CHARSET)
```

**More about Derived Tables**

Derived tables can

- be nested
- be unions, and can be used in unions
- contain aggregate functions, subqueries and joins
- be used in aggregate functions, subqueries and joins
be calls to selectable stored procedures or queries to them

- have WHERE, ORDER BY and GROUP BY clauses, FIRST/SKIP or ROWS directives, et al.

Furthermore,

- Each column in a derived table must have a name. If it does not have a name, such as when it is a constant or a run-time expression, it should be given an alias, either in the regular way or by including it in the list of column aliases in the derived table’s specification.
  
  ◦ The list of column aliases is optional but, if it exists, it must contain an alias for every column in the derived table

- The optimizer can process derived tables very effectively. However, if a derived table is included in an inner join and contains a subquery, the optimizer will be unable to use any other join order.

A more useful example

Suppose we have a table COEFFS which contains the coefficients of a number of quadratic equations we have to solve. It has been defined like this:

```sql
create table coeffs (
    a double precision not null,
    b double precision not null,
    c double precision not null,
    constraint chk_a_not_zero check (a <> 0)
)
```

Depending on the values of a, b and c, each equation may have zero, one or two solutions. It is possible to find these solutions with a single-level query on table COEFFS, but the code will look messy and several values (like the discriminant) will have to be calculated multiple times per row. A derived table can help keep things clean here:

```sql
select
    iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
    iif (D > 0, (-b + sqrt(D)) / denom, null) sol_2
from
    (select b, b*b - 4*a*c, 2*a from coeffs) (b, D, denom)
```

If we want to show the coefficients next to the solutions (which may not be a bad idea), we can alter the query like this:

```sql
select
    a, b, c,
    iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
    iif (D > 0, (-b + sqrt(D)) / denom, null) sol_2
from
    (select b, b*b - 4*a*c, 2*a from coeffs) (b, D, denom)
```
(select a, b, c, \(b^2 - 4ac\) as D, \(2a\) as denom
from coeffs)

Notice that whereas the first query used a column aliases list for the derived table, the second adds aliases internally where needed. Both methods work, as long as every column is guaranteed to have a name.

All columns in the derived table will be evaluated as many times as they are specified in the main query. This is important, as it can lead to unexpected results when using non-deterministic functions. The following shows an example of this.

```
SELECT
    UUID_TO_CHAR(X) AS C1,
    UUID_TO_CHAR(X) AS C2,
    UUID_TO_CHAR(X) AS C3
FROM (SELECT GEN_UUID() AS X
      FROM RDB$DATABASE) T;
```

The result if this query produces three different values:

```
C1  80AAECE6-65CD-4C2F-90AB-5D548C3C7279
C2  C1214CD3-423C-406D-B5BD-95BF432ED3E3
C3  EB176C10-F754-4689-8B84-64B666381154
```

To ensure a single result of the `GEN_UUID` function, you can use the following method:

```
SELECT
    UUID_TO_CHAR(X) AS C1,
    UUID_TO_CHAR(X) AS C2,
    UUID_TO_CHAR(X) AS C3
FROM (SELECT GEN_UUID() AS X
      FROM RDB$DATABASE
      UNION ALL
      SELECT NULL FROM RDB$DATABASE WHERE 1 = 0) T;
```

This query produces a single result for all three columns:

```
C1  80AAECE6-65CD-4C2F-90AB-5D548C3C7279
C2  80AAECE6-65CD-4C2F-90AB-5D548C3C7279
C3  80AAECE6-65CD-4C2F-90AB-5D548C3C7279
```

An alternative solution is to wrap the `GEN_UUID` query in a subquery:

```
SELECT
    UUID_TO_CHAR(X) AS C1,
    UUID_TO_CHAR(X) AS C2,
    UUID_TO_CHAR(X) AS C3
FROM (SELECT GEN_UUID() AS X
      FROM RDB$DATABASE)
```
This is an artifact of the current implementation. This behaviour may change in a future Firebird version.

**Selecting FROM a Common Table Expression (CTE)**

A common table expression — or **CTE** — is a more complex variant of the derived table, but it is also more powerful. A preamble, starting with the keyword `WITH`, defines one or more named **CTE**s, each with an optional column aliases list. The main query, which follows the preamble, can then access these **CTE**s as if they were regular tables or views. The **CTE**s go out of scope once the main query has run to completion.

For a full discussion of **CTE**s, please refer to the section **Common Table Expressions** ("WITH … AS … SELECT").

The following is a rewrite of our derived table example as a **CTE**:

```sql
with vars (b, D, denom) as (  
    select b, b*b - 4*a*c, 2*a from coeffs
  )
select
  iif (D >= 0, (-b - sqrt(D)) / denom, null) sol_1,
  iif (D > 0, (-b + sqrt(D)) / denom, null) sol_2
from vars
```

Except for the fact that the calculations that have to be made first are now at the beginning, this isn't a great improvement over the derived table version. However, we can now also eliminate the double calculation of `sqrt(D)` for every row:

```sql
with vars (b, D, denom) as (  
    select b, b*b - 4*a*c, 2*a from coeffs
  ),
vars2 (b, D, denom, sqrtD) as (  
    select b, D, denom, iif (D >= 0, sqrt(D), null) from vars
  )
select
  iif (D >= 0, (-b - sqrtD) / denom, null) sol_1,
  iif (D > 0, (-b + sqrtD) / denom, null) sol_2
from vars2
```

The code is a little more complicated now, but it might execute more efficiently (depending on what
takes more time: executing the \texttt{SQRT} function or passing the values of \( b \), \( D \) and \( \text{denom} \) through an extra \textit{CTE}). Incidentally, we could have done the same with derived tables, but that would involve nesting.

All columns in the \textit{CTE} will be evaluated as many times as they are specified in the main query. This is important, as it can lead to unexpected results when using non-deterministic functions. The following shows an example of this.

```sql
WITH T (X) AS (
    SELECT GEN_UUID()
    FROM RDB$DATABASE
) SELECT
    UUID_TO_CHAR(X) as c1,
    UUID_TO_CHAR(X) as c2,
    UUID_TO_CHAR(X) as c3
FROM T;
```

The result if this query produces three different values:

<table>
<thead>
<tr>
<th>C1</th>
<th>80AAE Ced-65CD-4C2F-90AB-5D54BC3C7279</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>C1214CD3-423C-406D-B5BD-95BF432ED3E3</td>
</tr>
<tr>
<td>C3</td>
<td>EB176C10-F754-4689-88B4-64B666B1154</td>
</tr>
</tbody>
</table>

To ensure a single result of the \texttt{GENUUID} function, you can use the following method:

```sql
WITH T (X) AS (
    SELECT GEN_UUID()
    FROM RDB$DATABASE
    UNION ALL
    SELECT NULL FROM RDB$DATABASE WHERE 1 = 0
) SELECT
    UUID_TO_CHAR(X) as c1,
    UUID_TO_CHAR(X) as c2,
    UUID_TO_CHAR(X) as c3
FROM T;
```

This query produces a single result for all three columns:

<table>
<thead>
<tr>
<th>C1</th>
<th>80AAE Ced-65CD-4C2F-90AB-5D54BC3C7279</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>80AAE Ced-65CD-4C2F-90AB-5D54BC3C7279</td>
</tr>
<tr>
<td>C3</td>
<td>80AAE Ced-65CD-4C2F-90AB-5D54BC3C7279</td>
</tr>
</tbody>
</table>

An alternative solution is to wrap the \texttt{GENUUID} query in a subquery:
WITH T (X) AS (  
    SELECT (SELECT GEN_UUID() FROM RDB$DATABASE)  
    FROM RDB$DATABASE  
    SELECT  
        UUID_TO_CHAR(X) as c1,  
        UUID_TO_CHAR(X) as c2,  
        UUID_TO_CHAR(X) as c3  
    FROM T;  

This is an artifact of the current implementation. This behaviour may change in a future Firebird version.

See also

Common Table Expressions ("WITH ... AS ... SELECT").

6.1.4. Joins

Joins combine data from two sources into a single set. This is done on a row-by-row basis and usually involves checking a join condition to determine which rows should be merged and appear in the resulting dataset. There are several types (INNER, OUTER) and classes (qualified, natural, etc.) of joins, each with its own syntax and rules.

Since joins can be chained, the datasets involved in a join may themselves be joined sets.

Syntax

```sql
SELECT  
...  
FROM <table-reference> [, <table-reference> ...]  
[...]

<table-reference> ::= <table-primary> | <joined-table>
<table-primary> ::=  
    <table-or-query-name> [AS] correlation-name  
| [LATERAL] <derived-table> [<correlation-or-recognition>]  
| <parenthesized-joined-table>
<table-or-query-name> ::=  
    table-name  
| query-name  
| [package-name.]procedure-name [[<procedure-args>]]

<procedure-args> ::= <value-expression [, <value-expression> ...]
<correlation-or-recognition> ::=  
    [AS] correlation-name [[<column-name-list>]]
<column-name-list> ::= column-name [, column-name ...]
```

267
<derived-table> ::= (query-expression)

(parenthesized-joined-table) ::= 
  (parenthesized-joined-table) 
  | (joined-table)

joined-table ::= 
  cross-join 
  | natural-join 
  | qualified-join

cross-join
  <table-reference> CROSS JOIN <table-primary>

natural-join ::= 
  <table-reference> NATURAL [join-type] JOIN <table-primary>

join-type ::= INNER | { LEFT | RIGHT | FULL } [OUTER]

qualified-join ::= 
  <table-reference> [join-type] JOIN <table-primary> 
  { ON <search-condition> 
   | USING (<column-name-list>) }

Table 78. Arguments for JOIN Clauses

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table-name</td>
<td>Name of a table or view</td>
</tr>
<tr>
<td>query-name</td>
<td>Name of a CTE</td>
</tr>
<tr>
<td>package-name</td>
<td>Name of a package</td>
</tr>
<tr>
<td>procedure-name</td>
<td>Name of a selectable stored procedure</td>
</tr>
<tr>
<td>procedure-args</td>
<td>Selectable stored procedure input parameter(s)</td>
</tr>
<tr>
<td>derived-table</td>
<td>Derived table query expression</td>
</tr>
<tr>
<td>correlation-name</td>
<td>The alias of a data source (table, view, procedure, CTE, derived table)</td>
</tr>
<tr>
<td>column-name</td>
<td>Name or alias for a column in a relation, CTE or derived table</td>
</tr>
<tr>
<td>search-condition</td>
<td>Join condition (criterion)</td>
</tr>
<tr>
<td>column-name-list</td>
<td>List of aliases of the columns of a derived table, or the list of columns used for an equi-join</td>
</tr>
</tbody>
</table>

Inner vs. Outer Joins

A join combines data rows from two sets (usually referred to as the left set and the right set). By default, only rows that meet the join condition (i.e. that match at least one row in the other set when the join condition is applied) make it into the result set. This default type of join is called an inner join. Suppose we have the following two tables:
If we join these tables like this:

```sql
select *
from A
join B on A.id = B.code;
```

then the result set will be:

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
<tr>
<td>235</td>
<td>Silence</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The first row of $A$ has been joined with the second row of $B$ because together they met the condition “$A.id = B.code$”. The other rows from the source tables have no match in the opposite set and are therefore not included in the join. Remember, this is an **INNER** join. We can make that fact explicit by writing:

```sql
select *
from A
inner join B on A.id = B.code;
```

However, since **INNER** is the default, it is usually omitted.

It is perfectly possible that a row in the left set matches several rows from the right set or vice versa. In that case, all those combinations are included, and we can get results like:

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>-1.0</td>
</tr>
<tr>
<td>-23</td>
<td>Don't know</td>
<td>-23</td>
<td>56.7735</td>
</tr>
<tr>
<td>-23</td>
<td>Still don't know</td>
<td>-23</td>
<td>56.7735</td>
</tr>
<tr>
<td>-23</td>
<td>I give up</td>
<td>-23</td>
<td>56.7735</td>
</tr>
</tbody>
</table>
Sometimes we want (or need) all the rows of one or both of the sources to appear in the joined set, even if they don’t match a record in the other source. This is where outer joins come in. A LEFT outer join includes all the records from the left set, but only matching records from the right set. In a RIGHT outer join it’s the other way around. A FULL outer joins include all the records from both sets. In all outer joins, the “holes” (the places where an included source record doesn’t have a match in the other set) are filled up with NULLs.

To make an outer join, you must specify LEFT, RIGHT or FULL, optionally followed by the keyword OUTER.

Below are the results of the various outer joins when applied to our original tables A and B:

```sql
select *
from A
left outer join B on A.id = B.code;
```

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
<tr>
<td>235</td>
<td>Silence</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
</tr>
</tbody>
</table>

```sql
select *
from A
right outer join B on A.id = B.code
```

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>-23</td>
<td>56.7735</td>
</tr>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
</tbody>
</table>

```sql
select *
from A
full outer join B on A.id = B.code
```

<table>
<thead>
<tr>
<th>ID</th>
<th>S</th>
<th>CODE</th>
<th>X</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>-23</td>
<td>56.7735</td>
</tr>
<tr>
<td>87</td>
<td>Just some text</td>
<td>87</td>
<td>416.0</td>
</tr>
<tr>
<td>235</td>
<td>Silence</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
</tr>
</tbody>
</table>

**Qualified joins**

Qualified joins specify conditions for the combining of rows. This happens either explicitly in an ON clause or implicitly in a USING clause.
Syntax

<qualified-join> ::= 
  <table-reference> [<join-type>] JOIN <table-primary>
  { ON <search-condition>
    | USING (<column-name-list>) }

<join-type> ::= INNER | {LEFT | RIGHT | FULL} [OUTER]

Explicit-condition joins

Most qualified joins have an ON clause, with an explicit condition that can be any valid Boolean expression, but usually involves a comparison between the two sources involved.

Often, the condition is an equality test (or a number of ANDed equality tests) using the “=” operator. Joins like these are called equi-joins. (The examples in the section on inner and outer joins were all equi-joins.)

Examples of joins with an explicit condition:

/* Select all Detroit customers who made a purchase
   in 2013, along with the purchase details: */
select * from customers c
join sales s on s.cust_id = c.id
where c.city = 'Detroit' and s.year = 2013;

/* Same as above, but include non-buying customers: */
select * from customers c
  left join sales s on s.cust_id = c.id
  where c.city = 'Detroit' and s.year = 2013;

/* For each man, select the women who are taller than he.
   Men for whom no such woman exists are not included. */
select m.fullname as man, f.fullname as woman
from males m
join females f on f.height > m.height;

/* Select all pupils with their class and mentor.
   Pupils without a mentor are also included.
   Pupils without a class are not included. */
select p.firstname, p.middlename, p.lastname,
    c.name, m.name
from pupils p
join classes c on c.id = p.class
  left join mentors m on m.id = p.mentor;
Equi-joins often compare columns that have the same name in both tables. If this is the case, we can also use the second type of qualified join: the **named columns join**.  

Named columns joins are not supported in Dialect 1 databases.

Named columns joins have a **USING** clause which states only the column names. So instead of this:

```sql
select * from flotsam f
join jetsam j
on f.sea = j.sea
and f.ship = j.ship;
```

we can also write:

```sql
select * from flotsam
join jetsam using (sea, ship)
```

which is considerably shorter. The result set is a little different though—at least when using “SELECT *”:

- The explicit-condition join — with the **ON** clause — will contain each of the columns **SEA** and **SHIP** twice: once from table **FLOTSAM**, and once from table **JETSAM**. Obviously, they will have the same values.
- The named columns join — with the **USING** clause — will contain these columns only once.

If you want all the columns in the result set of the named columns join, set up your query like this:

```sql
select f.*, j.*
from flotsam f
join jetsam j using (sea, ship);
```

This will give you the same result set as the explicit-condition join.

For an **OUTER** named columns join, there’s an additional twist when using “SELECT *” or an unqualified column name from the **USING** list:

If a row from one source set doesn’t have a match in the other but must still be included because of the **LEFT**, **RIGHT** or **FULL** directive, the merged column in the joined set gets the non-NULL value. That is fair enough, but now you can’t tell whether this value came from the left set, the right set, or both. This can be especially deceiving when the value came from the right hand set, because “*” always shows combined columns in the left hand part — even in the case of a **RIGHT** join.

Whether this is a problem or not depends on the situation. If it is, use the “a.*, b.*” approach shown above, with a and b the names or aliases of the two sources. Or better yet, avoid “*” altogether in your serious queries and qualify all column names in joined sets. This has the
additional benefit that it forces you to think about which data you want to retrieve and where from.

It is your responsibility to make sure the column names in the USING list are of compatible types between the two sources. If the types are compatible but not equal, the engine converts them to the type with the broadest range of values before comparing the values. This will also be the data type of the merged column that shows up in the result set if “SELECT *” or the unqualified column name is used. Qualified columns on the other hand will always retain their original data type.

If, when joining by named columns, you are using a join column in the WHERE clause, always use the qualified column name, otherwise an index on this column will not be used.

```
SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE x = 0;
-- PLAN JOIN (A NATURAL, B INDEX (RDB$2))
```

However:

```
SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE a.x = 0;
-- PLAN JOIN (A INDEX (RDB$1), B INDEX (RDB$2))

SELECT 1 FROM t1 a JOIN t2 b USING (x) WHERE b.x = 0;
-- PLAN JOIN (A INDEX (RDB$1), B INDEX (RDB$2))
```

The fact is, the unspecified column in this case is implicitly replaced by `COALESCE(a.x, b.x)`. This trick is used to disambiguate column names, but it also interferes with the use of the index.

**Natural joins**

Taking the idea of the named columns join a step further, a natural join performs an automatic equi-join on all the columns that have the same name in the left and right table. The data types of these columns must be compatible.

Natural joins are not supported in Dialect 1 databases.

**Syntax**

```
<natural-join> ::= 
    <table-reference> NATURAL [<join-type>] JOIN <table-primary>

<join-type> ::= INNER | {LEFT | RIGHT | FULL} [OUTER]
```

Given these two tables:

```
create table TA ( 
```
A natural join on TA and TB would involve the columns a and ins_date, and the following two statements would have the same effect:

```sql
select * from TA
natural join TB;
```

```sql
select * from TA
join TB using (a, ins_date);
```

Like all joins, natural joins are inner joins by default, but you can turn them into outer joins by specifying LEFT, RIGHT or FULL before the JOIN keyword.

If there are no columns with the same name in the two source relations, a CROSS JOIN is performed. We'll get to this type of join next.

**Cross joins**

A cross join produces the full set product — or Cartesian product — of the two data sources. This means that it successfully matches every row in the left source to every row in the right source.

**Syntax**

```
FROM <table-reference> [, <table-reference> ...]
<cross-join>
<table-reference> CROSS JOIN <table-primary>
```

Use of the comma syntax is discouraged, and we recommend using the explicit join syntax.

Cross-joining two sets is equivalent to joining them on a tautology (a condition that is always true). The following two statements have the same effect:

```sql
select * from TA
```
Cross joins are inner joins, because they only include matching records — it just so happens that every record matches! An outer cross join, if it existed, wouldn't add anything to the result, because what outer joins add are non-matching records, and these don't exist in cross joins.

Cross joins are seldom useful, except if you want to list all the possible combinations of two or more variables. Suppose you are selling a product that comes in different sizes, different colors and different materials. If these variables are each listed in a table of their own, this query would return all the combinations:

```sql
SELECT m.name, s.size, c.name
FROM materials m
  CROSS JOIN sizes s
  CROSS JOIN colors c;
```

**Implicit Joins**

In the SQL:89 standard, the tables involved in a join were specified as a comma-delimited list in the `FROM` clause (in other words, a cross join). The join conditions were then specified in the `WHERE` clause among other search terms. This type of join is called an implicit join.

An example of an implicit join:

```sql
/*
 * A sample of all Detroit customers who
 * made a purchase.
 */
SELECT *
FROM customers c, sales s
WHERE s.cust_id = c.id AND c.city = 'Detroit'
```

**Mixing Explicit and Implicit Joins**

Mixing explicit and implicit joins is not recommend, but is allowed. However, some types of mixing are not supported by Firebird.

For example, the following query will raise the error “Column does not belong to referenced table”

```sql
SELECT *
FROM TA, TB
JOIN TC ON TA.COL1 = TC.COL1
```

`Chapter 6. Data Manipulation (DML) Statements`
WHERE TA.COL2 = TB.COL2

That is because the explicit join cannot see the TA table. However, the next query will complete without error, since the restriction is not violated.

```
SELECT *
FROM TA, TB
JOIN TC ON TB.COL1 = TC.COL1
WHERE TA.COL2 = TB.COL2
```

### A Note on Equality

This note about equality and inequality operators applies everywhere in Firebird's SQL language, not only in `JOIN` conditions.

The `"="` operator, which is explicitly used in many conditional joins and implicitly in named column joins and natural joins, only matches values to values. According to the SQL standard, `NULL` is not a value and hence two `NULL`s are neither equal nor unequal to one another. If you need `NULL`s to match each other in a join, use the `IS NOT DISTINCT FROM` operator. This operator returns true if the operands have the same value or if they are both `NULL`.

```
select *
from A join B
on A.id is not distinct from B.code;
```

Likewise, when you want to join on inequality, use `IS DISTINCT FROM`, not `"<>"`, if you want `NULL` to be considered different from any value and two `NULL`s considered equal:

```
select *
from A join B
on A.id is distinct from B.code;
```

### Ambiguous field names in joins

Firebird rejects unqualified field names in a query if these field names exist in more than one dataset involved in a join. This is even true for inner equi-joins where the field name figures in the `ON` clause like this:

```
select a, b, c
from TA
join TB on TA.a = TB.a;
```

There is one exception to this rule: with named columns joins and natural joins, the unqualified field name of a column taking part in the matching process may be used legally and refers to the
merged column of the same name. For named columns joins, these are the columns listed in the USING clause. For natural joins, they are the columns that have the same name in both relations. But please notice again that, especially in outer joins, plain colname isn’t always the same as left.colname or right.colname. Types may differ, and one of the qualified columns may be NULL while the other isn’t. In that case, the value in the merged, unqualified column may mask the fact that one of the source values is absent.

**Joins with LATERAL Derived Tables**

A derived table defined with the LATERAL keyword is called a lateral derived table. If a derived table is defined as lateral, then it is allowed to refer to other tables in the same FROM clause, but only those declared before it in the FROM clause.

**Lateral Derived Table Examples**

```sql
/* select customers with their last order date and number */
select c.name, ox.order_date as last_order, ox.number
from customer c
left join LATERAL (  
    select first 1 o.order_date, o.number
    from orders o
    where o.id_customer = c.id
    order by o.ORDER_DATE desc
) as ox on true
--
select dt.population, dt.city_name, c.country_name
from (select distinct country_name from cities) AS c
    cross join LATERAL (  
    select first 1 city_name, population
    from cities
    where cities.country_name = c.country_name
    order by population desc
    ) AS dt;
--
select salespeople.name,
    max_sale.amount,
    customer_of_max_sale.customer_name
from salespeople,
    LATERAL ( select max(amount) as amount
                                from all_sales
                                where all_sales.salesperson_id = salespeople.id
    ) as max_sale,
    LATERAL ( select customer_name
                                from all_sales
                                where all_sales.salesperson_id = salespeople.id
                                and all_sales.amount = max_sale.amount
    ) as customer_of_max_sale;
```

277
6.1.5. The WHERE clause

The WHERE clause serves to limit the rows returned to the ones that the caller is interested in. The condition following the keyword WHERE can be as simple as a check like “AMOUNT = 3” or it can be a multilayered, convoluted expression containing subselects, predicates, function calls, mathematical and logical operators, context variables and more.

The condition in the WHERE clause is often called the search condition, the search expression or simply the search.

In DSQL and ESQL, the search condition may contain parameters. This is useful if a query has to be repeated a number of times with different input values. In the SQL string as it is passed to the server, question marks are used as placeholders for the parameters. These question marks are called positional parameters because they can only be told apart by their position in the string. Connectivity libraries often support named parameters of the form :id, :amount, :a etc. These are more user-friendly; the library takes care of translating the named parameters to positional parameters before passing the statement to the server.

The search condition may also contain local (PSQL) or host (ESQL) variable names, preceded by a colon.

Syntax

```
SELECT ...  
  FROM ...  
  [...]  
  WHERE <search-condition>  
  [...]  
```

Table 79. Argument of WHERE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>search-condition</td>
<td>A Boolean expression returning TRUE, FALSE or UNKNOWN (NULL)</td>
</tr>
</tbody>
</table>

Only those rows for which the search condition evaluates to TRUE are included in the result set. Be careful with possible NULL outcomes: if you negate a NULL expression with NOT, the result will still be NULL and the row will not pass. This is demonstrated in one of the examples below.

Examples

```sql
select genus, species from mammals  
  where family = 'Felidae'  
  order by genus;
```

```sql
select * from persons  
  where birthyear in (1880, 1881)  
    or birthyear between 1891 and 1898;
```
The following example shows what can happen if the search condition evaluates to `NULL`.

Suppose you have a table listing children’s names and the number of marbles they possess. At a certain moment, the table contains this data:

<table>
<thead>
<tr>
<th>CHILD</th>
<th>MARBLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anita</td>
<td>23</td>
</tr>
<tr>
<td>Bob E.</td>
<td>12</td>
</tr>
<tr>
<td>Chris</td>
<td>&lt;null&gt;</td>
</tr>
<tr>
<td>Deirdre</td>
<td>1</td>
</tr>
<tr>
<td>Eve</td>
<td>17</td>
</tr>
<tr>
<td>Fritz</td>
<td>0</td>
</tr>
<tr>
<td>Gerry</td>
<td>21</td>
</tr>
<tr>
<td>Hadassah</td>
<td>&lt;null&gt;</td>
</tr>
<tr>
<td>Isaac</td>
<td>6</td>
</tr>
</tbody>
</table>
First, please notice the difference between NULL and 0: Fritz is known to have no marbles at all, Chris’s and Hadassah’s marble counts are unknown.

Now, if you issue this SQL statement:

```sql
select list(child) from marbletable where marbles > 10;
```

you will get the names Anita, Bob E., Eve and Gerry. These children all have more than 10 marbles.

If you negate the expression:

```sql
select list(child) from marbletable where not marbles > 10
```

it’s the turn of Deirdre, Fritz and Isaac to fill the list. Chris and Hadassah are not included, because they aren’t known to have ten or fewer marbles. Should you change that last query to:

```sql
select list(child) from marbletable where marbles <= 10;
```

the result will still be the same, because the expression NULL <= 10 yields UNKNOWN. This is not the same as TRUE, so Chris and Hadassah are not listed. If you want them listed with the “poor” children, change the query to:

```sql
select list(child) from marbletable
where marbles <= 10 or marbles is null;
```

Now the search condition becomes true for Chris and Hadassah, because “marbles is null” obviously returns TRUE in their case. In fact, the search condition cannot be NULL for anybody now.

Lastly, two examples of SELECT queries with parameters in the search. It depends on the application how you should define query parameters and even if it is possible at all. Notice that queries like these cannot be executed immediately: they have to be prepared first. Once a parameterized query has been prepared, the user (or calling code) can supply values for the parameters and have it executed many times, entering new values before every call. How the values are entered and the execution started is up to the application. In a GUI environment, the user typically types the parameter values in one or more text boxes and then clicks an “Execute”, “Run” or “Refresh” button.

```sql
select name, address, phone frome stores
where city = ? and class = ?;
```

```sql
select * from pants
where model = :model and size = :size and color = :col;
```
The last query cannot be passed directly to the engine; the application must convert it to the other format first, mapping named parameters to positional parameters.

### 6.1.6. The GROUP BY clause

GROUP BY merges output rows that have the same combination of values in its item list into a single row. Aggregate functions in the select list are applied to each group individually instead of to the dataset as a whole.

If the select list only contains aggregate columns or, more generally, columns whose values don't depend on individual rows in the underlying set, GROUP BY is optional. When omitted, the final result set consists of a single row (provided that at least one aggregated column is present).

If the select list contains both aggregate columns and columns whose values may vary per row, the GROUP BY clause becomes mandatory.

**Syntax**

```sql
SELECT ... FROM ...
GROUP BY <grouping-item> [, <grouping-item> ...]
[HAVING <grouped-row-condition>]
...

<grouping-item> ::= <non-aggr-select-item>
| <non-aggr-expression>

<non-aggr-select-item> ::= column-copy
| column-alias
| column-position
```

**Table 80. Arguments for the GROUP BY Clause**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;grouping-item&gt;</td>
<td>Expression to group on; in the rest of this chapter, we use <code>&lt;value-expression&gt;</code> in GROUP BY syntax</td>
</tr>
<tr>
<td>non-aggr-expression</td>
<td>Any non-aggregating expression that is not included in the SELECT list, i.e. unselected columns from the source set or expressions that do not depend on the data in the set at all</td>
</tr>
<tr>
<td>column-copy</td>
<td>A literal copy, from the SELECT list, of an expression that contains no aggregate function</td>
</tr>
<tr>
<td>column-alias</td>
<td>The alias, from the SELECT list, of an expression (column) that contains no aggregate function</td>
</tr>
<tr>
<td>column-position</td>
<td>The position number, in the SELECT list, of an expression (column) that contains no aggregate function</td>
</tr>
</tbody>
</table>

A general rule of thumb is that every non-aggregate item in the SELECT list must also be in the GROUP
BY list. You can do this in three ways:

1. By copying the item verbatim from the select list, e.g. “class” or “’D:’ || upper(doccode)”.

2. By specifying the column alias, if it exists.

3. By specifying the column position as an integer literal between 1 and the number of columns. Integer values resulting from expressions or parameter substitutions are simple constant values and not column position and will be used as such in the grouping. They will have no effect though, as their value is the same for each row.

If you group by a column position, the expression at that position is copied internally from the select list. If it concerns a subquery, that subquery will be executed again in the grouping phase. That is to say, grouping by the column position, rather than duplicating the subquery expression in the grouping clause, saves keystrokes and bytes, but it is not a way of saving processing cycles!

In addition to the required items, the grouping list may also contain:

- Columns from the source table that are not in the select list, or non-aggregate expressions based on such columns. Adding such columns may further subdivide the groups. However, since these columns are not in the select list, you can't tell which aggregated row corresponds to which value in the column. So, in general, if you are interested in this information, you also include the column or expression in the select list—which brings you back to the rule: “every non-aggregate column in the select list must also be in the grouping list”.

- Expressions that aren't dependent on the data in the underlying set, e.g. constants, context variables, single-value non-correlated subselects etc. This is only mentioned for completeness, as adding such items is utterly pointless: they don't affect the grouping at all. “Harmless but useless” items like these may also figure in the select list without being copied to the grouping list.

**Examples**

When the select list contains only aggregate columns, GROUP BY is not mandatory:

```sql
select count(*), avg(age) from students
where sex = 'M';
```

This will return a single row listing the number of male students and their average age. Adding expressions that don't depend on values in individual rows of table STUDENTS doesn't change that:

```sql
select count(*), avg(age), current_date from students
where sex = 'M';
```

The row will now have an extra column showing the current date, but other than that, nothing fundamental has changed. A GROUP BY clause is still not required.

However, in both the above examples it is allowed. This is perfectly valid:
select count(*), avg(age) from students
    where sex = 'M'
    group by class;

This will return a row for each class that has boys in it, listing the number of boys and their average age in that particular class. (If you also leave the current_date field in, this value will be repeated on every row, which is not very exciting.)

The above query has a major drawback though: it gives you information about the different classes, but it doesn't tell you which row applies to which class. To get that extra bit of information, add the non-aggregate column CLASS to the select list:

select class, count(*), avg(age) from students
    where sex = 'M'
    group by class;

Now we have a useful query. Notice that the addition of column CLASS also makes the GROUP BY clause mandatory. We can't drop that clause anymore, unless we also remove CLASS from the column list.

The output of our last query may look something like this:

<table>
<thead>
<tr>
<th>CLASS</th>
<th>COUNT</th>
<th>AVG</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>12</td>
<td>13.5</td>
</tr>
<tr>
<td>2B</td>
<td>9</td>
<td>13.9</td>
</tr>
<tr>
<td>3A</td>
<td>11</td>
<td>14.6</td>
</tr>
<tr>
<td>3B</td>
<td>12</td>
<td>14.4</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

The headings “COUNT” and “AVG” are not very informative. In a simple case like this, you might get away with that, but in general you should give aggregate columns a meaningful name by aliasing them:

select class,
    count(*) as num_boys,
    avg(age) as boys_avg_age
from students
    where sex = 'M'
    group by class;

Adding more non-aggregate (or, row-dependent) columns requires adding them to the GROUP BY clause too. For instance, you might want to see the above information for girls as well; and you may also want to differentiate between boarding and day students:
select class, 
  sex, 
  boarding_type, 
  count(*) as number, 
  avg(age) as avg_age 
from students 
group by class, sex, boarding_type;

This may give you the following result:

<table>
<thead>
<tr>
<th>CLASS</th>
<th>SEX</th>
<th>BOARDING_TYPE</th>
<th>NUMBER</th>
<th>AVG_AGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2A</td>
<td>F</td>
<td>BOARDING</td>
<td>9</td>
<td>13.3</td>
</tr>
<tr>
<td>2A</td>
<td>F</td>
<td>DAY</td>
<td>6</td>
<td>13.5</td>
</tr>
<tr>
<td>2A</td>
<td>M</td>
<td>BOARDING</td>
<td>7</td>
<td>13.6</td>
</tr>
<tr>
<td>2A</td>
<td>M</td>
<td>DAY</td>
<td>5</td>
<td>13.4</td>
</tr>
<tr>
<td>2B</td>
<td>F</td>
<td>BOARDING</td>
<td>11</td>
<td>13.7</td>
</tr>
<tr>
<td>2B</td>
<td>F</td>
<td>DAY</td>
<td>5</td>
<td>13.7</td>
</tr>
<tr>
<td>2B</td>
<td>M</td>
<td>BOARDING</td>
<td>6</td>
<td>13.8</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Each row in the result set corresponds to one particular combination of the columns CLASS, SEX and BOARDING_TYPE. The aggregate results—number and average age—are given for each of these groups individually. In a query like this, you don’t see a total for boys as a whole, or day students as a whole. That’s the tradeoff: the more non-aggregate columns you add, the more you can pinpoint specific groups, but the more you also lose sight of the general picture. Of course, you can still obtain the “coarser” aggregates through separate queries.

**HAVING**

Just as a WHERE clause limits the rows in a dataset to those that meet the search condition, so the HAVING sub-clause imposes restrictions on the aggregated rows in a grouped set. HAVING is optional, and can only be used in conjunction with GROUP BY.

The condition(s) in the HAVING clause can refer to:

- Any aggregated column in the select list. This is the most widely used case.
- Any aggregated expression that is not in the select list, but allowed in the context of the query. This is sometimes useful too.
- Any column in the GROUP BY list. While legal, it is more efficient to filter on these non-aggregated data at an earlier stage: in the WHERE clause.
- Any expression whose value doesn’t depend on the contents of the dataset (like a constant or a context variable). This is valid but not useful, because it will either suppress the entire set or leave it untouched, based on conditions that have nothing to do with the set itself.
A HAVING clause can not contain:

- Non-aggregated column expressions that are not in the GROUP BY list.
- Column positions. An integer in the HAVING clause is just an integer, not a column position.
- Column aliases — not even if they appear in the GROUP BY clause!

**Examples**

Building on our earlier examples, this could be used to skip small groups of students:

```sql
select class, 
    count(*) as num_boys, 
    avg(age) as boys_avg_age 
from students 
where sex = 'M' 
group by class 
having count(*) >= 5;
```

To select only groups that have a minimum age spread:

```sql
select class, 
    count(*) as num_boys, 
    avg(age) as boys_avg_age 
from students 
where sex = 'M' 
group by class 
having max(age) - min(age) > 1.2;
```

Notice that if you're interested in this information, you'll likely also include min(age) and max(age) — or the expression “max(age) - min(age)”.

To include only 3rd classes:

```sql
select class, 
    count(*) as num_boys, 
    avg(age) as boys_avg_age 
from students 
where sex = 'M' 
group by class 
having class starting with '3';
```

Better would be to move this condition to the WHERE clause:

```sql
select class, 
    count(*) as num_boys, 
    avg(age) as boys_avg_age 
```
from students
where sex = 'M' and class starting with '3'
group by class;

6.1.7. The WINDOW Clause

The WINDOW clause defines one or more named windows that can be referenced by window functions in the current query specification.

Syntax

<query_spec> ::=  
  SELECT  
  [<limit_clause>]  
  [<distinct_clause>]  
  <select_list>  
  <from_clause>  
  [<where_clause>]  
  [<group_clause>]  
  [<having_clause>]  
  [<named_windows_clause>]  
  [<plan_clause>]

<named_windows_clause> ::=  
  WINDOW <window_definition> [, <window_definition> ...]

<window definition> ::=  
  new-window-name AS (<window-specification-details>)

<window-specification-details> ::=  
  !! See Window (Analytical) Functions !!

In a query with multiple SELECT and WINDOW clauses (for example, with subqueries), the scope of the `new_window_name` is confined to its query context. That means a window name from an inner context cannot be used in an outer context, nor vice versa. However, the same window name can be used independently in different contexts, though to avoid confusion it might be better to avoid this.

For more information, see Window (Analytical) Functions.

Example Using Named Windows

select  
id,  
department,  
salary,  
count(*) over w1,  
first_value(salary) over w2,  
last_value(salary) over w2
from employee
window w1 as (partition by department),
    w2 as (w1 order by salary)
order by department, salary;

6.1.8. The PLAN Clause

The PLAN clause enables the user to submit a data retrieval plan, thus overriding the plan that the optimizer would have generated automatically.

Syntax

```
PLAN <plan-expression>

<plan-expression> ::=  
  (<plan-item> [, <plan-item> ...])  
  <sorted-item>  
  <joined-item>  
  <merged-item>  
  <hash-item>

<sorted-item> ::= SORT (<plan-item>)

<joined-item> ::=  
  JOIN (<plan-item>, <plan-item> [, <plan-item> ...])

<merged-item> ::=  
  [SORT] MERGE (<sorted-item>, <sorted-item> [, <sorted-item> ...])

<hash-item> ::=  
  HASH (<plan-item>, <plan-item> [, <plan-item> ...])

<plan-item> ::= <basic-item> | <plan-expression>

<basic-item> ::=  
  <relation> { NATURAL  
    | INDEX (<indexlist>)  
    | ORDER index [INDEX (<indexlist>)] }  
  <relation> ::= table | view [table]
  <indexlist> ::= index [, index ...]
```

Table 81. Arguments for the PLAN Clause

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>table</td>
<td>Table name or its alias</td>
</tr>
<tr>
<td>view</td>
<td>View name</td>
</tr>
</tbody>
</table>
Every time a user submits a query to the Firebird engine, the optimizer computes a data retrieval strategy. Most Firebird clients can make this retrieval plan visible to the user. In Firebird’s own isql utility, this is done with the command SET PLAN ON. If you are only interested in looking at query plans, SET PLANONLY ON will show the plan without executing the query. Use SET PLANONLY OFF to execute the query and show the plan.

A more detailed plan can be obtained when you enable an advanced plan. In isql this can be done with SET EXPLAIN ON. The advanced plan displays more detailed information about the access methods used by the optimizer, however it cannot be included in the PLAN clause of a statement. The description of the advanced plan is beyond the scope of this Language Reference.

In most situations, you can trust that Firebird will select the optimal query plan for you. However, if you have complicated queries that seem to be underperforming, it may be worth your while to examine the plan and see if you can improve on it.

**SimplePlans**

The simplest plans consist of a relation name followed by a retrieval method. For example, for an unsorted single-table select without a WHERE clause:

```sql
select * from students
plan (students natural);
```

Advanced plan:

```
Select Expression
  -> Table "STUDENTS" Full Scan
```

If there’s a WHERE or a HAVING clause, you can specify the index to be used for finding matches:

```sql
select * from students
where class = '3C'
plan (students index (ix_stud_class));
```

Advanced plan:

```
Select Expression
  -> Filter
    -> Table "STUDENTS" Access By ID
    -> Bitmap
```
The `INDEX` directive is also used for join conditions (to be discussed a little later). It can contain a list of indexes, separated by commas.

`ORDER` specifies the index for sorting the set if an `ORDER BY` or `GROUP BY` clause is present:

```sql
select * from students
plan (students order pk_students)
order by id;
```

Advanced plan:

```
Select Expression
  -> Table "STUDENTS" Access By ID
  -> Index "PK_STUDENTS" Full Scan
```

`ORDER` and `INDEX` can be combined:

```sql
select * from students
  where class >= '3'
plan (students order pk_students index (ix_stud_class))
order by id;
```

Advanced plan:

```
Select Expression
  -> Filter
  -> Table "STUDENTS" Access By ID
  -> Index "PK_STUDENTS" Full Scan
  -> Bitmap
  -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)
```

It is perfectly OK if `ORDER` and `INDEX` specify the same index:

```sql
select * from students
  where class >= '3'
plan (students order ix_stud_class index (ix_stud_class))
order by class;
```

Advanced plan:

```
Select Expression
  -> Filter
```

Chapter 6. Data Manipulation (DML) Statements
For sorting sets when there's no usable index available (or if you want to suppress its use), leave out ORDER and prepend the plan expression with SORT:

```sql
select * from students
plan sort (students natural)
order by name;
```

Advanced plan:

```
Select Expression
  -> Sort (record length: 128, key length: 56)
  -> Table "STUDENTS" Full Scan
```

Or when an index is used for the search:

```sql
select * from students
where class >= '3'
plan sort (students index (ix_stud_class))
order by name;
```

Advanced plan:

```
elect Expression
  -> Sort (record length: 136, key length: 56)
  -> Filter
  -> Table "STUDENTS" Access By ID
  -> Bitmap
  -> Index "IX_STUD_CLASS" Range Scan (lower bound: 1/1)
```

Notice that SORT, unlike ORDER, is outside the parentheses. This reflects the fact that the data rows are retrieved unordered and sorted afterward by the engine.

When selecting from a view, specify the view and the table involved. For instance, if you have a view FRESHMEN that selects the first-year students:

```sql
select * from freshmen
plan (freshmen students natural);
```

Advanced plan:
Select Expression
-> Table "STUDENTS" as "FRESHMEN" Full Scan

Or, for instance:

select * from freshmen
where id > 10
plan sort (freshmen students index (pk_students))
order by name desc;

Advanced plan:

Select Expression
-> Sort (record length: 144, key length: 24)
-> Filter
-> Table "STUDENTS" as "FRESHMEN" Access By ID
-> Bitmap
-> Index "PK_STUDENTS" Range Scan (lower bound: 1/1)

If a table or view has been aliased, it is the alias, not the original name, that must be used in the PLAN clause.

Composite Plans

When a join is made, you can specify the index which is to be used for matching. You must also use the JOIN directive on the two streams in the plan:

select s.id, s.name, s.class, c.mentor
from students s
join classes c on c.name = s.class
plan join (s natural, c index (pk_classes));

Advanced plan:

Select Expression
-> Nested Loop Join (inner)
-> Table "STUDENTS" as "S" Full Scan
-> Filter
-> Table "CLASSES" as "C" Access By ID
-> Bitmap
-> Index "PK_CLASSES" Unique Scan

The same join, sorted on an indexed column:
select s.id, s.name, s.class, c.mentor
from students s
join classes c on c.name = s.class
plan join (s order pk_students, c index (pk_classes))
order by s.id;

Advanced plan:

Select Expression
  -> Nested Loop Join (inner)
    -> Table "STUDENTS" as "S" Access By ID
    -> Index "PK_STUDENTS" Full Scan
    -> Filter
    -> Table "CLASSES" as "C" Access By ID
      -> Bitmap
      -> Index "PK_CLASSES" Unique Scan

And on a non-indexed column:

select s.id, s.name, s.class, c.mentor
from students s
join classes c on c.name = s.class
plan sort (join (s natural, c index (pk_classes)))
order by s.name;

Advanced plan:

Select Expression
  -> Sort (record length: 152, key length: 12)
    -> Nested Loop Join (inner)
      -> Table "STUDENTS" as "S" Full Scan
      -> Filter
      -> Table "CLASSES" as "C" Access By ID
        -> Bitmap
        -> Index "PK_CLASSES" Unique Scan

With a search condition added:

select s.id, s.name, s.class, c.mentor
from students s
join classes c on c.name = s.class
where s.class <= '2'
plan sort (join (s index (fk_student_class), c index (pk_classes)))
order by s.name;
Advanced plan:

```
Select Expression
  - Sort (record length: 152, key length: 12)
    - Nested Loop Join (inner)
      - Filter
        - Table "STUDENTS" as "S" Access By ID
          - Bitmap
            - Index "FK_STUDENT_CLASS" Range Scan (lower bound: 1/1)
        - Filter
          - Table "CLASSES" as "C" Access By ID
            - Bitmap
              - Index "PK_CLASSES" Unique Scan
```

As a left outer join:

```
select s.id, s.name, s.class, c.mentor
from classes c
  left join students s on c.name = s.class
where s.class <= '2'
plan sort (join (c natural, s index (fk_student_class)))
order by s.name;
```

Advanced plan:

```
Select Expression
  - Sort (record length: 192, key length: 56)
    - FILTER
      - Table "CLASSES" as "C" Full Scan
      - Filter
        - Table "STUDENTS" as "S" Access By ID
          - Bitmap
            - Index "FK_STUDENT_CLASS" Range Scan (full match)
```

If there are no indices available to match the join condition (or if you don't want to use it), then it is possible connect the streams using HASH or MERGE method.

To connect using the HASH method in the plan, the HASH directive is used instead of the JOIN directive. In this case, the smaller (secondary) stream is materialized completely into an internal buffer. While reading this secondary stream, a hash function is applied and a pair `{hash, pointer to buffer}` is written to a hash table. Then the primary stream is read and its hash key is tested against the hash table.

```
select *
  from students s
    join classes c on c.cookie = s.cookie
```
plan hash (c natural, s natural)

Advanced plan:

Select Expression
  -> Filter
    -> Hash Join (inner)
      -> Table "STUDENTS" as "S" Full Scan
      -> Table "CLASSES" as "C" Full Scan

For a MERGE join, the plan must first sort both streams on their join column(s) and then merge. This is achieved with the SORT directive (which we've already seen) and MERGE instead of JOIN:

```
select * from students s
  join classes c on c.cookie = s.cookie
plan merge (sort (c natural), sort (s natural));
```

Adding an ORDER BY clause means the result of the merge must also be sorted:

```
select * from students s
  join classes c on c.cookie = s.cookie
plan sort (merge (sort (c natural), sort (s natural)))
  order by c.name, s.id;
```

Finally, we add a search condition on two indexable columns of table STUDENTS:

```
select * from students s
  join classes c on c.cookie = s.cookie
  where s.id < 10 and s.class <= '2'
plan sort (merge (sort (c natural),
                  sort (s index (pk_students, fk_student_class))))
  order by c.name, s.id;
```

As follows from the formal syntax definition, JOINs and MERGEs in the plan may combine more than two streams. Also, every plan expression may be used as a plan item in an encompassing plan. This means that plans of certain complicated queries may have various nesting levels.

Finally, instead of MERGE you may also write SORT MERGE. As this makes no difference and may create confusion with “real” SORT directives (the ones that do make a difference), it's best to stick to plain MERGE.

In addition to the plan for the main query, you can specify a plan for each subquery. For example, the following query with multiple plans will work:
Occasionally, the optimizer will accept a plan and then not follow it, even though it
does not reject it as invalid. One such example was

```
MERGE (unsorted stream, unsorted stream)
```

It is advisable to treat such a plan as “deprecated”.

### 6.1.9. UNION

The **UNION** clause concatenates two or more datasets, thus increasing the number of rows but not
the number of columns. Datasets taking part in a **UNION** must have the same number of columns,
and columns at corresponding positions must be of the same type.

By default, a union suppresses duplicate rows. **UNION ALL** shows all rows, including any duplicates.
The optional **DISTINCT** keyword makes the default behaviour explicit.

**Syntax**

```
<query-expression> ::=  
  [with-clause] <query-expression-body> [order-by-clause]  
  [{{ rows-clause  
    | [result-offset-clause] [fetch-first-clause] }}]  

<query-expression-body> ::=  
  <query-term>  
  | <query-expression-body> UNION [DISTINCT | ALL] <query-term>  

<query-term> ::=  
  <query-primary>  

<query-primary> ::=  
  query specification  
  | (<query-expression-body> [order-by-clause]  
    [result-offset-clause] [fetch-first-clause])  

<query-specification> ::=  
  SELECT <limit-clause> [ALL | DISTINCT] <select-list>  
  FROM <table-reference> [, <table-reference> ...]  
  [WHERE <search-condition>]  
  [GROUP BY <value-expression> [, <value-expression> ...]]
```
Unions take their column names from the first select query. If you want to alias union columns, do so in the column list of the topmost SELECT. Aliases in other participating selects are allowed and may even be useful, but will not propagate to the union level.

If a union has an ORDER BY clause, the only allowed sort items are integer literals indicating 1-based column positions, optionally followed by an ASC/DESC and/or a NULLS {FIRST | LAST} directive. This also implies that you cannot order a union by anything that isn't a column in the union. (You can, however, wrap it in a derived table, which gives you back all the usual sort options.)

Unions are allowed in subqueries of any kind and can themselves contain subqueries. They can also contain joins, and can take part in a join when wrapped in a derived table.

**Examples**

This query presents information from different music collections in one dataset using unions:

```sql
select id, title, artist, length, 'CD' as medium
  from cds
union
select id, title, artist, length, 'LP'
  from records
union
select id, title, artist, length, 'MC'
  from cassettes
order by 3, 2  -- artist, title;
```

If id, title, artist and length are the only fields in the tables involved, the query can also be written as:

```sql
select c.*, 'CD' as medium
  from cds c
union
select r.*, 'LP'
  from records r
union
select c.*, 'MC'
  from cassettes c
order by 3, 2  -- artist, title;
```

Qualifying the “stars” is necessary here because they are not the only item in the column list. Notice how the “c” aliases in the first and third select do not conflict with each other: their scopes are not
union-wide but apply only to their respective select queries.

The next query retrieves names and phone numbers from translators and proofreaders. Translators who also work as proofreaders will show up only once in the result set, provided their phone number is the same in both tables. The same result can be obtained without DISTINCT. With ALL, these people would appear twice.

```sql
select name, phone from translators
  union distinct
select name, telephone from proofreaders;
```

A UNION within a subquery:

```sql
select name, phone, hourly_rate from clowns
where hourly_rate < all
  (select hourly_rate from jugglers
   union
   select hourly_rate from acrobats)
order by hourly_rate;
```

Using parenthesized query expressions to show the employees with the highest and lowest salaries:

```sql
(  
  select emp_no, salary, 'lowest' as type  
  from employee  
  order by salary asc  
  fetch first row only  
)
union all  
(  
  select emp_no, salary, 'highest' as type  
  from employee  
  order by salary desc  
  fetch first row only  
);
```

### 6.1.10. ORDER BY

When a SELECT statement is executed, the result set is not sorted in any way. It often happens that rows appear to be sorted chronologically, simply because they are returned in the same order they were added to the table by INSERT statements. This is not something you should rely on: the order may change depending on the plan or updates to rows, etc. To specify an explicit sorting order for the set specification, an ORDER BY clause is used.

**Syntax**

```sql
SELECT ... FROM ...
```
ORDER BY <sort-specification> [, <sort-specification> ...]

<sort-specification> ::=  
  <value-expression> [ordering-specification] [null-ordering]

<ordering-specification> ::=  
  ASC | ASCENDING  
  | DESC | DESCENDING

<null-ordering> ::=  
  NULLS FIRST  
  | NULLS LAST

Table 82. Arguments for the ORDER BY Clause

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value-expression</td>
<td>Any expression; an expression that is only an integer literal represents the column position</td>
</tr>
</tbody>
</table>

The ORDER BY consists of a comma-separated list of the columns or expressions on which the result data set should be sorted. The sort order can be specified by the name of the column — but only if the column was not previously aliased in the SELECT columns list. The alias must be used if it was used in the select list. The ordinal position number of the column in the SELECT column list, the alias given to the column in the SELECT list with the help of the AS keyword, or the number of the column in the SELECT list can be used without restriction.

The three forms of expressing the columns for the sort order can be mixed in the same ORDER BY clause. For instance, one column in the list can be specified by its name and another column can be specified by its number.

- **WARNING:** If you sort by column position or alias, then the expression corresponding to this position (alias) will be copied from the SELECT list. This also applies to subqueries, thus, the subquery will be executed at least twice.

- **INFO:** If you use the column position to specify the sort order for a query of the SELECT * style, the server expands the asterisk to the full column list to determine the columns for the sort. It is, however, considered “sloppy practice” to design ordered sets this way.

**Sorting Direction**

The keyword ASC — short for ASCENDING — specifies a sort direction from lowest to highest. ASC is the default sort direction.

The keyword DESC — short for DESCENDING — specifies a sort direction from highest to lowest.

Specifying ascending order for one column and descending order for another is allowed.
Collation Order

Using the keyword `COLLATE` in a `<value-expression>` specifies the collation order to apply for a string column if you need a collation order that is different from the normal collation for this column. The normal collation order is defined by either the default collation for the database character set, or the collation set explicitly in the column’s definition.

NULLs Position

The keyword `NULLS` defines where NULL in the associated column will fall in the sort order: `NULLS FIRST` places the rows with the NULL column above rows ordered by that column’s value; `NULLS LAST` places those rows after the ordered rows.

`NULLS FIRST` is the default.

Ordering UNION-ed Sets

Not-parenthesized query expressions contributing to a `UNION` cannot take an `ORDER BY` clause. You can order the entire output, using one `ORDER BY` clause at the end of the overall query, or use parenthesized query expressions, which do allow `ORDER BY`.

The simplest — and, in some cases, the only — method for specifying the sort order is by the ordinal column position. However, it is also valid to use the column names or aliases, from the first contributing query only.

The `ASC/DESC` and/or `NULLS` directives are available for this global set.

If discrete ordering within the contributing set is required, use parenthesized query expressions, derived tables, or common table expressions for those sets.

Examples of `ORDER BY`

Sorting the result set in ascending order, ordering by the `RDB$CHARACTER_SET_ID` and `RDB$COLLATION_ID` columns of the `RDB$COLLATIONS` table:

```sql
SELECT
    RDB$CHARACTER_SET_ID AS CHARSET_ID,
    RDB$COLLATION_ID AS COLL_ID,
    RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY RDB$CHARACTER_SET_ID, RDB$COLLATION_ID;
```

The same, but sorting by the column aliases:

```sql
SELECT
    RDB$CHARACTER_SET_ID AS CHARSET_ID,
    RDB$COLLATION_ID AS COLL_ID,
    RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY RDB$CHARACTER_SET_ID, RDB$COLLATION_ID;
```
ORDER BY CHARSET_ID, COLL_ID;

Sorting the output data by the column position numbers:

SELECT
  RDB$CHARACTER_SET_ID AS CHARSET_ID,
  RDB$COLLATION_ID AS COLL_ID,
  RDB$COLLATION_NAME AS NAME
FROM RDB$COLLATIONS
ORDER BY 1, 2;

Sorting a SELECT * query by position numbers — possible, but nasty and not recommended:

SELECT *
FROM RDB$COLLATIONS
ORDER BY 3, 2;

Sorting by the second column in the BOOKS table, or—if BOOKS has only one column—the FILMS.DIRECTOR column:

SELECT
  BOOKS.*,
  FILMS.DIRECTOR
FROM BOOKS, FILMS
ORDER BY 2;

Sorting in descending order by the values of column PROCESS_TIME, with NULLs placed at the beginning of the set:

SELECT *
FROM MSG
ORDER BY PROCESS_TIME DESC NULLS FIRST;

Sorting the set obtained by a UNION of two queries. Results are sorted in descending order for the values in the second column, with NULLs at the end of the set; and in ascending order for the values of the first column with NULLs at the beginning.

SELECT
  DOC_NUMBER, DOC_DATE
FROM PAYORDER
UNION ALL
SELECT
  DOC_NUMBER, DOC_DATE
FROM BUDGORDER
6.1.11. ROWS

Retrieves a slice of rows from an ordered set

**Syntax**

```
SELECT <columns> FROM ...
[WHERE ...]
[ORDER BY ...]
ROWS <value-expression> [TO <value-expression>]
```

**Table 83. Arguments for the ROWS Clause**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value-expression</td>
<td>Any integer expressions</td>
</tr>
</tbody>
</table>

ROWS is non-standard syntax

ROWS is a Firebird-specific clause. Use the SQL-standard `OFFSET, FETCH` syntax wherever possible.

ROWS limits the amount of rows returned by the SELECT statement to a specified number or range.

The ROWS clause also does the same job as the FIRST and SKIP clauses, but neither are SQL-compliant. Unlike FIRST and SKIP, and OFFSET and FETCH, the ROWS and TO clauses accept any type of integer expression as their arguments, without parentheses. Of course, parentheses may still be needed for nested evaluations inside the expression, and a subquery must always be enclosed in parentheses.

- Numbering of rows in the intermediate set— the overall set cached on disk before the “slice” is extracted — starts at 1.

- OFFSET/FETCH, FIRST/Skip, and ROWS can all be used without the ORDER BY clause, although it rarely makes sense to do so — except perhaps when you want to take a quick look at the table data and don’t care that rows will be in a non-deterministic order. For this purpose, a query like “SELECT * FROM TABLE1 ROWS 20” would return the first 20 rows instead of a whole table that might be rather big.

**Characteristics of Using ROWS m Without a TO Clause:**

Calling `ROWS m` retrieves the first `m` records from the set specified.

- If `m` is greater than the total number of records in the intermediate data set, the entire set is returned
- If `m = 0`, an empty set is returned
- If `m < 0`, the SELECT statement call fails with an error
Characteristics of Using ROWS m With a TO Clause:

Calling \texttt{ROWS m TO n} retrieves the rows from the set, starting at row \textit{m} and ending after row \textit{n} — the set is inclusive.

- If \textit{m} is greater than the total number of rows in the intermediate set and \textit{n} \(\geq m\), an empty set is returned
- If \textit{m} is not greater than \textit{n} and \textit{n} is greater than the total number of rows in the intermediate set, the result set will be limited to rows starting from \textit{m}, up to the end of the set
- If \textit{m} < 1 and \textit{n} < 1, the SELECT statement call fails with an error
- If \textit{n} = \textit{m} - 1, an empty set is returned
- If \textit{n} < \textit{m} - 1, the SELECT statement call fails with an error

Not Possible to Use a TO Clause Without a ROWS Clause:

While \texttt{ROWS} is an alternative to the \texttt{FIRST} and \texttt{SKIP} syntax, there is one situation where the \texttt{ROWS} syntax does not provide the same behaviour: specifying \texttt{SKIP n} on its own returns the entire intermediate set, without the first \textit{n} rows. The \texttt{ROWS \ldots TO} syntax needs a little help to achieve this.

With the \texttt{ROWS} syntax, you need a \texttt{ROWS} clause \textit{in association with} the \texttt{TO} clause and deliberately make the second (\textit{n}) argument greater than the size of the intermediate data set. This is achieved by creating an expression for \textit{n} that uses a subquery to retrieve the count of rows in the intermediate set and adds 1 to it, or use a literal with a sufficiently large value.

Replacing of FIRST/Skip and OFFSET/FETCH

The \texttt{ROWS} clause can be used instead of the SQL-standard \texttt{OFFSET/FETCH} or non-standard \texttt{FIRST/SKIP} clauses, except the case where only \texttt{OFFSET} or \texttt{SKIP} is used, that is when the whole result set is returned except for skipping the specified number of rows from the beginning.

To implement this behaviour using \texttt{ROWS}, you must specify the \texttt{TO} clause with a value larger than the size of the returned result set.

Mixing ROWS and FIRST/Skip or OFFSET/FETCH

\texttt{ROWS} syntax cannot be mixed with \texttt{FIRST/SKIP} or \texttt{OFFSET/FETCH} in the same \texttt{SELECT} expression. Using the different syntaxes in different subqueries in the same statement is allowed.

ROWS Syntax in UNION Queries

When \texttt{ROWS} is used in a \texttt{UNION} query, the \texttt{ROWS} directive is applied to the unioned set and must be placed after the last \texttt{SELECT} statement.

If a need arises to limit the subsets returned by one or more \texttt{SELECT} statements inside \texttt{UNION}, there are a couple of options:

1. Use \texttt{FIRST/SKIP} syntax in these \texttt{SELECT} statements — bearing in mind that an ordering clause (\texttt{ORDER BY}) cannot be applied locally to the discrete queries, but only to the combined output.
2. Convert the queries to derived tables with their own \texttt{ROWS} clauses.
3. Use parenthesized query expressions with OFFSET/FETCH

**Examples of ROWS**

The following examples rewrite the examples used in the section about FIRST and SKIP, earlier in this chapter.

Retrieve the first ten names from the output of a sorted query on the PEOPLE table:

```sql
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 1 TO 10;
```

or its equivalent

```sql
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 10;
```

Return all records from the PEOPLE table except for the first 10 names:

```sql
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 11 TO (SELECT COUNT(*) FROM People);
```

And this query will return the last 10 records (pay attention to the parentheses):

```sql
SELECT id, name
FROM People
ORDER BY name ASC
ROWS (SELECT COUNT(*) - 9 FROM People)
TO (SELECT COUNT(*) FROM People);
```

This one will return rows 81-100 from the PEOPLE table:

```sql
SELECT id, name
FROM People
ORDER BY name ASC
ROWS 81 TO 100;
```

ROWS can also be used with the UPDATE and DELETE statements.
6.1.12. OFFSET, FETCH

Retrieves a slice of rows from an ordered set

**Syntax**

```sql
SELECT <columns> FROM ... 
[WHERE ...] 
[ORDER BY ...] 
[OFFSET <offset-fetch-expression> { ROW | ROWS }] 
[FETCH { FIRST | NEXT } 
[<offset-fetch-expression>] { ROW | ROWS } ONLY]
```

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>integer-literal</td>
<td>Integer literal</td>
</tr>
<tr>
<td>query-parameter</td>
<td>Query parameter place-holder. ? in DSQL and :paramname in PSQL</td>
</tr>
</tbody>
</table>

The OFFSET and FETCH clauses are an SQL standard-compliant equivalent for FIRST/Skip, and an alternative for ROWS. The OFFSET clause specifies the number of rows to skip. The FETCH clause specifies the number of rows to fetch.

When `<offset-fetch-expression>` is left out of the FETCH clause (e.g. FETCH FIRST ROW ONLY), one row will be fetched.

The choice between ROW or ROWS, or FIRST or NEXT in the clauses is just for aesthetic purposes (e.g. making the query more readable or grammatically correct). There is no difference between OFFSET 10 ROW or OFFSET 10 ROWS, or FETCH NEXT 10 ROWS ONLY or FETCH FIRST 10 ROWS ONLY.

As with SKIP and FIRST, OFFSET and FETCH clauses can be applied independently, in both top-level and nested query expressions.

1. Firebird doesn’t support the percentage FETCH nor the FETCH ... WITH TIES defined in the SQL standard.
2. The FIRST/Skip and ROWS clause are non-standard alternatives.
3. The OFFSET and/or FETCH clauses cannot be combined with ROWS or FIRST/Skip on the same query expression.
4. Expressions, column references, etc. are not allowed within either clause.
5. Contrary to the ROWS clause, OFFSET and FETCH are only available on SELECT
Examples of OFFSET and FETCH

Return all rows except the first 10, ordered by column COL1

```
SELECT *
FROM T1
ORDER BY COL1
OFFSET 10 ROWS
```

Return the first 10 rows, ordered by column COL1

```
SELECT *
FROM T1
ORDER BY COL1
FETCH FIRST 10 ROWS ONLY
```

Using OFFSET and FETCH clauses in a derived table and in the outer query

```
SELECT *
FROM (  
    SELECT *
    FROM T1
    ORDER BY COL1 DESC
    OFFSET 1 ROW
    FETCH NEXT 10 ROWS ONLY
  ) a
ORDER BY a.COL1
FETCH FIRST ROW ONLY
```

The following examples rewrite the FIRST/SKIP examples and ROWS examples earlier in this chapter.

Retrieve the first ten names from the output of a sorted query on the PEOPLE table:

```
SELECT id, name
FROM People
ORDER BY name ASC
FETCH NEXT 10 ROWS ONLY;
```

Return all records from the PEOPLE table except for the first 10 names:

```
SELECT id, name
FROM People
ORDER BY name ASC
OFFSET 10 ROWS;
```
And this query will return the last 10 records. Contrary to FIRST/SKIP and ROWS we cannot use expressions (including sub-queries). To retrieve the last 10 rows, reverse the sort to the first (last) 10 rows, and then sort in the right order.

```sql
SELECT id, name
FROM ( SELECT id, name
          FROM People
          ORDER BY name DESC
          FETCH FIRST 10 ROWS ONLY
       ) a
ORDER BY name ASC;
```

This one will return rows 81-100 from the PEOPLE table:

```sql
SELECT id, name
FROM People
ORDER BY name ASC
OFFSET 80 ROWS
FETCH NEXT 20 ROWS;
```

See also
FIRST, SKIP, ROWS

### 6.1.13. FOR UPDATE [OF]

**Syntax**

```sql
SELECT ... FROM single_table
[WHERE ...]
FOR UPDATE [OF <column-name-list>]
```

FOR UPDATE does not do what its name suggests. Its only effect currently is to disable the pre-fetch buffer.

It is likely to change in a future Firebird version: the plan is to validate cursors marked with FOR UPDATE if they are truly updatable and reject positioned updates and deletes for cursors evaluated as non-updatable.

The OF sub-clause does not do anything at all, and is only provided for syntax compatibility with other database systems.

### 6.1.14. WITH LOCK

Applies limited pessimistic locking
WITH_LOCK provides a limited explicit pessimistic locking capability for cautious use in conditions where the affected row set is:

- extremely small (ideally singleton), and
- precisely controlled by the application code.

This is for experts only!
The need for a pessimistic lock in Firebird is very rare indeed and should be well understood before use of this extension is considered.

It is essential to understand the effects of transaction isolation and other transaction attributes before attempting to implement explicit locking in your application.

If the WITH LOCK clause succeeds, it will secure a lock on the selected rows and prevent any other transaction from obtaining write access to any of those rows, or their dependants, until your transaction ends.

WITH LOCK can only be used with a top-level, single-table SELECT statement. It is not available:

- in a subquery specification
- for joined sets
- with the DISTINCT operator, a GROUP BY clause or any other aggregating operation
- with a view
- with the output of a selectable stored procedure
- with an external table
- with a UNION query

As the engine considers, in turn, each record falling under an explicit lock statement, it returns either the record version that is the most currently committed, regardless of database state when the statement was submitted, or an exception.

When the optional SKIP LOCKED clause is specified, records locked by a different transaction are skipped.

If a statement has both SKIP LOCKED and OFFSET/SKIP/ROWS subclauses, locked rows may be skipped before OFFSET/SKIP/ROWS subclause can account for them, thus skipping more rows than specified in OFFSET/SKIP/ROWS.
Wait behaviour and conflict reporting depend on the transaction parameters specified in the TPB block:

### Table 85. How TPB settings affect explicit locking

<table>
<thead>
<tr>
<th>TPB mode</th>
<th>Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>isc_tpb_consistency</td>
<td>Explicit locks are overridden by implicit or explicit table-level locks and are ignored.</td>
</tr>
<tr>
<td>isc_tpb_concurrency + isc_tpb_nowait</td>
<td>If a record is modified by any transaction that was committed since the transaction attempting to get explicit lock started, or an active transaction has performed a modification of this record, an update conflict exception is raised immediately.</td>
</tr>
<tr>
<td>isc_tpb_concurrency + isc_tpb_wait</td>
<td>If the record is modified by any transaction that has committed since the transaction attempting to get explicit lock started, an update conflict exception is raised immediately. If an active transaction is holding ownership on this record (via explicit locking or by a normal optimistic write-lock) the transaction attempting the explicit lock waits for the outcome of the blocking transaction and, when it finishes, attempts to get the lock on the record again. This means that, if the blocking transaction committed a modified version of this record, an update conflict exception will be raised.</td>
</tr>
<tr>
<td>isc_tpb_read_committed + isc_tpb_nowait</td>
<td>If there is an active transaction holding ownership on this record (via explicit locking or normal update), an update conflict exception is raised immediately.</td>
</tr>
<tr>
<td>isc_tpb_read_committed + isc_tpb_wait</td>
<td>If there is an active transaction holding ownership on this record (via explicit locking or by a normal optimistic write-lock), the transaction attempting the explicit lock waits for the outcome of blocking transaction and when it finishes, attempts to get the lock on the record again. Update conflict exceptions can never be raised by an explicit lock statement in this TPB mode.</td>
</tr>
</tbody>
</table>

#### Usage with a FOR UPDATE Clause

If the FOR UPDATE sub-clause precedes the WITH LOCK sub-clause, buffered fetches are suppressed. Thus, the lock will be applied to each row, one by one, at the moment it is fetched. It becomes possible, then, that a lock which appeared to succeed when requested will nevertheless fail subsequently, when an attempt is made to fetch a row which has become locked by another transaction in the meantime. This can be avoided by also using SKIP LOCKED.

As an alternative, it may be possible in your access components to set the size of the fetch buffer to 1. This would enable you to process the currently-locked row before the next is fetched and locked, or to handle errors without rolling back your transaction.

See also
**FOR UPDATE [OF]**

**How the engine deals with WITH LOCK**

When an UPDATE statement tries to access a record that is locked by another transaction, it either raises an update conflict exception or waits for the locking transaction to finish, depending on TPB mode. Engine behaviour here is the same as if this record had already been modified by the locking transaction.

No special error codes are returned from conflicts involving pessimistic locks.

The engine guarantees that all records returned by an explicit lock statement are locked and do meet the search conditions specified in WHERE clause, as long as the search conditions do not depend on any other tables, via joins, subqueries, etc. It also guarantees that rows not meeting the search conditions will not be locked by the statement. It can not guarantee that there are no rows which, though meeting the search conditions, are not locked.

This situation can arise if other, parallel transactions commit their changes during the course of the locking statement’s execution.

The engine locks rows at fetch time. This has important consequences if you lock several rows at once. Many access methods for Firebird databases default to fetching output in packets of a few hundred rows ("buffered fetches"). Most data access components cannot bring you the rows contained in the last-fetched packet, when an error occurred.

**Caveats using WITH LOCK**

- Rolling back of an implicit or explicit savepoint releases record locks that were taken under that savepoint, but it doesn’t notify waiting transactions. Applications should not depend on this behaviour as it may get changed in the future.

- While explicit locks can be used to prevent and/or handle unusual update conflict errors, the volume of deadlock errors will grow unless you design your locking strategy carefully and control it rigorously.

- Most applications do not need explicit locks at all. The main purposes of explicit locks are:
  1. to prevent expensive handling of update conflict errors in heavily loaded applications, and
  2. to maintain integrity of objects mapped to a relational database in a clustered environment.

If your use of explicit locking doesn’t fall in one of these two categories, then it’s probably the wrong way to do the task in Firebird.

- Explicit locking is an advanced feature; do not misuse it! While solutions for these kinds of problems may be important for websites handling thousands of concurrent writers, or for ERP/CRM systems operating in large corporations, most application programs do not need to work in such conditions.

**Examples using explicit locking**

i. Simple:
SELECT * FROM DOCUMENT WHERE ID=? WITH LOCK;

ii. Multiple rows, one-by-one processing with DSQL cursor:

SELECT * FROM DOCUMENT WHERE PARENT_ID=? FOR UPDATE WITH LOCK;

### 6.1.15. OPTIMIZE FOR

**Syntax**

```sql
SELECT ...
[WITH LOCK [SKIP LOCKED]]
OPTIMIZE FOR {FIRST | ALL} ROWS
```

The `OPTIMIZE FOR` clause can only occur on a top-level `SELECT`.

This feature allows the optimizer to consider another (hopefully better) plan if only a subset or rows is fetched initially by the user application (with the remaining rows being fetched on demand), thus improving the response time.

It can also be specified at the session level using the `SET OPTIMIZE` management statement.

The default behaviour can be specified globally using the `OptimizeForFirstRows` setting in `firebird.conf` or `databases.conf`.

### 6.1.16. INTO

Passes `SELECT` output into variables

**Available in**

PSQL

**Syntax**

In PSQL the `INTO` clause is placed at the end of the `SELECT` statement.

```sql
SELECT [...][<column-list>]
FROM ...
[...]
[INTO <variable-list>]

<variable-list> ::= <variable> [, <variable> ...]

<variable> ::= varname | ':' varname
```
The colon prefix before local variable names in PSQL is optional in the INTO clause.

In PSQL code (triggers, stored procedures and executable blocks), the results of a SELECT statement can be loaded row-by-row into local variables. It is often the only way to do anything with the returned values at all, unless an explicit or implicit cursor name is specified. The number, order and types of the variables must match the columns in the output row.

A “plain” SELECT statement can only be used in PSQL if it returns at most one row, i.e. if it is a singleton select. For multi-row selects, PSQL provides the FOR SELECT loop construct, discussed later in the PSQL chapter. PSQL also supports the DECLARE CURSOR statement, which binds a named cursor to a SELECT statement. The cursor can then be used to walk the result set.

**Examples**

1. Selecting aggregated values and passing them into previously declared variables min_amt, avg_amt and max_amt:

   ```sql
   select min(amount), avg(cast(amount as float)), max(amount)
   from orders
   where artno = 372218
   into min_amt, avg_amt, max_amt;
   ```

   The CAST serves to make the average a real number; otherwise, since amount is presumably an integer field, SQL rules would truncate it to the nearest lower integer.

2. A PSQL trigger that retrieves two values as a BLOB field (using the LIST() function) and assigns it INTO a third field:

   ```sql
   select list(name, ', ') 
   from persons p
   where p.id in (new.father, new.mother)
   into new.parentnames;
   ```

**6.1.17. Common Table Expressions ("WITH … AS … SELECT")**

**Syntax**

```
<query-expression> ::= 
  [ <with-clause> ] <query-expression-body> [ <order-by-clause> ] 
  [ [ <rows-clause> 
    | [ <result-offset-clause> ] <fetch-first-clause> ] ]

<with-clause> ::= 
  WITH [RECURSIVE] <with-list-element> [, <with-list-element> ...]

<with-list-element> ::= 
```

311
A common table expression or CTE can be described as a virtual table or view, defined in a preamble to a main query, and going out of scope after the main query’s execution. The main query can reference any CTEs defined in the preamble as if they were regular tables or views. CTEs can be recursive, i.e. self-referencing, but they cannot be nested.

CTE Notes

- A CTE definition can contain any legal query-expression, as long as it doesn’t have a “WITH…” preamble of its own (no nesting).
- CTEs defined for the same main query can reference each other, but care should be taken to avoid loops.
- CTEs can be referenced from anywhere in the main query.
- Each CTE can be referenced multiple times in the main query, using different aliases if necessary.
- When enclosed in parentheses, CTE constructs can be used as subqueries in SELECT statements, but also in UPDATES, MERGES etc.
- In PSQL, CTEs are also supported in FOR loop headers:

```sql
for
  with my_rivers as (select * from rivers where owner = 'me')
  select name, length from my_rivers into :rname, :rlen
do
begin
  ..
end
```

Example

```sql
with dept_year_budget as (  
  select fiscal_year,  
      dept_no,  
      sum(projected_budget) as budget  
  from proj_dept_budget  
  group by fiscal_year, dept_no  
)
```
select d.dept_no,  
    d.department,  
    dyb_2008.budget as budget_08,  
    dyb_2009.budget as budget_09  
from department d  
    left join dept_year_budget dyb_2008  
        on d.dept_no = dyb_2008.dept_no  
        and dyb_2008.fiscal_year = 2008  
    left join dept_year_budget dyb_2009  
        on d.dept_no = dyb_2009.dept_no  
        and dyb_2009.fiscal_year = 2009  
where exists (  
    select * from proj_dept_budget b  
    where d.dept_no = b.dept_no)  
);

Recursive CTEs

A recursive (self-referencing) CTE is a UNION which must have at least one non-recursive member, called the anchor. The non-recursive member(s) must be placed before the recursive member(s). Recursive members are linked to each other and to their non-recursive neighbour by UNION ALL operators. The unions between non-recursive members may be of any type.

Recursive CTEs require the RECURSIVE keyword to be present right after WITH. Each recursive union member may reference itself only once, and it must do so in a FROM clause.

A great benefit of recursive CTEs is that they use far less memory and CPU cycles than an equivalent recursive stored procedure.

Execution Pattern

The execution pattern of a recursive CTE is as follows:

- The engine begins execution from a non-recursive member.
- For each row evaluated, it starts executing each recursive member one by one, using the current values from the outer row as parameters.
- If the currently executing instance of a recursive member produces no rows, execution loops back one level and gets the next row from the outer result set.

Example of recursive CTEs

WITH RECURSIVE DEPT_YEAR_BUDGET AS (  
    SELECT  
        FISCAL_YEAR,  
        DEPT_NO,  
        SUM(PROJECTED_BUDGET) BUDGET  
    FROM PROJ_DEPT_BUDGET  
    GROUP BY FISCAL_YEAR, DEPT_NO  
),
DEPT_TREE AS ( 
    SELECT 
        DEPT_NO,
        HEAD_DEPT,
        DEPARTMENT,
        CAST('' AS VARCHAR(255)) AS INDENT
    FROM DEPARTMENT
    WHERE HEAD_DEPT IS NULL
    UNION ALL
    SELECT 
        D.DEPT_NO,
        D.HEAD_DEPT,
        D.DEPARTMENT,
        H.INDENT || ' ' 
    FROM DEPARTMENT D
    JOIN DEPT_TREE H ON H.HEAD_DEPT = D.DEPT_NO
)

SELECT 
    D.DEPT_NO,
    D.INDENT || D.DEPARTMENT DEPARTMENT,
    DYB_2008.BUDGET AS BUDGET_08,
    DYB_2009.BUDGET AS BUDGET_09
FROM DEPT_TREE D
    LEFT JOIN DEPT_YEAR_BUDGET DYB_2008 ON 
        (D.DEPT_NO = DYB_2008.DEPT_NO) AND 
        (DYB_2008.FISCAL_YEAR = 2008)
    LEFT JOIN DEPT_YEAR_BUDGET DYB_2009 ON 
        (D.DEPT_NO = DYB_2009.DEPT_NO) AND 
        (DYB_2009.FISCAL_YEAR = 2009);

The next example returns the pedigree of a horse. The main difference is that recursion occurs simultaneously in two branches of the pedigree.

WITH RECURSIVE PEDIGREE ( 
    CODE_HORSE,
    CODE_FATHER,
    CODE_MOTHER,
    NAME,
    MARK,
    DEPTH) 
AS (SELECT 
    HORSE.CODE_HORSE,
    HORSE.CODE_FATHER,
    HORSE.CODE_MOTHER,
    HORSE.NAME,
    CAST('' AS VARCHAR(80)),
    0
    FROM 
    HORSE
    WHERE
HORSE.CODE_HORSE = :CODE_HORSE
UNION ALL
SELECT
    HORSE.CODE_HORSE,
    HORSE.CODE_FATHER,
    HORSE.CODE_MOTHER,
    HORSE.NAME,
    'F' || PEDIGREE.MARK,
    PEDIGREE.DEPTH + 1
FROM
    HORSE
JOIN PEDIGREE
    ON HORSE.CODE_HORSE = PEDIGREE.CODE_FATHER
WHERE
    PEDIGREE.DEPTH < :MAX_DEPTH
UNION ALL
SELECT
    HORSE.CODE_HORSE,
    HORSE.CODE_FATHER,
    HORSE.CODE_MOTHER,
    HORSE.NAME,
    'M' || PEDIGREE.MARK,
    PEDIGREE.DEPTH + 1
FROM
    HORSE
JOIN PEDIGREE
    ON HORSE.CODE_HORSE = PEDIGREE.CODE_MOTHER
WHERE
    PEDIGREE.DEPTH < :MAX_DEPTH
)
SELECT
    CODE_HORSE,
    NAME,
    MARK,
    DEPTH
FROM
    PEDIGREE

Notes on recursive CTEs

- Aggregates (DISTINCT, GROUP BY, HAVING) and aggregate functions (SUM, COUNT, MAX etc) are not allowed in recursive union members.

- A recursive reference cannot participate in an outer join.

- The maximum recursion depth is 1024.

6.1.18. Full SELECT Syntax

The previous sections used incomplete or simplified fragments of the SELECT syntax. Following is the full syntax.
Where possible, the syntax below uses syntax names from the SQL standard, which do not necessarily match the syntax names in the Firebird source. In some cases, syntax productions have been collapsed, because the productions in the SQL standard are verbose as they are also used to add additional rules or definitions to a syntax element.

Although this is intended as the full syntax, some productions are not shown (e.g. `<value-expression>`) and assumed to be clear for the reader, and in some cases we take shortcuts like using `query-name` or `column-alias` for identifiers in a syntax production.

If you come across situations where these shortcuts do result in lack of clarity or other issues, let us know on [https://github.com/FirebirdSQL/firebird-documentation](https://github.com/FirebirdSQL/firebird-documentation) or on firebird-devel.

The syntax below does not include the PSQL SELECT … INTO syntax, which is essentially `<cursor-specification> INTO <variable-list>`.

```
<cursor-specification> ::=<br> <query-expression> [<updatability-clause>] [<lock-clause>]

<query-expression> ::=<br> [<with-clause>] <query-expression-body> [<order-by-clause>]
[ { <rows-clause>
  | [<result-offset-clause>] [<fetch-first-clause>] } ]

<with-clause> ::=<br> WITH [RECURSIVE] <with-list-element> [, <with-list-element> ...]

<with-list-element> ::=<br> query-name [((<column-name-list>))] AS (<query-expression>)

<column-name-list> ::= column-name [, column-name ...]

<query-expression-body> ::=<br> <query-term>
| <query-expression-body> UNION [{ DISTINCT | ALL }] <query-term>

<query-term> ::= <query-primary>

<query-primary> ::=<br> <query-specification>
| (<query-expression-body> [<order-by-clause>]
  [<result-offset-clause>] [<fetch-first-clause>])

<query-specification> ::=<br> SELECT <limit-clause> [{ ALL | DISTINCT }] <select-list>
  FROM <table-reference> [, <table-reference> ...]
  [WHERE <search-condition>]
```
Chapter 6. Data Manipulation (DML) Statements

[group-by <value-expression> [, <value-expression> ...]]
[having <search-condition>]
[window <window-definition> [, <window-definition> ...]]
[plan <plan-expression>]

<limit-clause> ::= [first <limit-expression>] [skip <limit-expression>]

<limit-expression> ::= 
  <integer-literal>
  | <query-parameter>
  | (<value-expression>)

<select-list> ::= * | <select-sublist> [, <select-sublist> ...]

<select-sublist> ::= 
  table-alias.*
  | <value-expression> [[as] column-alias]

<table-reference> ::= <table-primary> | <joined-table>

<table-primary> ::= 
  <table-or-query-name> [[as] correlation-name]
  | [lateral] <derived-table> [correlation-or-recognition]
  | <parenthesized-joined-table>

<table-or-query-name> ::= 
  table-name
  | query-name
  | [package-name.]procedure-name ((<procedure-args>))

<procedure-args> ::= <value-expression> [, <value-expression> ...]

<correlation-or-recognition> ::= 
  [as] correlation-name ((<column-name-list>))

<derived-table> ::= (<query-expression>)

<parenthesized-joined-table> ::= 
  (<parenthesized-joined-table>)
  | (<joined-table>)

<joined-table> ::= 
  <cross-join>
  | <natural-join>
  | <qualified-join>

<cross-join>
  <table-reference> cross join <table-primary>

<natural-join> ::= 
  <table-reference> natural [join-type] join <table-primary>
<join-type> ::= INNER | { LEFT | RIGHT | FULL } [OUTER]

<qualified-join> ::= 
<table-reference> [<join-type>] JOIN <table-primary> 
{ ON <search-condition> 
 | USING (<column-name-list>) }

>window-definition ::= 
new-window-name AS (<window-specification-details>)

>window-specification-details ::= 
[existing-window-name] 
[<window-partition-clause>] 
[<order-by-clause>] 
[<window-frame-clause>]

>window-partition-clause ::= 
PARTITION BY <value-expression> [, <value-expression> ...]

/order-by-clause ::= 
ORDER BY <sort-specification> [, <sort-specification> ...]

<sort-specification ::= 
<value-expression> [ordering-specification] [null-ordering]

/ordering-specification ::= 
ASC | ASCENDING
| DESC | DESCENDING

/null-ordering ::= 
NULLS FIRST
| NULLS LAST

/window-frame-clause ::= { RANGE | ROWS } <window-frame-extent>

/window-frame-extent ::= 
>window-frame-start
| <window-frame-between>

/window-frame-start ::= 
UNBOUNDED PRECEDING
| <value-expression> PRECEDING
| CURRENT ROW

/window-frame-between ::= 
BETWEEN { UNBOUNDED PRECEDING | <value-expression> PRECEDING
 | CURRENT ROW | <value-expression> FOLLOWING }
| <value-expression> PRECEDING | CURRENT ROW
| <value-expression> FOLLOWING | UNBOUNDED FOLLOWING }
6.2. INSERT

Inserts rows of data into a table or updatable view

Syntax

```
INSERT INTO target
{ DEFAULT VALUES
  | [(col_name_list)] [override_opt] <value-source> }
[RETURNING <returning_list> [INTO <variables>]]
```

```
<column_list> ::= col_name [, col_name ...]
```

```
<override_opt> ::= OVERRIDING {USER | SYSTEM} VALUE
```

```
<value-source> ::= VALUES (<value-list>) | <query-expression>
```

```
<value-list> ::= <ins-value> [, <ins-value> ...]
```

```
<ins-value> ::= <value-expression> | DEFAULT
```

```
<returning_list> ::= * | <output_column> [, <output_column]...
```

```
<output_column> ::= target.*
  | <return_expression> [COLLATE collation] [AS] alias
```

```
<return_expression> ::= <value-expression>
  | [target.]col_name
```

```
<value-expression> ::= 
```
<literal> | <context-variable>
| any other expression returning a single value of a Firebird data type or NULL

<variables> ::= [:]varname [, [:]varname ...]

Table 87. Arguments for the INSERT Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>The name of the table or view to which a new row, or batch of rows, should be added</td>
</tr>
<tr>
<td>col_name</td>
<td>Name of a table or view column</td>
</tr>
<tr>
<td>value-expression</td>
<td>An expression whose value is used for inserting into the table or for returning</td>
</tr>
<tr>
<td>return_expression</td>
<td>The expression to be returned in the RETURNING clause</td>
</tr>
<tr>
<td>literal</td>
<td>A literal</td>
</tr>
<tr>
<td>context-variable</td>
<td>Context variable</td>
</tr>
<tr>
<td>varname</td>
<td>Name of a PSQL local variable</td>
</tr>
</tbody>
</table>

The INSERT statement is used to add rows to a table or to one or more tables underlying a view:

- If the column values are supplied in a VALUES clause, exactly one row is inserted
- The values may be provided instead by a SELECT expression, in which case zero to many rows may be inserted
- With the DEFAULT VALUES clause, no values are provided at all and exactly one row is inserted.

Restrictions

- Columns returned to the NEW.column_name context variables in DML triggers should not have a colon (";") prefixed to their names
- No column may appear more than once in the column list.

**ALERT**: BEFORE INSERT Triggers

Regardless of the method used for inserting rows, be mindful of any columns in the target table or view that are populated by BEFORE INSERT triggers, such as primary keys and case-insensitive search columns. Those columns should be excluded from both the column_list and the VALUES list if, as they should, the triggers test the NEW.column_name for NULL.

6.2.1. INSERT ... VALUES

The VALUES list must provide a value for every column in the column list, in the same order and of the correct type. The column list need not specify every column in the target but, if the column list is absent, the engine requires a value for every column in the table or view (computed columns
The expression `DEFAULT` allows a column to be specified in the column list, but instructs Firebird to use the default value (either `NULL` or the value specified in the `DEFAULT` clause of the column definition). For identity columns, specifying `DEFAULT` will generate the identity value. It is possible to include calculated columns in the column list and specifying `DEFAULT` as the column value.

**Introducer syntax** provides a way to identify the character set of a value that is a string constant (literal). Introducer syntax works only with literal strings: it cannot be applied to string variables, parameters, column references or values that are expressions.

**Examples**

```sql
INSERT INTO cars (make, model, year)
VALUES ('Ford', 'T', 1908);

INSERT INTO cars
VALUES ('Ford', 'T', 1908, 'USA', 850);

-- notice the '_' prefix (introducer syntax)
INSERT INTO People
VALUES (_ISO8859_1 'Hans-Jörg Schäfer');
```

### 6.2.2. INSERT … SELECT

For this method of inserting, the output columns of the `SELECT` statement (or `<query-expression>`) must provide a value for every target column in the column list, in the same order and of the correct type.

Literal values, context variables or expressions of compatible type can be substituted for any column in the source row. In this case, a source column list and a corresponding `VALUES` list are required.

If the column list is absent—as it is when `SELECT *` is used for the source expression—the `column_list` must contain the names of every column in the target table or view (computed columns excluded).

**Examples**

```sql
INSERT INTO cars (make, model, year)
SELECT make, model, year
FROM new_cars;

INSERT INTO cars
SELECT * FROM new_cars;

INSERT INTO Members (number, name)
SELECT number, name FROM NewMembers;
```
WHERE Accepted = 1
UNION ALL
SELECT number, name FROM SuspendedMembers
WHERE Vindicated = 1

INSERT INTO numbers(num)
WITH RECURSIVE r(n) as (
    SELECT 1 FROM rdb$database
    UNION ALL
    SELECT n+1 FROM r WHERE n < 100
)
SELECT n FROM r

Of course, the column names in the source table need not be the same as those in the target table. Any type of SELECT statement is permitted, as long as its output columns exactly match the insert columns in number, order and type. Types need not be the same, but they must be assignment-compatible.

Since Firebird 5.0, an INSERT … SELECT with a RETURNING clause produces zero or more rows, and the statement is described as type isc_info_sql_stmt_select. In other words, an INSERT … SELECT … RETURNING will no longer produce a “multiple rows in singleton select” error when the select produces multiple rows.

For the time being, a INSERT … VALUES (…) or INSERT … DEFAULT VALUES with a RETURNING clause is still described as isc_info_sql_stmt_exec_procedure. This behaviour may change in a future Firebird version.

### 6.2.3. INSERT … DEFAULT VALUES

The DEFAULT VALUES clause allows insertion of a record without providing any values at all, either directly or from a SELECT statement. This is only possible if every NOT NULL or CHECKed column in the table either has a valid default declared or gets such a value from a BEFORE INSERT trigger. Furthermore, triggers providing required field values must not depend on the presence of input values.

Specifying DEFAULT VALUES is equivalent to specifying a values list with expression DEFAULT for all columns.

**Example**

```sql
INSERT INTO journal
DEFAULT VALUES
RETURNING entry_id;
```

### 6.2.4. OVERRIDING

The OVERRIDING clause controls the behaviour of an identity column for this statement only.
OVERRIDING SYSTEM VALUE

The user-provided value for the identity column is used, and no value is generated using the identity. In other words, for this insert, the identity will behave as if it is \textit{GENERATED BY DEFAULT}. This option can only be specified for tables with a \textit{GENERATED ALWAYS} identity column.

This can be useful when merging or importing data from another source. After such an insert, it may be necessary to change the next value of the identity sequence using \texttt{ALTER TABLE} to prevent subsequent inserts from generating colliding identity values.

OVERRIDING USER VALUE

The user-provided value for the identity column is ignored, and the column value is generated using the identity. In other words, for this insert, the identity will behave as if it is \textit{GENERATED ALWAYS}, while allowing the identity column in the column-list. This option can be specified for both types of identity columns.

It is usually simpler to leave out the identity column to achieve the same effect.

\textit{Examples of OVERRIDING}

\begin{verbatim}
-- for ALWAYS
-- value 11 is used anyway
insert into objects_always (id, name)
  OVERRIDING SYSTEM VALUE values (11, 'Laptop');

-- for both ALWAYS and BY DEFAULT
-- value 12 is not used
insert into objects_default (id, name)
  OVERRIDING USER VALUE values (12, 'Laptop');
\end{verbatim}

6.2.5. The \texttt{RETURNING} Clause

An \texttt{INSERT} statement may optionally include a \texttt{RETURNING} clause to return values from the inserted rows. The clause, if present, need not contain all columns referenced in the insert statement and may also contain other columns or expressions. The returned values reflect any changes that may have been made in \texttt{BEFORE INSERT} triggers.

The user executing the statement needs to have \texttt{SELECT} privileges on the columns specified in the \texttt{RETURNING} clause.

The syntax of the \textit{returning list} is similar to the column list of a \texttt{SELECT} clause. It is possible to reference all columns using \texttt{*} or \texttt{table_name.*}.

The optional \texttt{INTO} sub-clause is only valid in PSQL.

\begin{quote}
\textbf{Caveats for updatable views}

The values reported by \texttt{RETURNING} for updatable views may be incorrect if the view is made updatable through triggers. See \texttt{The RETURNING clause and updatable views}.
\end{quote}
Multiple INSERTs

In DSQL, an INSERT … VALUES (…) RETURNING or INSERT … DEFAULT VALUES RETURNING returns only one row, and a INSERT … SELECT … RETURNING can return zero or more rows.

In PSQL, if the RETURNING clause is specified and more than one row is inserted by the INSERT statement, the statement fails and a “multiple rows in singleton select” error is returned. This behaviour may change in future Firebird versions.

Examples

```sql
INSERT INTO Scholars (firstname, lastname, address, phone, email)
VALUES ('Henry', 'Higgins', '27A Wimpole Street', '3231212', NULL)
RETURNING lastname, fullname, id;

INSERT INTO Scholars (firstname, lastname, address, phone, email)
VALUES ('Henry', 'Higgins', '27A Wimpole Street', '3231212', NULL)
RETURNING *;

INSERT INTO Dumbbells (firstname, lastname, iq)
SELECT fname, lname, iq
FROM Friends
ORDER BY iq ROWS 1
RETURNING id, firstname, iq
INTO :id, :fname, :iq;
```

- In DSQL, an INSERT … VALUES (…) RETURNING always returns exactly one row. This behaviour may change in a future Firebird version.
- In DSQL, an INSERT … DEFAULT VALUES RETURNING always returns exactly one row.
- In DSQL, an INSERT … SELECT … RETURNING returns zero or more rows.
- In PSQL, if multiple rows are returned, the statement fails with a “multiple rows in singleton select” error. This behaviour may change in a future Firebird version.
- In PSQL, if no row was inserted, nothing is returned, and the target variables keep their existing values.

6.2.6. Inserting into BLOB columns

Inserting into BLOB columns is only possible under the following circumstances:

1. The client application has made special provisions for such inserts, using the Firebird API.
this case, the *modus operandi* is application-specific and outside the scope of this manual.

2. The value inserted is a string literal of no more than 65,533 bytes (64KB - 3).

A limit, in characters, is calculated at run-time for strings that are in multi-byte character sets, to avoid overrunning the bytes limit. For example, for a UTF8 string (max. 4 bytes/character), the run-time limit is likely to be about \((\text{floor}(65533/4)) = 16383\) characters.

3. You are using the “INSERT … SELECT” form and one or more columns in the result set are BLOBs.

### 6.3. UPDATE

Updates existing rows in tables and updatable views

**Syntax**

```
UPDATE target [[[AS] alias]
    SET col_name = <upd_value> [, col_name = <upd_value> ...]
    [WHERE {<search-conditions> | CURRENT OF cursorname}]
    [PLAN <plan_items>]
    [ORDER BY <sort_items>]
    [ROWS m [TO n]]
    [SKIP LOCKED]
    [RETURNING <returning_list> [INTO <variables>]]
```

<upd_value> ::= <value-expression> | DEFAULT

<returning_list> ::= * | <output_column> [, <output_column>]

<output_column> ::= target.* | NEW.* | OLD.*
    | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression> ::=<value-expression>
    | [target.]col_name
    | NEW.col_name
    | OLD.col_name

<value-expression> ::=<literal>
    | <context-variable>
    | any other expression returning a single value of a Firebird data type or NULL

<variables> ::= [::]varname [, [::]varname ...]
```

*Table 88. Arguments for the UPDATE Statement Parameters*
The `UPDATE` statement changes values in a table or in one or more of the tables that underlie a view. The columns affected are specified in the `SET` clause. The rows affected may be limited by the `WHERE` and `ROWS` clauses. If neither `WHERE` nor `ROWS` is present, all records in the table will be updated.

### 6.3.1. Using an alias

If you assign an alias to a table or a view, the alias must be used when specifying columns and also in any column references included in other clauses.

**Example**

Correct usage:

```sql
update Fruit set soort = 'pisang' where ...
update Fruit set Fruit.soort = 'pisang' where ...
update Fruit F set soort = 'pisang' where ...
update Fruit F set F.soort = 'pisang' where ...
```

Not possible:

```sql
update Fruit F set Fruit.soort = 'pisang' where ...
```
6.3.2. The SET Clause

In the SET clause, the assignment expressions, containing the columns with the values to be set, are separated by commas. In an assignment expression, column names are on the left and the values or expressions to assign are on the right. A column may be assigned only once in the SET clause.

A column name can be used in expressions on the right. The old value of the column will always be used in these right-side values, even if the column was already assigned a new value earlier in the SET clause.

Using the expression DEFAULT will set the column to its default value (either NULL or the value specified on the DEFAULT clause of the column definition). For an identity column, specifying DEFAULT will generate a new identity value. It is possible to “update” calculated columns in the SET clause if and only if the assigned value is DEFAULT.

It is not possible to assign DEFAULT as a parameter value.

Here is an example

Data in the TSET table:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

The statement:

```
UPDATE tset SET a = 5, b = a;
```

will change the values to:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Notice that the old values (1 and 2) are used to update the b column even after the column was assigned a new value (5).

6.3.3. The WHERE Clause

The WHERE clause sets the conditions that limit the set of records for a searched update.

In PSQL, if a named cursor is being used for updating a set, using the WHERE CURRENT OF clause, the action is limited to the row where the cursor is currently positioned. This is a positioned update.
To be able to use the WHERE CURRENT OF clause in DSQL, the cursor name needs to be set on the statement handle before executing the statement.

Examples

```
UPDATE People
    SET firstname = 'Boris'
    WHERE lastname = 'Johnson';

UPDATE employee e
    SET salary = salary * 1.05
    WHERE EXISTS(
        SELECT *
        FROM employee_project ep
        WHERE e.emp_no = ep.emp_no);

UPDATE addresses
    SET city = 'Saint Petersburg', citycode = 'PET'
    WHERE city = 'Leningrad'

UPDATE employees
    SET salary = 2.5 * salary
    WHERE title = 'CEO'
```

For string literals with which the parser needs help to interpret the character set of the data, the introducer syntax may be used. The string literal is preceded by the character set name, prefixed with an underscore character:

```
-- notice the '_' prefix

UPDATE People
    SET name = _ISO8859_1 'Hans-Jörg Schäfer'
    WHERE id = 53662;
```

### 6.3.4. The ORDER BY and ROWS Clauses

The ORDER BY and ROWS clauses make sense only when used together. However, they can be used separately.

If ROWS has one argument, $m$, the rows to be updated will be limited to the first $m$ rows.

**Points to note**

- If $m >$ the number of rows being processed, the entire set of rows is updated
- If $m = 0$, no rows are updated
- If $m < 0$, an error occurs and the update fails

If two arguments are used, $m$ and $n$, ROWS limits the rows being updated to rows from $m$ to $n$
inclusively. Both arguments are integers and start from 1.

**Points to note**

- If \( m > \) the number of rows being processed, no rows are updated
- If \( n > \) the number of rows, rows from \( m \) to the end of the set are updated
- If \( m < 1 \) or \( n < 1 \), an error occurs and the update fails
- If \( n = m - 1 \), no rows are updated
- If \( n < m - 1 \), an error occurs and the update fails

**ROWS Example**

```sql
UPDATE employees
SET salary = salary + 50
ORDER BY salary ASC
ROWS 20;
```

### 6.3.5. The **SKIP LOCKED** Clause

When the **SKIP LOCKED** clause is specified, records locked by a different transaction are skipped by the statement and are not updated.

When a **ROWS** clause is specified, the “skip locked” check is performed after skipping the requested number of rows specified, and before counting the number of rows to update.

### 6.3.6. The **RETURNING** Clause

An **UPDATE** statement may include **RETURNING** to return some values from the updated rows. **RETURNING** may include data from any column of the row, not only the columns that are updated by the statement. It can include literals or expressions not associated with columns, if there is a need for that.

The user executing the statement needs to have **SELECT** privileges on the columns specified in the **RETURNING** clause.

When the **RETURNING** set contains data from the current row, the returned values report changes made in the **BEFORE UPDATE** triggers, but not those made in **AFTER UPDATE** triggers.

The context variables **OLD.fieldname** and **NEW.fieldname** can be used as column names. If **OLD.** or **NEW.** is not specified, or if the table name (**target**) is specified instead, the column values returned are the **NEW.** ones.

The syntax of the **returning_list** is similar to the column list of a **SELECT** clause. It is possible to reference all columns using ***, or table_name.*, **NEW.* and/or **OLD.*.

In **DSQL**, a positioned update statement (**WHERE CURRENT OF ...**) with **RETURNING** always returns a single row, a normal update statement can return zero or more rows. The update is executed to completion before rows are returned. In **PSQL**, attempts to execute an **UPDATE ... RETURNING** that affects multiple rows will result in the error “multiple rows in singleton select”. This behaviour may
change in a future Firebird version.

**The INTO Sub-clause**

In PSQL, the INTO clause can be used to pass the returning values to local variables. It is not available in DSQL. If no records are updated, nothing is returned and variables specified in RETURNING will keep their previous values.

**RETURNING Example (DSQL)**

```sql
UPDATE Scholars
SET firstname = 'Hugh', lastname = 'Pickering'
WHERE firstname = 'Henry' and lastname = 'Higgins'
RETURNING id, old.lastname, new.lastname;
```

### 6.3.7. Updating BLOB columns

Updating a BLOB column always replaces the entire contents. Even the BLOB ID, the “handle” that is stored directly in the column, is changed. BLOBs can be updated if:

1. The client application has made special provisions for this operation, using the Firebird API. In this case, the modus operandi is application-specific and outside the scope of this manual.
2. The new value is a string literal of no more than 65,533 bytes (64KB - 3).

A limit, in characters, is calculated at run-time for strings that are in multi-byte character sets, to avoid overrunning the bytes limit. For example, for a UTF8 string (max. 4 bytes/character), the run-time limit is likely to be about (floor(65533/4)) = 16383 characters.

3. The source is itself a BLOB column or, more generally, an expression that returns a BLOB.
4. You use the INSERT CURSOR statement (ESQL only).

### 6.4. UPDATE OR INSERT

Updates existing rows in a table or updatable view, or — if it does not exist — inserts it

**Syntax**

```sql
UPDATE OR INSERT INTO
    target [(<column_list>)]
    [<override_opt>]
VALUES (<value_list>)
    [MATCHING (<column_list>)]
    [ORDER BY <ordering-list>]
    [ROWS <m> [TO <n>]]
    [RETURNING <returning_list> [INTO <variables>]]
```
Table 89. Arguments for the UPDATE OR INSERT Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>The name of the table or view where the record(s) is to be updated or a new record inserted</td>
</tr>
<tr>
<td>col_name</td>
<td>Name of a column in the table or view</td>
</tr>
<tr>
<td>value-expression</td>
<td>An expression whose value is to be used for inserting or updating the table, or returning a value</td>
</tr>
<tr>
<td>return_expression</td>
<td>An expression returned in the RETURNING clause</td>
</tr>
<tr>
<td>varname</td>
<td>Variable name — PSQL only</td>
</tr>
</tbody>
</table>

UPDATE OR INSERT inserts a new record or updates one or more existing records. The action taken depends on the values provided for the columns in the MATCHING clause (or, if the latter is absent, in the primary key). If there are records found matching those values, they are updated. If not, a new record is inserted. A match only counts if all the columns in the MATCHING clause or primary key columns are equal. Matching is done with the IS NOT DISTINCT operator, so one NULL matches another.
• If the table has no primary key, the MATCHING clause is mandatory.
• In the MATCHING list as well as in the update/insert column list, each column name may occur only once.
• The “INTO <variables>” subclause is only available in PSQL.
• When values are returned into the context variable NEW, this name must not be preceded by a colon (“:").

6.4.1. The ORDER BY and ROWS Clauses

See The ORDER BY and ROWS Clauses for UPDATE.

6.4.2. The RETURNING Clause

The optional RETURNING clause, if present, need not contain all the columns mentioned in the statement and may also contain other columns or expressions. The returned values reflect any changes that may have been made in BEFORE triggers, but not those in AFTER triggers. OLD.fieldname and NEW.fieldname may both be used in the list of columns to return; for field names not preceded by either of these, the new value is returned.

The user executing the statement needs to have SELECT privileges on the columns specified in the RETURNING clause.

The syntax of the returning_list is similar to the column list of a SELECT clause. It is possible to reference all columns using *, or table_name.*, NEW.* and/or OLD.*.

In DSQL, a statement with a RETURNING clause can return zero or more rows. The update or insert is executed to completion before rows are returned. In PSQL, if a RETURNING clause is present and more than one matching record is found, an error “multiple rows in singleton select” is raised. This behaviour may change in a future Firebird version.

The optional INTO sub-clause is only valid in PSQL.

6.4.3. Example of UPDATE OR INSERT

Modifying data in a table, using UPDATE OR INSERT in a PSQL module. The return value is passed to a local variable, whose colon prefix is optional.

```
UPDATE OR INSERT INTO Cows (Name, Number, Location)
VALUES ('Suzy Creamcheese', 3278823, 'Green Pastures')
MATCHING (Number)
RETURNING rec_id into :id;

UPDATE OR INSERT INTO Cows (Name, Number, Location)
VALUES ('Suzy Creamcheese', 3278823, 'Green Pastures')
MATCHING (Number)
RETURNING old.*, new.*;
```
6.5. DELETE

Deletes rows from a table or updatable view

Syntax

DELETE
FROM target [[AS] alias]
[WHERE {<search-conditions> | CURRENT OF cursorname}]
[PLAN <plan_items>]
[ORDER BY <sort_items>]
[ROWS m [TO n]]
[SKIP LOCKED]
[RETURNING <returning_list> [INTO <variables>]]

Table 90. Arguments for the DELETE Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>The name of the table or view from which the records are to be deleted</td>
</tr>
<tr>
<td>alias</td>
<td>Alias for the target table or view</td>
</tr>
<tr>
<td>search-conditions</td>
<td>Search condition limiting the set of rows being targeted for deletion</td>
</tr>
<tr>
<td>cursorname</td>
<td>The name of the cursor in which current record is positioned for deletion</td>
</tr>
<tr>
<td>plan_items</td>
<td>Query plan clause</td>
</tr>
<tr>
<td>sort_items</td>
<td>ORDER BY clause</td>
</tr>
<tr>
<td>m, n</td>
<td>Integer expressions for limiting the number of rows being deleted</td>
</tr>
<tr>
<td>return_expression</td>
<td>An expression to be returned in the RETURNING clause</td>
</tr>
<tr>
<td>value-expression</td>
<td>An expression whose value is used for returning</td>
</tr>
<tr>
<td>Argument</td>
<td>Description</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
</tr>
<tr>
<td>varname</td>
<td>Name of a PSQL variable</td>
</tr>
</tbody>
</table>

DELETE removes rows from a database table or from one or more of the tables that underlie a view. WHERE and ROWS clauses can limit the number of rows deleted. If neither WHERE nor ROWS is present, DELETE removes all the rows in the relation.

### 6.5.1. Aliases

If an alias is specified for the target table or view, it must be used to qualify all field name references in the DELETE statement.

**Examples**

Supported usage:

```sql
delete from Cities where name starting 'Alex';
delete from Cities where Cities.name starting 'Alex';
delete from Cities C where name starting 'Alex';
delete from Cities C where C.name starting 'Alex';
```

Not possible:

```sql
delete from Cities C where Cities.name starting 'Alex';
```

### 6.5.2. WHERE

The WHERE clause sets the conditions that limit the set of records for a searched delete.

In PSQL, if a named cursor is being used for deleting a set, using the WHERE CURRENT OF clause, the action is limited to the row where the cursor is currently positioned. This is a positioned delete.

To be able to use the WHERE CURRENT OF clause in DSQL, the cursor name needs to be set on the statement handle before executing the statement.

**Examples**

```sql
DELETE FROM People
WHERE firstname <> 'Boris' AND lastname <> 'Johnson';

DELETE FROM employee e
WHERE NOT EXISTS(
  SELECT *
```
FROM employee_project ep
    WHERE e.emp_no = ep.emp_no);

DELETE FROM Cities
    WHERE CURRENT OF Cur_Cities;  -- ESQL and PSQL only

6.5.3. PLAN

A PLAN clause allows the user to optimize the operation manually.

Example

DELETE FROM Submissions
    WHERE date_entered < '1-Jan-2002'
    PLAN (Submissions INDEX ix_subm_date);

6.5.4. ORDER BY and ROWS

The ORDER BY clause orders the set before the actual deletion takes place. It only makes sense in combination with ROWS, but is also valid without it.

The ROWS clause limits the number of rows being deleted. Integer literals or any integer expressions can be used for the arguments \( m \) and \( n \).

If ROWS has one argument, \( m \), the rows to be deleted will be limited to the first \( m \) rows.

Points to note

- If \( m > \) the number of rows being processed, the entire set of rows is deleted
- If \( m = 0 \), no rows are deleted
- If \( m < 0 \), an error occurs and the deletion fails

If two arguments are used, \( m \) and \( n \), ROWS limits the rows being deleted to rows from \( m \) to \( n \) inclusively. Both arguments are integers and start from 1.

Points to note

- If \( m > \) the number of rows being processed, no rows are deleted
- If \( m > 0 \) and \( <= \) the number of rows in the set and \( n \) is outside these values, rows from \( m \) to the end of the set are deleted
- If \( m < 1 \) or \( n < 1 \), an error occurs and the deletion fails
- If \( n = m - 1 \), no rows are deleted
- If \( n < m -1 \), an error occurs and the deletion fails

Examples

Deleting the oldest purchase:
DELETING FROM Purchases
ORDER BY date ROWS 1;

Deleting the highest custno(s):

DELETING FROM Sales
ORDER BY custno DESC ROWS 1 to 10;

Deleting all sales, ORDER BY clause pointless:

DELETING FROM Sales
ORDER BY custno DESC;

Deleting one record starting from the end, i.e. from Z...:

DELETING FROM popgroups
ORDER BY name DESC ROWS 1;

Deleting the five oldest groups:

DELETING FROM popgroups
ORDER BY formed ROWS 5;

No sorting (ORDER BY) is specified so 8 found records, starting from the fifth one, will be deleted:

DELETING FROM popgroups
ROWS 5 TO 12;

6.5.5. SKIP LOCKED

When the SKIP LOCKED clause is specified, records locked by a different transaction are skipped by the statement and are not deleted.

When a ROWS clause is specified, the “skip locked” check is performed after skipping the requested number of rows specified, and before counting the number of rows to delete.

6.5.6. RETURNING

A DELETE statement may optionally include a RETURNING clause to return values from the deleted rows. The clause, if present, need not contain all the relation’s columns and may also contain other columns or expressions.

The user executing the statement needs to have SELECT privileges on the columns specified in the
RETURNING clause.

The syntax of the returning_list is similar to the column list of a SELECT clause. It is possible to reference all columns using *, or table_name.*.

- In DSQL, a positioned delete statement (WHERE CURRENT OF ...) with RETURNING always returns a singleton, never a multi-row set. If no records is deleted, the returned columns contain NULL.
- A normal DELETE statement can return zero or more rows; the deletion is executed to completion before rows are returned.
- In PSQL, if a RETURNING clause is present and more than one matching record is found, an error “multiple rows in singleton select” is raised. This behaviour may change in a future Firebird version.
- The INTO clause is available only in PSQL
  - If no row is deleted, nothing is returned and the target variables keep their values

Examples

```sql
DELETE FROM Scholars
  WHERE firstname = 'Henry' and lastname = 'Higgins'
RETURNING lastname, fullname, id;

DELETE FROM Scholars
  WHERE firstname = 'Henry' and lastname = 'Higgins'
RETURNING *;

DELETE FROM Dumbbells
ORDER BY iq DESC
ROWS 1
RETURNING lastname, iq into :lname, :iq;
```

### 6.6. MERGE

Merges data from a source set into a target table or updatable view

**Syntax**

```sql
MERGE INTO target [[AS] target_alias]
  USING <table-reference>
  ON <join_condition>
  <merge_when> [<merge_when> ...]
  [PLAN <plan-expr>]
  [ORDER BY <ordering-list>]
  [RETURNING <returning_list> [INTO <variables>]]
  <merge_when> ::= 
```
Chapter 6. Data Manipulation (DML) Statements

<merge_when_matched>
 | <merge_when_not_matched_target>
 | <merge_when_not_matched_source>

<merge_when_matched> ::= WHEN MATCHED [AND <condition>] THEN { UPDATE SET <assignment-list>
 | DELETE }

<merge_when_not_matched_target> ::= WHEN NOT MATCHED [BY TARGET] [AND <condition>] THEN INSERT [( <column_list> )] [<override_opt>] VALUES ( <value_list> )

<merge_when_not_matched_source> ::= WHEN NOT MATCHED BY SOURCE [ AND <condition> ] THEN { UPDATE SET <assignment-list>
 | DELETE }

<table-reference> ::= <table-primary> | <joined-table>

<table-primary> ::= <table-or-query-name> [[AS] correlation-name]
 | [LATERAL] <derived-table> [<correlation-or-recognition>]
 | <parenthesized-joined-table>

<assignment_list ::= col_name = <m_value> [, <col_name> = <m_value> ...]]

<override_opt> ::= OVERRIDE {USER | SYSTEM} VALUE

<column_list ::= colname [, colname ...]

<value_list ::= <m_value> [, <m_value> ...]

<m_value ::= <value-expression> | DEFAULT

<returning_list ::= * | <output_column> [, <output_column]

<output_column ::= target.* | NEW.* | OLD.*
 | <return_expression> [COLLATE collation] [[AS] alias]

<return_expression ::= <value-expression>
 | [target.]col_name
 | NEW.col_name
 | OLD.col_name

有价值表达式
any other expression returning a single value of a Firebird data type or NULL

Table 91. Arguments for the MERGE Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>Name of target relation (table or updatable view)</td>
</tr>
<tr>
<td>table-reference</td>
<td>Data source. It can be a table, a view, a stored procedure, a derived table or a parenthesized joined table</td>
</tr>
<tr>
<td>target_alias</td>
<td>Alias for the target relation (table or updatable view)</td>
</tr>
<tr>
<td>join_conditions</td>
<td>The (ON) condition(s) for matching the source records with those in the target</td>
</tr>
<tr>
<td>condition</td>
<td>Additional test condition in WHEN MATCHED or WHEN NOT MATCHED clause</td>
</tr>
<tr>
<td>col_name</td>
<td>Name of a column in the target relation</td>
</tr>
<tr>
<td>value-expression</td>
<td>The value assigned to a column in the target table. This expression may be a literal value, a PSQL variable, a column from the source, or a compatible context variable</td>
</tr>
<tr>
<td>return_expression</td>
<td>The expression to be returned in the RETURNING clause Can be a column reference to source or target, or a column reference of the NEW or OLD context of the target, or a value.</td>
</tr>
<tr>
<td>ret_alias</td>
<td>Alias for the value expression in the RETURNING clause</td>
</tr>
<tr>
<td>varname</td>
<td>Name of a PSQL local variable</td>
</tr>
</tbody>
</table>

The MERGE statement merges records from a source `<table-reference>` into a target table or updatable view. The source may be a table, view or “anything you can SELECT from” in general. Each source record will be used to update one or more target records, insert a new record in the target table, delete a record from the target table or do nothing.

The action taken depends on the supplied join condition, the WHEN clause(s), and the — optional — condition in the WHEN clause. The join condition and condition in the WHEN will typically contain a comparison of fields in the source and target relations.

Multiple WHEN MATCHED and WHEN NOT MATCHED clauses are allowed. For each row in the source, the WHEN clauses are checked in the order they are specified in the statement. If the condition in the WHEN clause does not evaluate to true, the clause is skipped, and the next clause will be checked. This will be done until the condition for a WHEN clause evaluates to true, or a WHEN clauses without condition matches, or there are no more WHEN clauses. If a matching clause is found, the action associated with the clause is executed. For each row in the source, at most one action is executed. If the WHEN MATCHED clause is present, and several records match a single record in the target table, an error is raised.
Contrary to the other WHEN clauses, the WHEN NOT MATCHED BY SOURCE clauses evaluates records in the target which match no record in source.

At least one WHEN clause must be present.

WHEN NOT MATCHED is evaluated from the source viewpoint, that is, the table or set specified in USING. It has to work this way because if the source record does not match a target record, INSERT is executed. Of course, if there is a target record which does not match a source record, nothing is done.

Currently, in PSQL, the ROW_COUNT variable returns the value 1, even if more than one record is modified or inserted. For details and progress, refer to firebird#4722.

### 6.6.1. The ORDER BY Clause

The ORDER BY can be used to influence the order in which rows are evaluated. The primary use case is when combined with RETURNING, to influence the order rows are returned.

### 6.6.2. The RETURNING Clause

A MERGE statement can contain a RETURNING clause to return rows added, modified or removed. The merge is executed to completion before rows are returned. The RETURNING clause can contain any columns from the target table (or updatable view), as well as other columns (eg from the source) and expressions.

The user executing the statement needs to have SELECT privileges on the columns specified in the RETURNING clause.

In PSQL, if a RETURNING clause is present and more than one matching record is found, an error “multiple rows in singleton select” is raised. This behaviour may change in a future Firebird version.

The optional INTO sub-clause is only valid in PSQL.

Column names can be qualified by the OLD or NEW prefix to define exactly what value to return: before or after modification. The returned values include the changes made by BEFORE triggers.

The syntax of the returning_list is similar to the column list of a SELECT clause. It is possible to reference all columns using *, or table_name.*, NEW.* and/or OLD.*.

For the UPDATE or INSERT action, unqualified column names, or those qualified by the target table name or alias will behave as if qualified by NEW, while for the DELETE action as if qualified by OLD.

The following example modifies the previous example to affect one line, and adds a RETURNING clause to return the old and new quantity of goods, and the difference between those values.

**Using MERGE with a RETURNING clause**

```
MERGE INTO PRODUCT_INVENTORY AS TARGET
USING (
SELECT
    SL.ID_PRODUCT,
    SUM(SL.QUANTITY)
FROM SALES_ORDER_LINE SL
JOIN SALES_ORDER S ON S.ID = SL.ID_SALES_ORDER
WHERE S.BYDATE = CURRENT_DATE
    AND SL.ID_PRODUCT =: ID_PRODUCT
GROUP BY 1
) AS SRC (ID_PRODUCT, QUANTITY)
ON TARGET.ID_PRODUCT = SRC.ID_PRODUCT
WHEN MATCHED AND TARGET.QUANTITY - SRC.QUANTITY <= 0 THEN
    DELETE
WHEN MATCHED THEN
    UPDATE SET
        TARGET.QUANTITY = TARGET.QUANTITY - SRC.QUANTITY,
        TARGET.BYDATE = CURRENT_DATE
RETURNING OLD.QUANTITY, NEW.QUANTITY, SRC.QUANTITY
INTO : OLD_QUANTITY, :NEW_QUANTITY, :DIFF_QUANTITY

6.6.3. Examples of MERGE

1. Update books when present, or add new record if absent

    MERGE INTO books b
    USING purchases p
    ON p.title = b.title and p.type = 'bk'
    WHEN MATCHED THEN
        UPDATE SET b.desc = b.desc || '; ' || p.desc
    WHEN NOT MATCHED THEN
        INSERT (title, desc, bought) values (p.title, p.desc, p.bought);

2. Using a derived table

    MERGE INTO customers c
    USING (SELECT * from customers_delta WHERE id > 10) cd
    ON (c.id = cd.id)
    WHEN MATCHED THEN
        UPDATE SET name = cd.name
    WHEN NOT MATCHED THEN
        INSERT (id, name) values (cd.id, cd.name);

3. Together with a recursive CTE

    MERGE INTO numbers
    USING (
        WITH RECURSIVE r(n) AS (
            SELECT 1 FROM rdb$database
            ...
UNION ALL
    SELECT n+1 FROM r WHERE n < 200
)
SELECT n FROM r
) t
ON numbers.num = t.n
WHEN NOT MATCHED THEN
    INSERT(num) VALUES(t.n);

4. Using DELETE clause

MERGE INTO SALARY_HISTORY
USING (  
    SELECT EMP_NO  
    FROM EMPLOYEE  
    WHERE DEPT_NO = 120) EMP
ON SALARY_HISTORY.EMP_NO = EMP.EMP_NO
WHEN MATCHED THEN DELETE

5. The following example updates the PRODUCT_INVENTORY table daily based on orders processed in the SALES_ORDER_LINE table. If the stock level of the product would drop to zero or lower, then the row for that product is removed from the PRODUCT_INVENTORY table.

MERGE INTO PRODUCT_INVENTORY AS TARGET
USING (  
    SELECT  
        SL.ID_PRODUCT,  
        SUM (SL.QUANTITY)  
    FROM SALES_ORDER_LINE SL  
    JOIN SALES_ORDER S ON S.ID = SL.ID_SALES_ORDER  
    WHERE S.BYDATE = CURRENT_DATE  
    GROUP BY 1  
) AS SRC (ID_PRODUCT, QUANTITY)
ON TARGET.ID_PRODUCT = SRC.ID_PRODUCT
WHEN MATCHED AND TARGET.QUANTITY - SRC.QUANTITY <= 0 THEN
    DELETE
WHEN MATCHED THEN
    UPDATE SET  
        TARGET.QUANTITY = TARGET.QUANTITY - SRC.QUANTITY,  
        TARGET.BYDATE = CURRENT_DATE

See also
SELECT, INSERT, UPDATE, UPDATE OR INSERT, DELETE

6.7. EXECUTE PROCEDURE

Executes a stored procedure
**Syntax**

```sql
EXECUTE PROCEDURE procname
    [{ <inparam-list | ( <inparam-list> ) }]
    [RETURNING_VALUES { <outvar-list> | ( <outvar-list> ) }]
```

- `<inparam-list>` ::= 
  `<inparam> [, <inparam> ...]`

- `<outvar-list>` ::= 
  `<outvar> [, <outvar> ...]`

- `<outvar>` ::= `[:varname]`

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>procname</code></td>
<td>Name of the stored procedure</td>
</tr>
<tr>
<td><code>inparam</code></td>
<td>An expression evaluating to the declared data type of an input parameter</td>
</tr>
<tr>
<td><code>varname</code></td>
<td>A PSQL variable to receive the return value</td>
</tr>
</tbody>
</table>

Table 92. Arguments for the EXECUTE PROCEDURE Statement Parameters

Executes an *executable stored procedure*, taking a list of one or more input parameters, if they are defined for the procedure, and returning a one-row set of output values, if they are defined for the procedure.

### 6.7.1. “Executable” Stored Procedure

The `EXECUTE PROCEDURE` statement is most commonly used to invoke “executable” stored procedures to perform some data-modifying task at the server side — those that do not contain any `SUSPEND` statements in their code. They can be designed to return a result set, consisting of only one row, which is usually passed, via a set of `RETURNING_VALUES()` variables, to another stored procedure that calls it. Client interfaces usually have an API wrapper that can retrieve the output values into a single-row buffer when calling `EXECUTE PROCEDURE` in DSQL.

Invoking “selectable” stored procedures is also possible with `EXECUTE PROCEDURE`, but it returns only the first row of an output set which is almost surely designed to be multi-row. Selectable stored procedures are designed to be invoked by a `SELECT` statement, producing output that behaves like a virtual table.

- In PSQL and DSQL, input parameters may be any expression that resolves to the expected type.
- Although parentheses are not required after the name of the stored procedure to enclose the input parameters, their use is recommended for the sake of readability.
- Where output parameters have been defined in a procedure, the `RETURNING_VALUES` clause can be used in PSQL to retrieve them into a list of previously declared variables that conforms in sequence, data type and...
number with the defined output parameters.

- The list of RETURNING_VALUES may be optionally enclosed in parentheses and their use is recommended.
- When DSQL applications call EXECUTE PROCEDURE using the Firebird API or some form of wrapper for it, a buffer is prepared to receive the output row and the RETURNING_VALUES clause is not used.

### 6.7.2. Examples of EXECUTE PROCEDURE

1. In PSQL, with optional colons and without optional parentheses:

   ```sql
   EXECUTE PROCEDURE MakeFullName
   :FirstName, :MiddleName, :LastName
   RETURNING_VALUES :FullName;
   ```

2. In Firebird's command-line utility `isql`, with literal parameters and optional parentheses:

   ```sql
   EXECUTE PROCEDURE MakeFullName ('J', 'Edgar', 'Hoover');
   ```

   **Info**
   In DSQL (e.g. in `isql`), RETURNING_VALUES is not used. Any output values are captured by the application and displayed automatically.

3. A PSQL example with expression parameters and optional parentheses:

   ```sql
   EXECUTE PROCEDURE MakeFullName
   ('Mr./Mrs. ' || FirstName, MiddleName, upper(LastName))
   RETURNING_VALUES (FullName);
   ```

### 6.8. EXECUTE BLOCK

Creates an “anonymous” block of PSQL code in DSQL for immediate execution

*Available in*
DSQL

**Syntax**

```sql
EXECUTE BLOCK [(<inparams>)]
[RETURNS (<outparams>)]
<psql-module-body>

<inparams> ::= <param_decl> = ? [, <inparams> ]

<outparams> ::= <param_decl> [, <outparams>]
```
Table 93. Arguments for the EXECUTE BLOCK Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>param_decl</td>
<td>Name and description of an input or output parameter</td>
</tr>
<tr>
<td>paramname</td>
<td>The name of an input or output parameter of the procedural block, up to 63 characters long. The name must be unique among input and output parameters and local variables in the block</td>
</tr>
<tr>
<td>collation</td>
<td>Collation</td>
</tr>
</tbody>
</table>

Executes a block of PSQL code as if it were a stored procedure, optionally with input and output parameters and variable declarations. This allows the user to perform “on-the-fly” PSQL within a DSQL context.

6.8.1. Examples

1. This example injects the numbers 0 through 127 and their corresponding ASCII characters into the table ASCIITABLE:

   ```sql
   EXECUTE BLOCK
   AS
   declare i INT = 0;
   BEGIN
   WHILE (i < 128) DO
   BEGIN
   INSERT INTO AsciiTable VALUES (:i, ascii_char(:i));
   i = i + 1;
   END
   END
   END
   ```

2. The next example calculates the geometric mean of two numbers and returns it to the user:

   ```sql
   EXECUTE BLOCK (x DOUBLE PRECISION = ?, y DOUBLE PRECISION = ?)
   RETURNS (gmean DOUBLE PRECISION)
   AS
   BEGIN
   gmean = SQRT(x*y);
   SUSPEND;
   ```
Because this block has input parameters, it has to be prepared first. Then the parameters can be set and the block executed. It depends on the client software how this must be done and even if it is possible at all — see the notes below.

3. Our last example takes two integer values, smallest and largest. For all the numbers in the range smallest...largest, the block outputs the number itself, its square, its cube and its fourth power.

EXECUTE BLOCK (smallest INT = ?, largest INT = ?) 
RETURNS (number INT, square BIGINT, cube BIGINT, fourth BIGINT) 
AS 
BEGIN 
  number = smallest; 
  WHILE (number <= largest) DO 
    BEGIN 
      square = number * number; 
      cube   = number * square; 
      fourth = number * cube; 
      SUSPEND; 
      number = number + 1; 
    END 
  END 
END

Again, it depends on the client software if and how you can set the parameter values.

6.8.2. Input and output parameters

Executing a block without input parameters should be possible with every Firebird client that allows the user to enter their own DSQL statements. If there are input parameters, things get trickier: these parameters must get their values after the statement is prepared, but before it is executed. This requires special provisions, which not every client application offers. (Firebird's own isql, for one, doesn't.)

The server only accepts question marks ("?") as placeholders for the input values, not "":a", "":MyParam" etc., or literal values. Client software may support the "":xxx" form though, and will preprocess it before sending it to the server.

If the block has output parameters, you must use SUSPEND or nothing will be returned.

Output is always returned in the form of a result set, just as with a SELECT statement. You can't use RETURNING_VALUES or execute the block INTO some variables, even if there is only one result row.

PSQL Links

For more information about writing PSQL, consult Chapter Procedural SQL (PSQL)
6.8.3. Statement Terminators

Some SQL statement editors—specifically the `isql` utility that comes with Firebird, and possibly some third-party editors—employ an internal convention that requires all statements to be terminated with a semicolon. This creates a conflict with PSQL syntax when coding in these environments. If you are unacquainted with this problem and its solution, please study the details in the PSQL chapter in the section entitled *Switching the Terminator in isql*. 
Chapter 7. Procedural SQL (PSQL) Statements

Procedural SQL (PSQL) is a procedural extension of SQL. This language subset is used for writing PSQL modules: stored procedures, stored functions, triggers, and PSQL blocks.

PSQL provides all the basic constructs of traditional structured programming languages, and also includes DML statements (SELECT, INSERT, UPDATE, DELETE, etc.), with a slightly modified syntax in some cases.

7.1. Elements of PSQL

A PSQL module may contain declarations of local variables, subroutines and cursors, assignments, conditional statements, loops, statements for raising custom exceptions, error handling and sending messages (events) to client applications. DML triggers have access to special context variables, two “records” that store, respectively, the NEW values for all columns during insert and update activity, and the OLD values during update and delete work, and three Boolean variables — INSERTING, UPDATING and DELETING — to determine the event that fired the trigger.

Statements that modify metadata (DDL) are not available in PSQL.

7.1.1. DML Statements with Parameters

If DML statements (SELECT, INSERT, UPDATE, DELETE, etc.) in the body of a module (procedure, function, trigger or block) use parameters, only named parameters can be used. If DML statements contain named parameters, then they must be previously declared as local variables using DECLARE [VARIABLE] in the declaration section of the module, or as input or output variables in the module header.

When a DML statement with parameters is included in PSQL code, the parameter name must be prefixed by a colon (‘:’) in most situations. The colon is optional in statement syntax that is specific to PSQL, such as assignments and conditionals and the INTO clause. The colon prefix on parameters is not required when calling stored procedures from within another PSQL module.

7.1.2. Transactions

Stored procedures and functions (including those defined in packages) are executed in the context of the transaction in which they are called. Triggers are executed as an intrinsic part of the operation of the DML statement; thus, their execution is within the same transaction context as the statement itself. Individual transactions are launched for database event triggers fired on connect or disconnect.

Statements that start and end transactions are not available in PSQL, but it is possible to run a statement or a block of statements in an autonomous transaction.

7.1.3. Module Structure

PSQL code modules consist of a header and a body. The DDL statements for defining them are complex statements; that is, they consist of a single statement that encloses blocks of multiple
statements. These statements begin with a verb (CREATE, ALTER, DROP, RECREATE, CREATE OR ALTER, or EXECUTE BLOCK) and end with the last END statement of the body.

**The Module Header**

The header provides the module name and defines any input and output parameters or—for functions—the return type. Stored procedures and PSQL blocks may have input and output parameters. Functions may have input parameters and must have a scalar return type. Triggers do not have either input or output parameters, but DML triggers do have the NEW and OLD “records”, and INSERTING, UPDATING and DELETING variables.

The header of a trigger indicates the DML event (insert, update or delete, or a combination) or DDL or database event and the phase of operation (BEFORE or AFTER that event) that will cause it to “fire”.

**The Module Body**

The module body is either a PSQL module body, or an external module body. PSQL blocks can only have a PSQL module body.

**Syntax of a Module Body**

```
<module-body> ::=  
    <psql-module-body> | <external-module-body>

<psql-module-body> ::=  
    AS
    [<forward-declarations>]
    [<declarations>]
    BEGIN
    [<PSQL_statements>]
    END

<external-module-body> ::=  
    EXTERNAL [NAME <extname>] ENGINE engine
    [AS '<extbody>']

<forward-declarations> ::=  
    <forward-declare-item> [<forward-declare-item> ...]

<declarations> ::=  
    <declare-item> [<declare-item> ...]

<forward-declare-item> ::=  
    <subfunc-forward>
    | <subproc-forward>

<declare-item> ::=  
    <declare-var>
    | <declare-cursor>
    | <subfunc-def>
    | <subproc-def>
```
Chapter 7. Procedural SQL (PSQL) Statements

Table 94. Module Body Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>declarations</td>
<td>Section for declaring local variables, named cursors, and subroutines</td>
</tr>
<tr>
<td>PSQL_statements</td>
<td>Procedural SQL statements. Some PSQL statements may not be valid in all types of PSQL. For example, RETURN &lt;value&gt;; is only valid in functions.</td>
</tr>
<tr>
<td>subfunc-forward</td>
<td>Sub-function forward declaration</td>
</tr>
<tr>
<td>subproc-forward</td>
<td>Sub-procedure forward declaration</td>
</tr>
<tr>
<td>declare_var</td>
<td>Local variable declaration</td>
</tr>
<tr>
<td>declare_cursor</td>
<td>Named cursor declaration</td>
</tr>
<tr>
<td>subfunc-def</td>
<td>Sub-function declaration</td>
</tr>
<tr>
<td>subproc-def</td>
<td>Sub-procedure declaration</td>
</tr>
<tr>
<td>extname</td>
<td>String identifying the external procedure</td>
</tr>
<tr>
<td>engine</td>
<td>String identifying the UDR engine</td>
</tr>
<tr>
<td>extbody</td>
<td>External procedure body. A string literal that can be used by UDRs for various purposes.</td>
</tr>
<tr>
<td>module-name</td>
<td>The name of the module that contains the procedure</td>
</tr>
<tr>
<td>routine-name</td>
<td>The internal name of the procedure inside the external module</td>
</tr>
<tr>
<td>misc-info</td>
<td>Optional string that is passed to the procedure in the external module</td>
</tr>
</tbody>
</table>

The PSQL Module Body

The PSQL module body starts with an optional section that declares variables and subroutines, followed by a block of statements that run in a logical sequence, like a program. A block of statements — or compound statement — is enclosed by the BEGIN and END keywords, and is executed as a single unit of code. The main BEGIN…END block may contain any number of other BEGIN…END blocks, both embedded and sequential. Blocks can be nested to a maximum depth of 512 blocks. All statements except BEGIN and END are terminated by semicolons (‘;’). No other character is valid for
Switching the Terminator in *isql*

Here we digress a little, to explain how to switch the terminator character in the *isql* utility to make it possible to define PSQL modules in that environment without conflicting with *isql* itself, which uses the same character, semicolon (‘;’), as its own statement terminator.

**isql Command SET TERM**

Sets the terminator character(s) to avoid conflict with the terminator character in PSQL statements

*Available in*

ISQL only

*Syntax*

```
SET TERM new_terminator old_terminator
```

*Table 95. SET TERM Parameters*

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>new_terminator</td>
<td>New terminator</td>
</tr>
<tr>
<td>old_terminator</td>
<td>Old terminator</td>
</tr>
</tbody>
</table>

When you write your triggers, stored procedures, stored functions or PSQL blocks in *isql*—either in the interactive interface or in scripts—running a SET TERM statement is needed to switch the normal *isql* statement terminator from the semicolon to another character or short string, to avoid conflicts with the non-changeable semicolon terminator in PSQL. The switch to an alternative terminator needs to be done before you begin defining PSQL objects or running your scripts.

The alternative terminator can be any string of characters except for a space, an apostrophe or the current terminator character(s). Any letter character(s) used will be case-sensitive.

*Example*

Changing the default semicolon to ‘^’ (caret) and using it to submit a stored procedure definition: character as an alternative terminator character:

```
SET TERM ^;

CREATE OR ALTER PROCEDURE SHIP_ORDER (PO_NUM CHAR(8))
AS
BEGIN
    /* Stored procedure body */
END^  
```
The External Module Body

The external module body specifies the UDR engine used to execute the external module, and optionally specifies the name of the UDR routine to call (<extname>) and/or a string (<extbody>) with UDR-specific semantics.

Configuration of external modules and UDR engines is not covered further in this Language Reference. Consult the documentation of a specific UDR engine for details.

7.2. Stored Procedures

A stored procedure is executable code stored in the database metadata for execution on the server. It can be called by other stored procedures (including itself), functions, triggers and client applications. A procedure that calls itself is known as recursive.

7.2.1. Benefits of Stored Procedures

Stored procedures have the following advantages:

Modularity
applications working with the database can use the same stored procedure, thereby reducing the size of the application code and avoiding code duplication.

Simpler Application Support
when a stored procedure is modified, changes appear immediately to all host applications, without the need to recompile them if the parameters were unchanged.

Enhanced Performance
since stored procedures are executed on a server instead of at the client, network traffic is reduced, which improves performance.

7.2.2. Types of Stored Procedures

Firebird supports two types of stored procedures: executable and selectable.

Executable Procedures

Executable procedures usually modify data in a database. They can receive input parameters and return a single set of output (RETURNS) parameters. They are called using the EXECUTE PROCEDURE statement. See an example of an executable stored procedure at the end of the CREATE PROCEDURE section of Chapter 5, Data Definition (DDL) Statements.
Selectable Procedures

Selectable stored procedures usually retrieve data from a database, returning an arbitrary number of rows to the caller. The caller receives the output one row at a time from a row buffer that the database engine prepares for it.

Selectable procedures can be useful for obtaining complex sets of data that are often impossible or too difficult or too slow to retrieve using regular DSQ SELECT queries. Typically, this style of procedure iterates through a looping process of extracting data, perhaps transforming it before filling the output variables (parameters) with fresh data at each iteration of the loop. A SUSPEND statement at the end of the iteration fills the buffer and waits for the caller to fetch the row. Execution of the next iteration of the loop begins when the buffer has been cleared.

Selectable procedures may have input parameters, and the output set is specified by the RETURNS clause in the header.

A selectable stored procedure is called with a SELECT statement. See an example of a selectable stored procedure at the end of the CREATE PROCEDURE section of Chapter 5, Data Definition (DDL) Statements.

7.2.3. Creating a Stored Procedure

The syntax for creating executable stored procedures and selectable stored procedures is the same. The difference comes in the logic of the program code, specifically the absence or presence of a SUSPEND statement.

For information about creating stored procedures, see CREATE PROCEDURE in Chapter 5, Data Definition (DDL) Statements.

7.2.4. Modifying a Stored Procedure

For information about modifying existing stored procedures, see ALTER PROCEDURE, CREATE OR ALTER PROCEDURE, RECREATE PROCEDURE.

7.2.5. Dropping a Stored Procedure

For information about dropping (deleting) stored procedures, see DROP PROCEDURE.

7.3. Stored Functions

A stored function is executable code stored in the database metadata for execution on the server. It can be called by other stored functions (including itself), procedures, triggers, and client applications through DML statements. A function that calls itself is known as recursive.

Unlike stored procedures, stored functions always return one scalar value. To return a value from a stored function, use the RETURN statement, which immediately terminates the function.
### 7.3.1. Creating a Stored Function

For information about creating stored functions, see `CREATE FUNCTION` in Chapter 5, *Data Definition (DDL) Statements*.

### 7.3.2. Modifying a Stored Function

For information about modifying stored functions, see `ALTER FUNCTION`, `CREATE OR ALTER FUNCTION`, `RECREATE FUNCTION`.

### 7.3.3. Dropping a Stored Function

For information about dropping (deleting) stored functions, see `DROP FUNCTION`.

### 7.4. PSQL Blocks

A self-contained, unnamed (“anonymous”) block of PSQL code can be executed dynamically in DSQL, using the `EXECUTE BLOCK` syntax. The header of a PSQL block may optionally contain input and output parameters. The body may contain local variables, cursor declarations and local routines, followed by a block of PSQL statements, and is similar to a stored procedure. A PSQL block cannot use a UDR module body.

A PSQL block is not defined and stored as an object, unlike stored procedures and triggers. It executes in run-time and cannot reference itself.

Like stored procedures, anonymous PSQL blocks can be used to process data and to retrieve data from the database.

**Syntax (incomplete)**

```sql
EXECUTE BLOCK
  [([<inparam> = ? [, <inparam> = ? ...]])
  [RETURNS (<outparam> [, <outparam> ...]])
  <psql-module-body>

<psql-module-body> ::= 
  !! See Syntax of Module Body !!
```

**Table 96. PSQL Block Parameters**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>inparam</td>
<td>Input parameter description</td>
</tr>
<tr>
<td>outparam</td>
<td>Output parameter description</td>
</tr>
<tr>
<td>declarations</td>
<td>A section for declaring local variables and named cursors</td>
</tr>
<tr>
<td>PSQL statements</td>
<td>PSQL and DML statements</td>
</tr>
</tbody>
</table>

*See also*
See EXECUTE BLOCK for details.

7.5. Packages

A package is a group of stored procedures and functions defined as a single database object.

Firebird packages are made up of two parts: a header (PACKAGE keyword) and a body (PACKAGE BODY keywords). This separation is similar to Delphi modules; the header corresponds to the interface part, and the body corresponds to the implementation part.

7.5.1. Benefits of Packages

The notion of “packaging” the code components of a database operation addresses has several advantages:

Modularisation

Blocks of interdependent code are grouped into logical modules, as done in other programming languages.

In programming, it is well recognised that grouping code in various ways, in namespaces, units or classes, for example, is a good thing. This is not possible with standard stored procedures and functions in the database. Although they can be grouped in different script files, two problems remain:

a. The grouping is not represented in the database metadata.

b. Scripted routines all participate in a flat namespace and are callable by everyone (we are not referring to security permissions here).

Easier tracking of dependencies

Packages make it easy to track dependencies between a collection of related routines, as well as between this collection and other routines, both packaged and unpackaged.

Whenever a packaged routine determines that it uses a certain database object, a dependency on that object is registered in Firebird’s system tables. Thereafter, to drop, or maybe alter that object, you first need to remove what depends on it. Since the dependency on other objects only exists for the package body, and not the package header, this package body can easily be removed, even if another object depends on this package. When the body is dropped, the header remains, allowing you to recreate its body once the changes related to the removed object are done.

Simplify permission management

As Firebird — by default — runs routines with the caller (invoker) privileges, it is necessary also to grant resource usage to each routine when these resources would not be directly accessible to the caller. Usage of each routine needs to be granted to users and/or roles.

Packaged routines do not have individual privileges. The privileges apply to the package as a whole. Privileges granted to packages are valid for all package body routines, including private ones, but are stored for the package header. An EXECUTE privilege on a package granted to a user (or other object), grants that user the privilege to execute all routines defined in the package.
For example

```
GRANT SELECT ON TABLE secret TO PACKAGE pk_secret;
GRANT EXECUTE ON PACKAGE pk_secret TO ROLE role_secret;
```

**Private scopes**

Stored procedures and functions can be privates; that is, make them available only for internal usage within the defining package.

All programming languages have the notion of routine scope, which is not possible without some form of grouping. Firebird packages also work like Delphi units in this regard. If a routine is not declared in the package header (interface) and is implemented in the body (implementation), it becomes a private routine. A private routine can only be called from inside its package.

### 7.5.2. Creating a Package

For information on creating packages, see `CREATE PACKAGE` and `CREATE PACKAGE BODY` in Chapter 5, *Data Definition (DDL) Statements*.

### 7.5.3. Modifying a Package

For information on modifying existing package header or bodies, see `ALTER PACKAGE`, `CREATE OR ALTER PACKAGE`, `RECREATE PACKAGE`, and `RECREATE PACKAGE BODY`.

### 7.5.4. Dropping a Package

For information on dropping (deleting) a package, see `DROP PACKAGE` and `DROP PACKAGE BODY`.

### 7.6. Triggers

A trigger is another form of executable code that is stored in the metadata of the database for execution by the server. A trigger cannot be called directly. It is called automatically (“fired”) when data-changing events involving one particular table or view occur, or on a specific database or DDL event.

A trigger applies to exactly one table or view or database event, and only one phase in an event (BEFORE or AFTER the event). A single DML trigger might be written to fire only when one specific data-changing event occurs (INSERT, UPDATE or DELETE), or it might be written to apply to more than one of those.

A DML trigger is executed in the context of the transaction in which the data-changing DML statement is running. For triggers that respond to database events, the rule is different: for DDL triggers and transaction triggers, the trigger runs in the same transaction that executed the DDL, for other types, a new default transaction is started.
7.6.1. Firing Order (Order of Execution)

More than one trigger can be defined for each phase-event combination. The order in which they are executed — also known as “firing order” — can be specified explicitly with the optional POSITION argument in the trigger definition. You have 32,767 numbers to choose from. Triggers with the lowest position numbers fire first.

If a POSITION clause is omitted, or if several matching event-phase triggers have the same position number, then the triggers will fire in alphabetical order.

7.6.2. DML Triggers

DML triggers are those that fire when a DML operation changes the state of data: updating rows in tables, inserting new rows or deleting rows. They can be defined for both tables and views.

Trigger Options

Six base options are available for the event-phase combination for tables and views:

- Before a new row is inserted: BEFORE INSERT
- After a new row is inserted: AFTER INSERT
- Before a row is updated: BEFORE UPDATE
- After a row is updated: AFTER UPDATE
- Before a row is deleted: BEFORE DELETE
- After a row is deleted: AFTER DELETE

These base forms are for creating single phase/single-event triggers. Firebird also supports forms for creating triggers for one phase and multiple-events, BEFORE INSERT OR UPDATE OR DELETE, for example, or AFTER UPDATE OR DELETE: the combinations are your choice.

“Multi-phase” triggers, such as BEFORE OR AFTER …, are not possible.

The Boolean context variables INSERTING, UPDATING and DELETING can be used in the body of a trigger to determine the type of event that fired the trigger.

OLD and NEW Context Variables

For DML triggers, the Firebird engine provides access to sets of OLD and NEW context variables (or, “records”). Each is a record of the values of the entire row: one for the values as they are before the data-changing event (the BEFORE phase) and one for the values as they will be after the event (the AFTER phase). They are referenced in statements using the form NEW.column_name and OLD.column_name, respectively. The column_name can be any column in the table’s definition, not just those that are being updated.

The NEW and OLD variables are subject to some rules:

- In all triggers, OLD is read-only
• In BEFORE UPDATE and BEFORE INSERT code, the NEW value is read/write, unless it is a COMPUTED BY column
• In INSERT triggers, references to OLD are invalid and will throw an exception
• In DELETE triggers, references to NEW are invalid and will throw an exception
• In all AFTER trigger code, NEW is read-only

### 7.6.3. Database Triggers

A trigger associated with a database or transaction event can be defined for the following events:

| Connecting to a database | ON CONNECT | Before the trigger is executed, a transaction is automatically started with the default isolation level (snapshot (concurrency), write, wait) |
| Disconnecting from a database | ON DISCONNECT | Before the trigger is executed, a transaction is automatically started with the default isolation level (snapshot (concurrency), write, wait) |
| When a transaction is started | ON TRANSACTION START | The trigger is executed in the transaction context of the started transaction (immediately after start) |
| When a transaction is committed | ON TRANSACTION COMMIT | The trigger is executed in the transaction context of the committing transaction (immediately before commit) |
| When a transaction is cancelled | ON TRANSACTION ROLLBACK | The trigger is executed in the transaction context of the rolling back transaction (immediately before roll back) |

### 7.6.4. DDL Triggers

DDL triggers fire on specified metadata change events in a specified phase. BEFORE triggers run before changes to system tables. AFTER triggers run after changes to system tables.

DDL triggers are a specific type of database trigger, so most rules for and semantics of database triggers also apply for DDL triggers.

#### Semantics

1. BEFORE triggers are fired before changes to the system tables. AFTER triggers are fired after system table changes.

   **Important Rule**
   
   The event type [BEFORE | AFTER] of a DDL trigger cannot be changed.

2. When a DDL statement fires a trigger that raises an exception (BEFORE or AFTER, intentionally or unintentionally) the statement will not be committed. That is, exceptions can be used to ensure that a DDL operation will fail if the conditions are not precisely as intended.

3. DDL trigger actions are executed only when committing the transaction in which the affected DDL command runs. Never overlook the fact that what is possible to do in an AFTER trigger is exactly what is possible to do after a DDL command without autocommit. You cannot, for
example, create a table and then use it in the trigger.

4. With “CREATE OR ALTER” statements, a trigger is fired one time at the CREATE event or the ALTER event, according to the previous existence of the object. With RECREATE statements, a trigger is fired for the DROP event if the object exists, and for the CREATE event.

5. ALTER and DROP events are generally not fired when the object name does not exist. For the exception, see point 6.

6. The exception to rule 5 is that BEFORE ALTER/DROP USER triggers fire even when the username does not exist. This is because, underneath, these commands perform DML on the security database, and the verification is not done before the command on it is run. This is likely to be different with embedded users, so do not write code that depends on this.

7. If an exception is raised after the DDL command starts its execution and before AFTER triggers are fired, AFTER triggers will not be fired.

8. Packaged procedures and functions do not fire individual {CREATE | ALTER | DROP} {PROCEDURE | FUNCTION} triggers.

**The DDL_TRIGGER Context Namespace**

When a DDL trigger is running, the DDL_TRIGGER namespace is available for use with RDB$GETCONTEXT. This namespace contains information on the currently firing trigger.

See also The DDL_TRIGGER Namespace in RDB$GETCONTEXT in Chapter 8, *Built-in Scalar Functions*.

**7.6.5. Creating Triggers**

For information on creating triggers, see CREATE TRIGGER, CREATE OR ALTER TRIGGER, and RECREATE TRIGGER in Chapter 5, *Data Definition (DDL) Statements*.

**7.6.6. Modifying Triggers**

For information on modifying triggers, see ALTER TRIGGER, CREATE OR ALTER TRIGGER, and RECREATE TRIGGER.

**7.6.7. Dropping a Trigger**

For information on dropping (deleting) triggers, see DROP TRIGGER.

**7.7. Writing the Body Code**

This section takes a closer look at the procedural SQL language constructs and statements that are available for coding the body of a stored procedure, functions, trigger, and PSQL blocks.

---

**Colon Marker (‘::’)**

The colon marker prefix (‘::’) is used in PSQL to mark a reference to a variable in a DML statement. The colon marker is not required before variable names in other PSQL code.
The colon prefix can also be used for the NEW and OLD contexts, and for cursor variables.

### 7.7.1. Assignment Statements

Assigns a value to a variable

**Syntax**

```
varname = <value_expr>;
```

**Table 97. Assignment Statement Parameters**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>varname</td>
<td>Name of a parameter or local variable</td>
</tr>
<tr>
<td>value_expr</td>
<td>An expression, constant or variable whose value resolves to the same data type as varname</td>
</tr>
</tbody>
</table>

PSQL uses the equal symbol (‘=’) as its assignment operator. The assignment statement assigns a SQL expression value on the right to the variable on the left of the operator. The expression can be any valid SQL expression: it may contain literals, internal variable names, arithmetic, logical and string operations, calls to internal functions, stored functions or external functions (UDFs).

**Example using assignment statements**

```
CREATE PROCEDURE MYPROC (  
a INTEGER,
b INTEGER,
  name VARCHAR (30)
)
RETURNS (  
  c INTEGER,
  str VARCHAR(100)
) AS
BEGIN
  -- assigning a constant
  c = 0;
  str = '';  
  SUSPEND;
  -- assigning expression values
  c = a + b;
  str = name || CAST(b AS VARCHAR(10));
  SUSPEND;
  -- assigning expression value built by a query
  c = (SELECT 1 FROM rdb$database);
  -- assigning a value from a context variable
  str = CURRENT_USER;
  SUSPEND;
```

See also

DECLARE VARIABLE

7.7.2. Management Statements in PSQL

Management statements are allowed in PSQL modules (triggers, procedures, functions and PSQL blocks), which is especially helpful for applications that need management statements to be executed at the start of a session, specifically in `ON CONNECT` triggers.

The management statements permitted in PSQL are:

- ALTER SESSION RESET
- SET BIND
- SET DECFLOAT
- SET ROLE
- SET SESSION IDLE TIMEOUT
- SET STATEMENT TIMEOUT
- SET TIME ZONE
- SET TRUSTED ROLE

Example of Management Statements in PSQL

```sql
create or alter trigger on_connect on connect
as
begin
    set bind of decfloat to double precision;
    set time zone 'America/Sao_Paulo';
end
```

Although useful as a workaround, using `ON CONNECT` triggers to configure bind and time zone is usually not the right approach. Alternatives are handling this through `DefaultTimeZone` in `firebird.conf` and `DataTypeCompatibility` in `firebird.conf` or `databases.conf`, or `isc_dpb_session_time_zone` or `isc_dpb_set_bind` in the DPB.

See also

Management Statements

7.7.3. DECLARE VARIABLE

Declares a local variable
Syntax

```sql
DECLARE [VARIABLE] varname
    <domain_or_non_array_type> [NOT NULL] [COLLATE collation]
    [{DEFAULT | = } <initvalue>];

<domain_or_non_array_type> ::= !! See Scalar Data Types Syntax !!
<initvalue> ::= <literal> | <context_var>
```

**Table 98. DECLARE VARIABLE Statement Parameters**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>varname</td>
<td>Name of the local variable</td>
</tr>
<tr>
<td>collation</td>
<td>Collation</td>
</tr>
<tr>
<td>initvalue</td>
<td>Initial value for this variable</td>
</tr>
<tr>
<td>literal</td>
<td>Literal of a type compatible with the type of the local variable</td>
</tr>
<tr>
<td>context_var</td>
<td>Any context variable whose type is compatible with the type of the local variable</td>
</tr>
</tbody>
</table>

The statement `DECLARE [VARIABLE]` is used for declaring a local variable. One `DECLARE [VARIABLE]` statement is required for each local variable. Any number of `DECLARE [VARIABLE]` statements can be included and in any order. The name of a local variable must be unique among the names of local variables and input and output parameters declared for the module.

A special case of `DECLARE [VARIABLE]`—declaring cursors—is covered separately in `DECLARE .. CURSOR`.

**Data Type for Variables**

A local variable can be of any SQL type other than an array.

- A domain name can be specified as the type; the variable will inherit all of its attributes.
- If the `TYPE OF domain` clause is used instead, the variable will inherit only the domain's data type, and, if applicable, its character set and collation attributes. Any default value or constraints such as `NOT NULL` or `CHECK` constraints are not inherited.
- If the `TYPE OF COLUMN relation.column` option is used to “borrow” from a column in a table or view, the variable will inherit only the column's data type, and, if applicable, its character set and collation attributes. Any other attributes are ignored.

**NOT NULL Constraint**

For local variables, you can specify the `NOT NULL` constraint, disallowing `NULL` values for the variable. If a domain has been specified as the data type and the domain already has the `NOT NULL` constraint, the declaration is unnecessary. For other forms, including use of a domain that is nullable, the `NOT NULL` constraint can be included if needed.
CHARACTER SET and COLLATE clauses

Unless specified, the character set and collation of a string variable will be the database defaults. A CHARACTER SET clause can be specified to handle string data that needs a different character set. A valid collation (COLLATE clause) can also be included, with or without the character set clause.

Initializing a Variable

Local variables are NULL when execution of the module begins. They can be explicitly initialized so that a starting or default value is available when they are first referenced. The initial value can be specified in two ways, DEFAULT <initvalue> and = <initvalue>. The value can be any type-compatible literal or context variable, including NULL.

Be sure to use this clause for any variables that have a NOT NULL constraint and do not otherwise have a default value available (i.e. inherited from a domain).

Examples of various ways to declare local variables

```sql
CREATE OR ALTER PROCEDURE SOME_PROC
AS
    -- Declaring a variable of the INT type
    DECLARE I INT;
    -- Declaring a variable of the INT type that does not allow NULL
    DECLARE VARIABLE J INT NOT NULL;
    -- Declaring a variable of the INT type with the default value of 0
    DECLARE VARIABLE K INT DEFAULT 0;
    -- Declaring a variable of the INT type with the default value of 1
    DECLARE VARIABLE L INT = 1;
    -- Declaring a variable based on the COUNTRYNAME domain
    DECLARE FARM_COUNTRY COUNTRYNAME;
    -- Declaring a variable of the type equal to the COUNTRYNAME domain
    DECLARE FROM_COUNTRY TYPE OF COUNTRYNAME;
    -- Declaring a variable with the type of the CAPITAL column in the COUNTRY table
    DECLARE CAPITAL TYPE OF COLUMN COUNTRY.CAPITAL;
BEGIN
    /* PSQL statements */
END
```

See also

Data Types and Subtypes, Custom Data Types — Domains, CREATE DOMAIN

7.7.4. DECLARE .. CURSOR

 DECLARE [VARIABLE] cursor_name
[[NO] SCROLL] CURSOR
FOR (<select>);

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor_name</td>
<td>Cursor name</td>
</tr>
<tr>
<td>select</td>
<td>SELECT statement</td>
</tr>
</tbody>
</table>

The DECLARE … CURSOR … FOR statement binds a named cursor to the result set obtained by the SELECT statement specified in the FOR clause. In the body code, the cursor can be opened, used to iterate row-by-row through the result set, and closed. While the cursor is open, the code can perform positioned updates and deletes using the WHERE CURRENT OF in the UPDATE or DELETE statement.

Syntactically, the DECLARE … CURSOR statement is a special case of DECLARE VARIABLE.

### Forward-Only and Scrollable Cursors

The cursor can be forward-only (unidirectional) or scrollable. The optional clause SCROLL makes the cursor scrollable, the NO SCROLL clause, forward-only. By default, cursors are forward-only.

Forward-only cursors can — as the name implies — only move forward in the dataset. Forward-only cursors only support the FETCH [NEXT FROM] statement, other fetch options raise an error. Scrollable cursors allow you to move not only forward in the dataset, but also back, as well as $N$ positions relative to the current position.

Scrollable cursors are materialized as a temporary dataset, as such, they consume additional memory or disk space, so use them only when you really need them.

### Cursor Idiosyncrasies

- The optional FOR UPDATE clause can be included in the SELECT statement, but its absence does not prevent successful execution of a positioned update or delete
- Care should be taken to ensure that the names of declared cursors do not conflict with any names used subsequently in statements for AS CURSOR clauses
- If the cursor is needed only to walk the result set, it is nearly always easier and less error-prone to use a FOR SELECT statement with the AS CURSOR clause. Declared cursors must be explicitly opened, used to fetch data, and closed. The context variable ROW_COUNT has to be checked after each fetch and, if its value is zero, the loop has to be terminated. A FOR SELECT statement does this automatically.

    Nevertheless, declared cursors provide a high level of control over sequential events and allow several cursors to be managed in parallel.

- The SELECT statement may contain parameters. For instance:
SELECT NAME || :SFX FROM NAMES WHERE NUMBER = :NUM

Each parameter has to have been declared beforehand as a PSQL variable, or as input or output parameters. When the cursor is opened, the parameter is assigned the current value of the variable.

### Unstable Variables and Cursors

If the value of the PSQL variable used in the SELECT statement of the cursor changes during the execution of the loop, then its new value may—but not always—be used when selecting the next rows. It is better to avoid such situations. If you really need this behaviour, then you should thoroughly test your code and make sure you understand how changes to the variable affect the query results.

Note particularly that the behaviour may depend on the query plan, specifically on the indexes being used. Currently, there are no strict rules for this behaviour, and this may change in future versions of Firebird.

### Examples Using Named Cursors

1. Declaring a named cursor in a trigger.

   ```sql
   CREATE OR ALTER TRIGGER TBU_STOCK
   BEFORE UPDATE ON STOCK
   AS
   DECLARE C_COUNTRY CURSOR FOR (
       SELECT
           COUNTRY,
           CAPITAL
       FROM COUNTRY
   );
   BEGIN
   /* PSQL statements */
   END
   ```

2. Declaring a scrollable cursor

   ```sql
   EXECUTE BLOCK
   RETURNS (n INT, RNAME CHAR(63))
   AS
   - Declaring a scrollable cursor
   DECLARE C SCROLL CURSOR FOR (
       SELECT
           ROW_NUMBER() OVER (ORDER BY RDB$RELATION_NAME) AS N,
           RDB$RELATION_NAME
   )
   ```
3. A collection of scripts for creating views with a PSQL block using named cursors.

EXECUTE BLOCK
RETURNS (SCRIPT BLOB SUB_TYPE TEXT)
AS
DECLARE VARIABLE FIELDS VARCHAR(8191);
DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
DECLARE VARIABLE RELATION RDB$RELATION_NAME;
DECLARE VARIABLE SOURCE TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
DECLARE VARIABLE CUR_R CURSOR FOR (
    SELECT
        RDB$RELATION_NAME, RDB$VIEW_SOURCE
    FROM
        RDB$RELATIONS
    WHERE
        RDB$VIEW_SOURCE IS NOT NULL);
-- Declaring a named cursor where
-- a local variable is used
DECLARE CUR_F CURSOR FOR (
    SELECT
        RDB$FIELD_NAME
    FROM
        RDB$RELATION_FIELDS
    WHERE
        -- the variable must be declared earlier
        RDB$RELATION_NAME = :RELATION);
BEGIN
    OPEN CUR_R;
    WHILE (1 = 1) DO
        BEGIN
            FETCH CUR_R
            INTO :RELATION, :SOURCE;
            IF (ROW_COUNT = 0) THEN
                LEAVE;
            END;
            FIELDS = NULL;
            -- The CUR_F cursor will use the value
            -- of the RELATION variable initiated above
            OPEN CUR_F;
            WHILE (1 = 1) DO
                BEGIN
                    FETCH CUR_F
INTO :FIELD_NAME;
IF (ROW_COUNT = 0) THEN
  LEAVE;
IF (FIELDS IS NULL) THEN
  FIELDS = TRIM(FIELD_NAME);
ELSE
  FIELDS = FIELDS || ', ' || TRIM(FIELD_NAME);
END
CLOSE CUR_F;

SCRIPT = 'CREATE VIEW ' || RELATION;

IF (FIELDS IS NOT NULL) THEN
  SCRIPT = SCRIPT || ' (' || FIELDS || ')';
SCRIPT = SCRIPT || ' AS ' || ASCII_CHAR(13);
SCRIPT = SCRIPT || SOURCE;
SUSPEND;
END
CLOSE CUR_R;
END

See also
OPEN, FETCH, CLOSE

### 7.7.5. DECLARE FUNCTION

Declares a sub-function

**Syntax**

\[
\begin{align*}
\langle\text{subfunc-forward}\rangle & \ ::= \langle\text{subfunc-header}\rangle; \\
\langle\text{subfunc-def}\rangle & \ ::= \langle\text{subfunc-header}\rangle \ \langle\text{psql-module-body}\rangle \\
\langle\text{subfunc-header}\rangle & \ ::= \\
& \text{DECLARE FUNCTION } \operatorname{subfuncname} [ \ ( \ ( \langle\text{in_params}\rangle) \ ) ] \\
& \text{RETURNS } \langle\text{domain_or_non_array_type}\rangle \ [\text{COLLATE } \operatorname{collation}] \\
& \text{[DETERMINISTIC]} \\
\langle\text{in_params}\rangle & \ ::= \\
& \text{!! See } \text{CREATE FUNCTION Syntax} \text{!!} \\
\langle\text{domain_or_non_array_type}\rangle & \ ::= \\
& \text{!! See } \text{Scalar Data Types Syntax} \text{!!} \\
\langle\text{psql-module-body}\rangle & \ ::= \\
& \text{!! See } \text{Syntax of Module Body} \text{!!}
\end{align*}
\]
### Table 100. DECLARE FUNCTION Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>subfuncname</td>
<td>Sub-function name</td>
</tr>
<tr>
<td>collation</td>
<td>Collation name</td>
</tr>
</tbody>
</table>

The DECLARE FUNCTION statement declares a sub-function. A sub-function is only visible to the PSQL module that defined the sub-function.

A sub-function can use variables, but not cursors, from its parent module. It can access other routines from its parent modules, including recursive calls to itself.

Sub-functions have a number of restrictions:

- A sub-function cannot be nested in another subroutine. Subroutines are only supported in top-level PSQL modules (stored procedures, stored functions, triggers and PSQL blocks). This restriction is not enforced by the syntax, but attempts to create nested sub-functions will raise an error “feature is not supported” with detail message “nested sub function”.

- Currently, a sub-function has no direct access to use cursors from its parent module.

A sub-function can be forward declared to resolve mutual dependencies between subroutines, and must be followed by its actual definition. When a sub-function is forward declared and has parameters with default values, the default values should only be specified in the forward declaration, and should not be repeated in `subfunc_def`.

Declaring a sub-function with the same name as a stored function will hide that stored function from your module. It will not be possible to call that stored function.

Contrary to DECLARE [VARIABLE], a DECLARE FUNCTION is not terminated by a semicolon. The END of its main BEGIN … END block is considered its terminator.

### Examples of Sub-Functions

1. Sub-function within a stored function

   ```sql
   CREATE OR ALTER FUNCTION FUNC1 (n1 INTEGER, n2 INTEGER)
     RETURNS INTEGER
   AS
   - Subfunction
     DECLARE FUNCTION SUBFUNC (n1 INTEGER, n2 INTEGER)
       RETURNS INTEGER
     AS BEGIN
       RETURN n1 + n2;
     END
   BEGIN
     RETURN SUBFUNC (n1, n2);
   ```
2. Recursive function call

```sql
execute block returns (i integer, o integer) as
    -- Recursive function without forward declaration.
    declare function fibonacci(n integer) returns integer as
        begin
            if (n = 0 or n = 1) then
                return n;
            else
                return fibonacci(n - 1) + fibonacci(n - 2);
            end
        begin
            i = 0;
            while (i < 10)
                do
                    o = fibonacci(i);
                    suspend;
                    i = i + 1;
                end
            end
    end
```

See also

DECLARE PROCEDURE, CREATE FUNCTION

7.7.6. DECLARE PROCEDURE

Declares a sub-procedure

Syntax

```sql
<subproc-forward> ::= <subproc-header>;

<subproc-def> ::= <subproc-header> <psql-module-body>

<subproc-header>  ::=
    DECLARE subprocname [ ( [ <in_params> ] ) ]
    [RETURNS (<out_params>)]

<in_params> ::=    !! See CREATE PROCEDURE Syntax !!

<domain_or_non_array_type> ::=    !! See Scalar Data Types Syntax !!
```
The DECLARE PROCEDURE statement declares a sub-procedure. A sub-procedure is only visible to the PSQL module that defined the sub-procedure.

A sub-procedure can use variables, but not cursors, from its parent module. It can access other routines from its parent modules.

Sub-procedures have a number of restrictions:

- A sub-procedure cannot be nested in another subroutine. Subroutines are only supported in top-level PSQL modules (stored procedures, stored functions, triggers and PSQL blocks). This restriction is not enforced by the syntax, but attempts to create nested sub-procedures will raise an error “feature is not supported” with detail message “nested sub procedure”.
- Currently, the sub-procedure has no direct access to use cursors from its parent module.

A sub-procedure can be forward declared to resolve mutual dependencies between subroutines, and must be followed by its actual definition. When a sub-procedure is forward declared and has parameters with default values, the default values should only be specified in the forward declaration, and should not be repeated in subproc_def.

Declaring a sub-procedure with the same name as a stored procedure, table or view will hide that stored procedure, table or view from your module. It will not be possible to call that stored procedure, table or view.

Contrary to DECLARE [VARIABLE], a DECLARE PROCEDURE is not terminated by a semicolon. The END of its main BEGIN … END block is considered its terminator.

Examples of Sub-Procedures

1. Subroutines in EXECUTE BLOCK

```sql
EXECUTE BLOCK
  RETURNS (name VARCHAR(63))
AS
  -- Sub-procedure returning a list of tables
  DECLARE PROCEDURE get_tables
    RETURNS (table_name VARCHAR(63))
  AS
  BEGIN
```
FOR SELECT RDB$RELATION_NAME
    FROM RDB$RELATIONS
    WHERE RDB$VIEW_BLR IS NULL
    INTO table_name
DO SUSPEND;
END

-- Sub-procedure returning a list of views
DECLARE PROCEDURE get_views
    RETURNS (view_name VARCHAR(63))
AS
BEGIN
    FOR SELECT RDB$RELATION_NAME
        FROM RDB$RELATIONS
        WHERE RDB$VIEW_BLR IS NOT NULL
        INTO view_name
    DO SUSPEND;
END

BEGIN
    FOR SELECT table_name
        FROM get_tables
    UNION ALL
    SELECT view_name
    FROM get_views
    INTO name
    DO SUSPEND;
END

2. With forward declaration and parameter with default value

execute block returns (o integer)
as
    -- Forward declaration of P1.
    declare procedure p1(i integer = 1) returns (o integer);

    -- Forward declaration of P2.
    declare procedure p2(i integer) returns (o integer);

    -- Implementation of P1 should not re-declare parameter default value.
    declare procedure p1(i integer) returns (o integer)
    as
    begin
        execute procedure p2(i) returning_values o;
    end

    declare procedure p2(i integer) returns (o integer)
    as
    begin
        o = i;
    end
begin
**7.7.7. BEGIN … END**

Delimits a block of statements

**Syntax**

\[
<\text{block}> ::= \\
\quad \text{BEGIN} \\
\quad \quad [,<\text{compound\_statement}> ...] \\
\quad \text{END}
\]

\[
<\text{compound\_statement}> ::= \{<\text{block}> | <\text{statement}>\}
\]

The `BEGIN … END` construct is a two-part statement that wraps a block of statements that are executed as one unit of code. Each block starts with the keyword `BEGIN` and ends with the keyword `END`. Blocks can be nested a maximum depth of 512 nested blocks. A block can be empty, allowing them to act as stubs, without the need to write dummy statements.

The `BEGIN … END` itself should not be followed by a statement terminator (semicolon). However, when defining or altering a PSQL module in the `isql` utility, that application requires that the last `END` statement be followed by its own terminator character, that was previously switched — using `SET TERM` — to a string other than a semicolon. That terminator is not part of the PSQL syntax.

The final, or outermost, `END` statement in a trigger terminates the trigger. What the final `END` statement does in a stored procedure depends on the type of procedure:

- In a selectable procedure, the final `END` statement returns control to the caller, returning SQLCODE 100, indicating that there are no more rows to retrieve
- In an executable procedure, the final `END` statement returns control to the caller, along with the current values of any output parameters defined.

**BEGIN … END Examples**

A sample procedure from the `employee.fdb database, showing simple usage of BEGIN … END blocks:

```sql
SET TERM ^;
CREATE OR ALTER PROCEDURE DEPT_BUDGET (  
  DNO CHAR(3))
RETURNS (  
  TOT DECIMAL(12,2))
AS
  DECLARE VARIABLE SUMB DECIMAL(12,2);
```
DECLARE VARIABLE RDNO CHAR(3);
DECLARE VARIABLE CNT INTEGER;
BEGIN
  TOT = 0;

  SELECT BUDGET
  FROM DEPARTMENT
  WHERE DEPT_NO = :DNO
  INTO :TOT;

  SELECT COUNT(BUDGET)
  FROM DEPARTMENT
  WHERE HEAD_DEPT = :DNO
  INTO :CNT;

  IF (CNT = 0) THEN
    SUSPEND;
  END

  FOR SELECT DEPT_NO
    FROM DEPARTMENT
    WHERE HEAD_DEPT = :DNO
    INTO :RDNO
  DO
    BEGIN
      EXECUTE PROCEDURE DEPT_BUDGET(:RDNO)
        RETURNING_VALUES :SUMB;
      TOT = TOT + SUMB;
    END

    SUSPEND;
  END

  SET TERM ;^
### Argument Description

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
<tr>
<td>compound_statement</td>
<td>A single statement, or statements wrapped in BEGIN … END</td>
</tr>
</tbody>
</table>

The conditional branch statement `IF … THEN` is used to branch the execution process in a PSQL module. The condition is always enclosed in parentheses. If the condition returns the value TRUE, execution branches to the statement or the block of statements after the keyword `THEN`. If an `ELSE` is present, and the condition returns FALSE or UNKNOWN, execution branches to the statement or the block of statements after it.

---

**Multi-Branch Decisions**

PSQL does not provide more advanced multi-branch jumps, such as `CASE` or `SWITCH`. However, it is possible to chain `IF … THEN … ELSE` statements, see the example section below. Alternatively, the `CASE` statement from DSQL is available in PSQL and is able to satisfy at least some use cases in the manner of a switch:

```sql
CASE <test_expr>
  WHEN <expr> THEN <result>
  [WHEN <expr> THEN <result> ...]
  [ELSE <defaultresult>]
END

CASE
  WHEN <bool_expr> THEN <result>
  [WHEN <bool_expr> THEN <result> ...]
  [ELSE <defaultresult>]
END
```

**Example in PSQL**

```sql
...
C = CASE
    WHEN A=2 THEN 1
    WHEN A=1 THEN 3
    ELSE 0
END;
...
```

**If Examples**

1. An example using the If statement. Assume that the variables FIRST, LINE2 and LAST were declared earlier.

```sql
...
```
IF (FIRST IS NOT NULL) THEN
    LINE2 = FIRST || ' ' || LAST;
ELSE
    LINE2 = LAST;
...

2. Given IF … THEN … ELSE is a statement, it is possible to chain them together. Assume that the\nINT_VALUE and STRING_VALUE variables were declared earlier.

IF (INT_VALUE = 1) THEN
    STRING_VALUE = 'one';
ELSE IF (INT_VALUE = 2) THEN
    STRING_VALUE = 'two';
ELSE IF (INT_VALUE = 3) THEN
    STRING_VALUE = 'three';
ELSE
    STRING_VALUE = 'too much';

This specific example can be replaced with a simple CASE or the DECODE function.

See also
WHILE … DO, CASE

7.7.9. WHILE … DO

Looping construct

Syntax

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Optional label for LEAVE and CONTINUE. Follows the rules for identifiers.</td>
</tr>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
<tr>
<td>compound_statement</td>
<td>A single statement, or statements wrapped in BEGIN ⋯ END</td>
</tr>
</tbody>
</table>

A WHILE statement implements the looping construct in PSQL. The statement or the block of statements will be executed as long as the condition returns TRUE. Loops can be nested to any depth.

WHILE … DO Examples

A procedure calculating the sum of numbers from 1 to I shows how the looping construct is used.
CREATE PROCEDURE SUM_INT (I INTEGER)
RETURNS (S INTEGER)
AS
BEGIN
  s = 0;
  WHILE (i > 0) DO
    BEGIN
      s = s + i;
      i = i - 1;
    END
  END
END

Executing the procedure in isql:

EXECUTE PROCEDURE SUM_INT(4);

the result is:

S =========
10

See also
IF … THEN … ELSE, BREAK, LEAVE, CONTINUE, EXIT, FOR SELECT, FOR EXECUTE STATEMENT

7.7.10. BREAK

Exits a loop

Syntax

[label:] <loop_stmt>
BEGIN
  ...
  BREAK;
  ...
END

Table 104. BREAK Statement Parameters
The **BREAK** statement immediately terminates the inner loop of a **WHILE** or **FOR** looping statement. Code continues to be executed from the first statement after the terminated loop block.

**BREAK** is similar to **LEAVE**, except it doesn't support a label.

*See also*

**LEAVE**

### 7.7.11. LEAVE

Exits a loop

**Syntax**

```
[<label:>
<loop_stmt>
BEGIN
...
LEAVE [<label>];
...
END

<loop_stmt> ::= 
  FOR <select_stmt> INTO <var_list> DO
  | FOR EXECUTE STATEMENT ... INTO <var_list> DO
  | WHILE (<condition>)} DO
```

**Table 105. LEAVE Statement Parameters**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Label</td>
</tr>
<tr>
<td>select_stmt</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
</tbody>
</table>

The **LEAVE** statement immediately terminates the inner loop of a **WHILE** or **FOR** looping statement. Using the optional **label** parameter, **LEAVE** can also exit an outer loop, that is, the loop labelled with **label**. Code continues to be executed from the first statement after the terminated loop block.

**LEAVE Examples**

1. Leaving a loop if an error occurs on an insert into the **NUMBERS** table. The code continues to be executed from the line `C = 0`. 
... WHILE (B < 10) DO
BEGIN
    INSERT INTO NUMBERS(B)
    VALUES (:B);
    B = B + 1;
    WHEN ANY DO
    BEGIN
        EXECUTE PROCEDURE LOG_ERROR (
            CURRENT_TIMESTAMP,
            'ERROR IN B LOOP');
        LEAVE;
    END
END
C = 0;
...

2. An example using labels in the LEAVE statement. LEAVE LOOPA terminates the outer loop and LEAVE LOOPB terminates the inner loop. Note that the plain LEAVE statement would be enough to terminate the inner loop.

... 
STMT1 = 'SELECT NAME FROM FARMS';
LOOPA:
FOR EXECUTE STATEMENT :STMT1
INTO :FARM DO
BEGIN
    STMT2 = 'SELECT NAME ' || 'FROM ANIMALS WHERE FARM = ''';
LOOPB:
FOR EXECUTE STATEMENT :STMT2 || :FARM || '''
INTO :ANIMAL DO
BEGIN
    IF (ANIMAL = 'FLUFFY') THEN
    LEAVE LOOPB;
    ELSE IF (ANIMAL = FARM) THEN
    LEAVE LOOPA;
    SUSPEND;
    END
END
END
...

See also
BREAK, CONTINUE, EXIT

7.7.12. CONTINUE

Continues with the next iteration of a loop
Syntax

[label:] <loop_stmt>
BEGIN...
  CONTINUE [label];
...
END

<loop_stmt> ::= FOR <select_stmt> INTO <var_list> DO
| FOR EXECUTE STATEMENT ... INTO <var_list> DO
| WHILE (<condition>) DO

Table 106. CONTINUE Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Label</td>
</tr>
<tr>
<td>select_stmt</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>condition</td>
<td>A logical condition returning TRUE, FALSE or UNKNOWN</td>
</tr>
</tbody>
</table>

The CONTINUE statement skips the remainder of the current block of a loop and starts the next iteration of the current WHILE or FOR loop. Using the optional *label* parameter, CONTINUE can also start the next iteration of an outer loop, that is, the loop labelled with *label*.

**CONTINUE Examples**

Using the CONTINUE statement

```
FOR SELECT A, D
  FROM ATABLE INTO achar, ddate
DO
BEGIN
  IF (ddate < current_date - 30) THEN
    CONTINUE;
  /* do stuff */
END
```

See also

BREAK, LEAVE, EXIT

7.7.13. EXIT

Terminates execution of a module
Syntax

EXIT;

The EXIT statement causes execution of the current PSQL module to jump to the final END statement from any point in the code, thus terminating the program.

Calling EXIT in a function will result in the function returning NULL.

EXIT Examples

Using the EXIT statement in a selectable procedure

```sql
CREATE PROCEDURE GEN_100
    RETURNS (I INTEGER)
AS
BEGIN
    I = 1;
    WHILE (I=1) DO
        BEGIN
            SUSPEND;
            IF (I=100) THEN
                EXIT;
            I = I + 1;
        END
    END
END
```

See also

BREAK, LEAVE, CONTINUE, SUSPEND

7.7.14. SUSPEND

Passes output to the buffer and suspends execution while waiting for caller to fetch it

Syntax

SUSPEND;

The SUSPEND statement is used in selectable stored procedures to pass the values of output parameters to a buffer and suspend execution. Execution remains suspended until the calling application fetches the contents of the buffer. Execution resumes from the statement directly after the SUSPEND statement. In practice, this is likely to be a new iteration of a looping process.

<table>
<thead>
<tr>
<th>Important Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The SUSPEND statement can only occur in stored procedures or sub-procedures</td>
</tr>
<tr>
<td>2. The presence of the SUSPEND keyword defines a stored procedure as a selectable procedure</td>
</tr>
</tbody>
</table>
3. Applications using interfaces that wrap the API perform the fetches from selectable procedures transparently.

4. If a selectable procedure is executed using EXECUTE PROCEDURE, it behaves as an executable procedure. When a SUSPEND statement is executed in such a stored procedure, it is the same as executing the EXIT statement, resulting in immediate termination of the procedure.

5. SUSPEND "breaks" the atomicity of the block in which it is located. If an error occurs in a selectable procedure, statements executed after the final SUSPEND statement will be rolled back. Statements that executed before the final SUSPEND statement will not be rolled back unless the transaction is rolled back.

**SUSPEND Examples**

*Using the SUSPEND statement in a selectable procedure*

```sql
CREATE PROCEDURE GEN_100
  RETURNS (I INTEGER)
AS
BEGIN
  I = 1;
  WHILE (I=1) DO
    BEGIN
    SUSPEND;
    IF (I=100) THEN
      EXIT;
    I = I + 1;
    END
  END
END
```

*See also*

EXIT

**7.7.15. EXECUTE STATEMENT**

Executes dynamically created SQL statements

**Syntax**

```sql
<execute_statement> ::= EXECUTE STATEMENT <argument>
  [<option> ...]
  [INTO <variables>];

<argument> ::= <paramless_stmt>
  | ( <paramless_stmt> )
  | ( <stmt_with_params> ) ( <param_values> )

<param_values> ::= <named_values> | <positional_values>

<named_values> ::= <named_value> [, <named_value> ...]
```
<named_value> ::= [EXCESS] paramname := <value_expr>

<positional_values> ::= <value_expr> [, <value_expr> ...]

<option> ::= 
  WITH {AUTONOMOUS | COMMON} TRANSACTION | WITH CALLER PRIVILEGES | AS USER user |
  | PASSWORD password | ROLE role |
  | ON EXTERNAL [DATA SOURCE] <connection_string>

<connection_string> ::= 
  !! See <filespec> in the CREATE DATABASE syntax !!

<variables> ::= [:]varname [, [:]varname ...]

Table 107. EXECUTE STATEMENT Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>paramless_stmt</td>
<td>Literal string or variable containing a non-parameterized SQL query</td>
</tr>
<tr>
<td>stmt_with_params</td>
<td>Literal string or variable containing a parameterized SQL query</td>
</tr>
<tr>
<td>paramname</td>
<td>SQL query parameter name</td>
</tr>
<tr>
<td>value_expr</td>
<td>SQL expression resolving to a value</td>
</tr>
<tr>
<td>user</td>
<td>Username. It can be a string, CURRENT_USER or a string variable</td>
</tr>
<tr>
<td>password</td>
<td>Password. It can be a string or a string variable</td>
</tr>
<tr>
<td>role</td>
<td>Role. It can be a string, CURRENT_ROLE or a string variable</td>
</tr>
<tr>
<td>connection_string</td>
<td>Connection string. It can be a string literal or a string variable</td>
</tr>
<tr>
<td>varname</td>
<td>Variable</td>
</tr>
</tbody>
</table>

The statement EXECUTE STATEMENT takes a string parameter and executes it as if it were a DSQL statement. If the statement returns data, it can be passed to local variables by way of an INTO clause.

EXECUTE STATEMENT can only produce a single row of data. Statements producing multiple rows of data must be executed with FOR EXECUTE STATEMENT.

Parameterized Statements

You can use parameters—either named or positional—in the DSQL statement string. Each parameter must be assigned a value.

Special Rules for Parameterized Statements

1. Named and positional parameters cannot be mixed in one query
2. Each parameter must be used in the statement text.
To relax this rule, named parameters can be prefixed with the keyword `EXCESS` to indicate that the parameter may be absent from the statement text. This option is useful for dynamically generated statements that conditionally include or exclude certain parameters.

3. If the statement has parameters, they must be enclosed in parentheses when `EXECUTE STATEMENT` is called, regardless of whether they come directly as strings, as variable names or as expressions.

4. Each named parameter must be prefixed by a colon (`:`) in the statement string itself, but not when the parameter is assigned a value.

5. Positional parameters must be assigned their values in the same order as they appear in the query text.

6. The assignment operator for parameters is the special operator `":="`, similar to the assignment operator in Pascal.

7. Each named parameter can be used in the statement more than once, but its value must be assigned only once.

8. With positional parameters, the number of assigned values must match the number of parameter placeholders (question marks) in the statement exactly.

9. A named parameter in the statement text can only be a regular identifier (it cannot be a quoted identifier).

**Examples of `EXECUTE STATEMENT` with parameters**

1. With named parameters:

   ```sql
   ... 
   DECLARE license_num VARCHAR(15); 
   DECLARE connect_string VARCHAR (100); 
   DECLARE stmt VARCHAR (100) = 
       'SELECT license ' 
       'FROM cars ' 
       'WHERE driver = :driver AND location = :loc'; 
   BEGIN 
   -- ... 
   EXECUTE STATEMENT (stmt) 
     (driver := current_driver, 
      loc := current_location) 
     ON EXTERNAL connect_string 
     INTO license_num; 
   ```

2. The same code with positional parameters:

   ```sql
   DECLARE license_num VARCHAR (15); 
   DECLARE connect_string VARCHAR (100); 
   DECLARE stmt VARCHAR (100) = 
       'SELECT license ' 
       'FROM cars '
   ```
'WHERE driver = ? AND location = ?';
BEGIN
   -- ...
   EXECUTE STATEMENT (stmt)
      (current_driver, current_location)
ON EXTERNAL connect_string
INTO license_num;

3. Use of EXCESS to allow named parameters to be unused (note: this is a FOR EXECUTE STATEMENT):

CREATE PROCEDURE P_EXCESS (A_ID INT, A_TRAN INT = NULL, A_CONN INT = NULL)
   RETURNS (ID INT, TRAN INT, CONN INT)
AS
DECLARE S VARCHAR(255) = 'SELECT * FROM TTT WHERE ID = :ID';
DECLARE W VARCHAR(255) = '';
BEGIN
   IF (A_TRAN IS NOT NULL)
      THEN W = W || ' AND TRAN = :a';
   IF (A_CONN IS NOT NULL)
      THEN W = W || ' AND CONN = :b';
   IF (W <> '')
      THEN S = S || W;
   -- could raise error if TRAN or CONN is null
   -- FOR EXECUTE STATEMENT (:S) (a := :A_TRAN, b := A_CONN, id := A_ID)
   -- OK in all cases
   FOR EXECUTE STATEMENT (:S) (EXCESS a := :A_TRAN, EXCESS b := A_CONN, id := A_ID)
      INTO :ID, :TRAN, :CONN
      DO SUSPEND;
END

WITH {AUTONOMOUS | COMMON} TRANSACTION

By default, the executed SQL statement runs within the current transaction. Using WITH AUTONOMOUS TRANSACTION causes a separate transaction to be started, with the same parameters as the current transaction. This separate transaction will be committed when the statement was executed without errors and rolled back otherwise.

The clause WITH COMMON TRANSACTION uses the current transaction whenever possible; this is the default behaviour. If the statement must run in a separate connection, an already started transaction within that connection is used, if available. Otherwise, a new transaction is started with the same parameters as the current transaction. Any new transactions started under the “COMMON” regime are committed or rolled back with the current transaction.
**WITH CALLER PRIVILEGES**

By default, the SQL statement is executed with the privileges of the current user. Specifying **WITH CALLER PRIVILEGES** combines the privileges of the calling procedure or trigger with those of the user, as if the statement were executed directly by the routine. **WITH CALLER PRIVILEGES** has no effect if the **ON EXTERNAL** clause is also present.

**ON EXTERNAL [DATA SOURCE]**

With **ON EXTERNAL [DATA SOURCE]**, the SQL statement is executed in a separate connection to the same or another database, possibly even on another server. If `connection_string` is NULL or "" (empty string), the entire **ON EXTERNAL [DATA SOURCE]** clause is considered absent, and the statement is executed against the current database.

**Connection Pooling**

- External connections made by statements **WITH COMMON TRANSACTION** (the default) will remain open until the current transaction ends. They can be reused by subsequent calls to **EXECUTE STATEMENT**, but only if `connection_string` is identical, including case.
- External connections made by statements **WITH AUTONOMOUS TRANSACTION** are closed as soon as the statement has been executed.
- Statements using **WITH AUTONOMOUS TRANSACTION** can and will re-use connections that were opened earlier by statements **WITH COMMON TRANSACTION**. If this happens, the reused connection will be left open after the statement has been executed. (It must be, because it has at least one active transaction!)

**Transaction Pooling**

- If **WITH COMMON TRANSACTION** is in effect, transactions will be reused as much as possible. They will be committed or rolled back together with the current transaction.
- If **WITH AUTONOMOUS TRANSACTION** is specified, a fresh transaction will always be started for the statement. This transaction will be committed or rolled back immediately after the statement's execution.

**Exception Handling**

When **ON EXTERNAL** is used, the extra connection is always made via a so-called external provider, even if the connection is to the current database. One of the consequences is that exceptions cannot be caught in the usual way. Every exception caused by the statement is wrapped in either an **eds_connection** or an **eds_statement** error. To catch them in your PSQL code, you have to use **WHEN GDSCODE eds_connection**, **WHEN GDSCODE eds_statement** or **WHEN ANY**.

Without **ON EXTERNAL**, exceptions are caught in the usual way, even if an extra connection is made to the current database.

**Miscellaneous Notes**

- The character set used for the external connection is the same as that for the current connection.
- Two-phase commits are not supported.
The optional `AS USER`, `PASSWORD` and `ROLE` clauses allow specification of which user will execute the SQL statement and with which role. The method of user login, and whether a separate connection is opened, depends on the presence and values of the `ON EXTERNAL [DATA SOURCE]`, `AS USER`, `PASSWORD` and `ROLE` clauses:

- **If `ON EXTERNAL` is present**, a new connection is always opened, and:
  - If at least one of `AS USER`, `PASSWORD` and `ROLE` is present, native authentication is attempted with the given parameter values (locally or remotely, depending on `connection_string`). No defaults are used for missing parameters.
  - If all three are absent, and `connection_string` contains no hostname, then the new connection is established on the local server with the same user and role as the current connection. The term 'local' means “on the same machine as the server” here. This is not necessarily the location of the client.
  - If all three are absent, and `connection_string` contains a hostname, then trusted authentication is attempted on the remote host (again, 'remote' from the perspective of the server). If this succeeds, the remote operating system will provide the username (usually the operating system account under which the Firebird process runs).

- **If `ON EXTERNAL` is absent**:
  - If at least one of `AS USER`, `PASSWORD` and `ROLE` is present, a new connection to the current database is opened with the supplied parameter values. No defaults are used for missing parameters.
  - If all three are absent, the statement is executed within the current connection.

If a parameter value is NULL or “’” (empty string), the entire parameter is considered absent. Additionally, `AS USER` is considered absent if its value is equal to `CURRENT_USER`, and `ROLE` if it is the same as `CURRENT_ROLE`.

**Caveats with EXECUTE STATEMENT**

1. There is no way to validate the syntax of the enclosed statement.
2. There are no dependency checks to discover whether tables or columns have been dropped.
3. Execution is considerably slower than when the same statements are executed directly as PSQL code.
4. Return values are strictly checked for data type to avoid unpredictable type-casting exceptions. For example, the string '1234' would convert to an integer, 1234, but 'abc' would give a conversion error.

All in all, this feature is meant to be used cautiously, and you should always take the caveats into account. If you can achieve the same result with PSQL and/or DSQL, it will almost always be preferable.

See also
FOR EXECUTE STATEMENT
7.7.16. FOR SELECT

Loops row-by-row through a query result set

Syntax

```
[label:] FOR <select_stmt> [AS CURSOR cursor_name] DO <compound_statement>
```

Table 108. FOR SELECT Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Optional label for LEAVE and CONTINUE. Follows the rules for identifiers.</td>
</tr>
<tr>
<td>select_stmt</td>
<td>SELECT statement</td>
</tr>
<tr>
<td>cursor_name</td>
<td>Cursor name. It must be unique among cursor names in the PSQL module (stored procedure, stored function, trigger or PSQL block)</td>
</tr>
<tr>
<td>compound_statement</td>
<td>A single statement, or statements wrapped in BEGIN…END, that performs all the processing for this FOR loop</td>
</tr>
</tbody>
</table>

The FOR SELECT statement

- retrieves each row sequentially from the result set, and executes the statement or block of statements for each row. In each iteration of the loop, the field values of the current row are copied into pre-declared variables.

  Including the AS CURSOR clause enables positioned deletes and updates to be performed—see notes below

- can embed other FOR SELECT statements

- can contain named parameters that must be previously declared in the DECLARE VARIABLE statement or exist as input or output parameters of the procedure

- requires an INTO clause at the end of the SELECT … FROM … specification if AS CURSOR is absent. In each iteration of the loop, the field values of the current row are copied to the list of variables specified in the INTO clause. The loop repeats until all rows are retrieved, after which it terminates

- can be terminated before all rows are retrieved by using a BREAK, LEAVE or EXIT statement

The Undeclared Cursor

The optional AS CURSOR clause surfaces the result set of the FOR SELECT structure as an undeclared, named cursor that can be operated on using the WHERE CURRENT OF clause inside the statement or block following the DO command, to delete or update the current row before execution moves to the next row. In addition, it is possible to use the cursor name as a record variable (similar to OLD and NEW in triggers), allowing access to the columns of the result set (i.e. `cursor_name.columnname`).

Rules for Cursor Variables
• When accessing a cursor variable in a DML statement, the colon prefix can be added before the cursor name (i.e. `:cursor_name.columnname`) for disambiguation, similar to variables.

The cursor variable can be referenced without colon prefix, but in that case, depending on the scope of the contexts in the statement, the name may resolve in the statement context instead of to the cursor (e.g. you select from a table with the same name as the cursor).

• Cursor variables are read-only

• In a `FOR SELECT` statement without an `AS CURSOR` clause, you must use the `INTO` clause. If an `AS CURSOR` clause is specified, the `INTO` clause is allowed, but optional; you can access the fields through the cursor instead.

• Reading from a cursor variable returns the current field values. This means that an `UPDATE` statement (with a `WHERE CURRENT OF` clause) will update not only the table, but also the fields in the cursor variable for subsequent reads. Executing a `DELETE` statement (with a `WHERE CURRENT OF` clause) will set all fields in the cursor variable to `NULL` for subsequent reads

Other points to take into account regarding undeclared cursors:

1. The `OPEN`, `FETCH` and `CLOSE` statements cannot be applied to a cursor surfaced by the `AS CURSOR` clause

2. The `cursor_name` argument associated with an `AS CURSOR` clause must not clash with any names created by `DECLARE VARIABLE` or `DECLARE CURSOR` statements at the top of the module body, nor with any other cursors surfaced by an `AS CURSOR` clause

3. The optional `FOR UPDATE` clause in the `SELECT` statement is not required for a positioned update

**Examples using `FOR SELECT`**

1. A simple loop through query results:

```sql
CREATE PROCEDURE SHOWNUMS
RETURNS (AA INTEGER, BB INTEGER, SM INTEGER, DF INTEGER)
AS
BEGIN
FOR SELECT DISTINCT A, B
FROM NUMBERS
ORDER BY A, B
INTO AA, BB
DO
BEGIN
SM = AA + BB;
DF = AA - BB;
SUSPEND;
END
```
2. Nested FOR SELECT loop:

```sql
CREATE PROCEDURE RELFIELDS
RETURNS (RELATION CHAR(32), POS INTEGER, FIELD CHAR(32))
AS
BEGIN
FOR SELECT RDB$RELATION_NAME
    FROM RDB$RELATIONS
    ORDER BY 1
    INTO :RELATION
DO BEGIN
    FOR SELECT
        RDB$FIELD_POSITION + 1,
        RDB$FIELD_NAME
    FROM RDB$RELATION_FIELDS
    WHERE
        RDB$RELATION_NAME = :RELATION
    ORDER BY RDB$FIELD_POSITION
    INTO :POS, :FIELD
    DO BEGIN
        IF (POS = 2) THEN
            RELATION = ' ''
        SUSPEND;
    END
END
END
```

Instead of nesting statements, this is generally better solved by using a single statement with a join.

3. Using the AS CURSOR clause to surface a cursor for the positioned delete of a record:

```sql
CREATE PROCEDURE DELTOWN (TOWNTODELETE VARCHAR(24))
RETURNS (TOWN VARCHAR(24), POP INTEGER)
AS
BEGIN
FOR SELECT TOWN, POP
4. Using an implicitly declared cursor as a cursor variable

```sql
EXECUTE BLOCK
RETURNS (o CHAR(63))
AS
BEGIN
  FOR SELECT rdb$relation_name AS name
  FROM rdb$relations AS CURSOR c
  DO
    BEGIN
      o = c.name;
      SUSPEND;
    END
  END
END
```

5. Disambiguating cursor variables within queries

```sql
EXECUTE BLOCK
RETURNS (o1 CHAR(63), o2 CHAR(63))
AS
BEGIN
  FOR SELECT rdb$relation_name
  FROM rdb$relations
  WHERE
    rdb$relation_name = 'RDB$RELATIONS' AS CURSOR c
  DO
    BEGIN
      FOR SELECT
        -- with a prefix resolves to the cursor
        :c.rdb$relation_name x1,
        -- no prefix as an alias for the rdb$relations table
        c.rdb$relation_name x2
      FROM rdb$relations c
      WHERE
        rdb$relation_name = 'RDB$DATABASE' AS CURSOR d
      DO
```
BEGIN
  o1 = d.x1;
  o2 = d.x2;
  SUSPEND;
END
END
END

See also
DECLARE .. CURSOR, BREAK, LEAVE, CONTINUE, EXIT, SELECT, UPDATE, DELETE

7.7.17. FOR EXECUTE STATEMENT

Executes dynamically created SQL statements and loops over its result set

Syntax

[label:]
FOR <execute_statement> DO <compound_statement>

Table 109. FOR EXECUTE STATEMENT Statement Parameters

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>label</td>
<td>Optional label for LEAVE and CONTINUE. Follows the rules for identifiers.</td>
</tr>
<tr>
<td>execute_stmt</td>
<td>An EXECUTE STATEMENT statement</td>
</tr>
<tr>
<td>compound_statement</td>
<td>A single statement, or statements wrapped in BEGIN … END, that performs all the processing for this FOR loop</td>
</tr>
</tbody>
</table>

The statement FOR EXECUTE STATEMENT is used, in a manner analogous to FOR SELECT, to loop through the result set of a dynamically executed query that returns multiple rows.

FOR EXECUTE STATEMENT Examples

Executing a dynamically constructed SELECT query that returns a data set

```
CREATE PROCEDURE DynamicSampleThree (  
    Q_FIELD_NAME VARCHAR(100),  
    Q_TABLE_NAME VARCHAR(100)  
) RETURNS(  
    LINE VARCHAR(32000)  
)  
AS  
DECLARE VARIABLE P_ONE_LINE VARCHAR(100);  
BEGIN  
  LINE = '';  
  FOR  
    EXECUTE STATEMENT  
      'SELECT T1.' || :Q_FIELD_NAME ||  
```
FROM ' ' || :Q_TABLE_NAME || ' ' T1
INTO :P_ONE_LINE
DO
  IF (:P_ONE_LINE IS NOT NULL) THEN
    LINE = LINE || :P_ONE_LINE || ' ';
    SUSPEND;
  END
END

See also
EXECUTE STATEMENT, BREAK, LEAVE, CONTINUE

7.7.18. OPEN

Opens a declared cursor

Syntax

OPEN cursor_name;

Table 110. OPEN Statement Parameter

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor_name</td>
<td>Cursor name. A cursor with this name must be previously declared with a</td>
</tr>
<tr>
<td></td>
<td>DECLARE CURSOR statement</td>
</tr>
</tbody>
</table>

An OPEN statement opens a previously declared cursor, executes its declared SELECT statement, and makes the first record of the result data set ready to fetch. OPEN can be applied only to cursors previously declared in a DECLARE .. CURSOR statement.

If the SELECT statement of the cursor has parameters, they must be declared as local variables, or input or output parameters before the cursor is declared. When the cursor is opened, the parameter is assigned the current value of the variable.

OPEN Examples

1. Using the OPEN statement:

SET TERM ^;

CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
RETURNS (RNAME CHAR(63))
AS
  DECLARE C CURSOR FOR (SELECT RDB$RELATION_NAME FROM RDB$RELATIONS);
BEGIN
2. A collection of scripts for creating views using a PSQL block with named cursors:

```sql
EXECUTE BLOCK
RETURNS (SCRIPT BLOB SUB_TYPE TEXT)
AS
DECLARE VARIABLE FIELDS VARCHAR(8191);
DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
DECLARE VARIABLE RELATION RDB$RELATION_NAME;
DECLARE VARIABLE SOURCE TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
-- named cursor
DECLARE VARIABLE CUR_R CURSOR FOR (SELECT RDB$RELATION_NAME, RDB$VIEW_SOURCE FROM RDB$RELATIONS WHERE RDB$VIEW_SOURCE IS NOT NULL);
-- named cursor with local variable
DECLARE CUR_F CURSOR FOR (SELECT RDB$FIELD_NAME FROM RDB$RELATION_FIELDS WHERE -- Important! The variable has to be declared earlier RDB$RELATION_NAME = :RELATION);
BEGIN
OPEN CUR_R;
WHILE (1 = 1) DO
BEGIN
FETCH CUR_R INTO :RELATION, :SOURCE;
IF (ROW_COUNT = 0) THEN LEAVE;
SUSPEND;
END
CLOSE C;
END
SET TERM ;^
```
FIELDS = NULL;
-- The CUR_F cursor will use
-- variable value of RELATION initialized above
OPEN CUR_F;
WHILE (1 = 1) DO
BEGIN
  FETCH CUR_F
  INTO :FIELD_NAME;
  IF (ROW_COUNT = 0) THEN
    LEAVE;
  IF (FIELDS IS NULL) THEN
    FIELDS = TRIM(FIELD_NAME);
  ELSE
    FIELDS = FIELDS || ', ' || TRIM(FIELD_NAME);
  END
END
CLOSE CUR_F;
SCRIPT = 'CREATE VIEW ' || RELATION;
IF (FIELDS IS NOT NULL) THEN
  SCRIPT = SCRIPT || ' (' || FIELDS || ')
  SCRIPT = SCRIPT || ' AS ' || ASCII_CHAR(13);
  SCRIPT = SCRIPT || SOURCE;
END
CLOSE CUR_R;
END

See also
DECLARE .. CURSOR, FETCH, CLOSE

7.7.19. FETCH

Fetches a record from a cursor

Syntax

FETCH [<fetch_scroll> FROM] cursor_name
[INTO [:]varname [, [:]varname ...]];

<fetch_scroll> ::= NEXT | PRIOR | FIRST | LAST
| RELATIVE n | ABSOLUTE n

Table 111. FETCH Statement Parameters
The `FETCH` statement fetches the next row from the result set of the cursor and assigns the column values to PSQL variables. The `FETCH` statement can be used only with a cursor declared with the `DECLARE .. CURSOR` statement.

Using the optional `fetch_scroll` part of the `FETCH` statement, you can specify in which direction and how many rows to advance the cursor position. The `NEXT` fetch option can be used for scrollable and forward-only cursors. Other fetch options are only supported for scrollable cursors.

### The Fetch Options

**NEXT**
- Moves the cursor one row forward; this is the default

**PRIOR**
- Moves the cursor one record back

**FIRST**
- Moves the cursor to the first record.

**LAST**
- Moves the cursor to the last record.

**RELATIVE \( n \)**
- Moves the cursor \( n \) rows from the current position; positive numbers move forward, negative numbers move backwards; using zero (0) will not move the cursor, and `ROW_COUNT` will be set to zero as no new row was fetched.

**ABSOLUTE \( n \)**
- Moves the cursor to the specified row; \( n \) is an integer expression, where 1 indicates the first row. For negative values, the absolute position is taken from the end of the result set, so -1 indicates the last row, -2 the second to last row, etc. A value of zero (0) will position before the first row.

The optional `INTO` clause gets data from the current row of the cursor and loads them into PSQL variables. If a fetch moves beyond the bounds of the result set, the variables will be set to `NULL`.

It is also possible to use the cursor name as a variable of a record type (similar to `OLD` and `NEW` in triggers), allowing access to the columns of the result set (i.e. `cursor_name.columnname`).

### Rules for Cursor Variables

- When accessing a cursor variable in a DML statement, the colon prefix can be added before the cursor name (i.e. `:cursor_name.columnname`) for disambiguation, similar to variables.
The cursor variable can be referenced without colon prefix, but in that case, depending on the scope of the contexts in the statement, the name may resolve in the statement context instead of to the cursor (e.g. you select from a table with the same name as the cursor).

- Cursor variables are read-only
- In a FOR SELECT statement without an AS CURSOR clause, you must use the INTO clause. If an AS CURSOR clause is specified, the INTO clause is allowed, but optional; you can access the fields through the cursor instead.
- Reading from a cursor variable returns the current field values. This means that an UPDATE statement (with a WHERE CURRENT OF clause) will update not only the table, but also the fields in the cursor variable for subsequent reads. Executing a DELETE statement (with a WHERE CURRENT OF clause) will set all fields in the cursor variable to NULL for subsequent reads
- When the cursor is not positioned on a row—it is positioned before the first row, or after the last row— attempts to read from the cursor variable will result in error “Cursor cursor_name is not positioned in a valid record”

For checking whether all the rows of the result set have been fetched, the context variable ROW_COUNT returns the number of rows fetched by the statement. If a record was fetched, then ROW_COUNT is one (1), otherwise zero (0).

**FETCH Examples**

1. Using the FETCH statement:

   ```sql
   CREATE OR ALTER PROCEDURE GET_RELATIONS_NAMES
   RETURNS (RNAME CHAR(63))
   AS
   DECLARE C CURSOR FOR
   (SELECT RDB$RELATION_NAME
   FROM RDB$RELATIONS);
   BEGIN
   OPEN C;
   WHILE (1 = 1) DO
   BEGIN
   FETCH C INTO RNAME;
   IF (ROW_COUNT = 0) THEN
   LEAVE;
   SUSPEND;
   END
   CLOSE C;
   END
   ```

2. Using the FETCH statement with nested cursors:

   ```sql
   EXECUTE BLOCK
   RETURNS (SCRIPT BLOB SUB_TYPE TEXT)
   AS
   ```
DECLARE VARIABLE FIELDS VARCHAR (8191);
DECLARE VARIABLE FIELD_NAME TYPE OF RDB$FIELD_NAME;
DECLARE VARIABLE RELATION RDB$RELATION_NAME;
DECLARE VARIABLE SRC TYPE OF COLUMN RDB$RELATIONS.RDB$VIEW_SOURCE;
-- Named cursor declaration
DECLARE VARIABLE CUR_R CURSOR FOR (
    SELECT
        RDB$RELATION_NAME,
        RDB$VIEW_SOURCE
    FROM RDB$RELATIONS
    WHERE RDB$VIEW_SOURCE IS NOT NULL);
-- Declaring a named cursor in which
-- a local variable is used
DECLARE CUR_F CURSOR FOR (
    SELECT RDB$FIELD_NAME
    FROM RDB$RELATION_FIELDS
    WHERE
        -- the variable must be declared earlier
        RDB$RELATION_NAME =: RELATION);
BEGIN
    OPEN CUR_R;
    WHILE (1 = 1) DO
        BEGIN
            FETCH CUR_R INTO RELATION, SRC;
            IF (ROW_COUNT = 0) THEN
                LEAVE;
            FIELDS = NULL;
            -- Cursor CUR_F will use the value
            -- the RELATION variable initialized above
            OPEN CUR_F;
            WHILE (1 = 1) DO
                BEGIN
                    FETCH CUR_F INTO FIELD_NAME;
                    IF (ROW_COUNT = 0) THEN
                        LEAVE;
                    IF (FIELDS IS NULL) THEN
                        FIELDS = TRIM (FIELD_NAME);
                    ELSE
                        FIELDS = FIELDS || ',' || TRIM(FIELD_NAME);
                    END
                    CLOSE CUR_F;
                    SCRIPT = 'CREATE VIEW' || RELATION;
                    IF (FIELDS IS NOT NULL) THEN
                        SCRIPT = SCRIPT || '(' || FIELDS || ')' ;
                        SCRIPT = SCRIPT || 'AS' || ASCII_CHAR (13);
                        SCRIPT = SCRIPT || SRC;
                        SUSPEND;
                    END
                CLOSE CUR_R;
                EN
3. An example of using the `FETCH` statement with a scrollable cursor

```sql
EXECUTE BLOCK
    RETURNS (N INT, RNAME CHAR (63))
AS
    DECLARE C SCROLL CURSOR FOR (
        SELECT
            ROW_NUMBER() OVER (ORDER BY RDB$RELATION_NAME) AS N,
            RDB$RELATION_NAME
        FROM RDB$RELATIONS
        ORDER BY RDB$RELATION_NAME);
BEGIN
    OPEN C;
    -- move to the first record (N = 1)
    FETCH FIRST FROM C;
    RNAME = C.RDB$RELATION_NAME;
    N = C.N;
    SUSPEND;
    -- move 1 record forward (N = 2)
    FETCH NEXT FROM C;
    RNAME = C.RDB$RELATION_NAME;
    N = C.N;
    SUSPEND;
    -- move to the fifth record (N = 5)
    FETCH ABSOLUTE 5 FROM C;
    RNAME = C.RDB$RELATION_NAME;
    N = C.N;
    SUSPEND;
    -- move 1 record backward (N = 4)
    FETCH PRIOR FROM C;
    RNAME = C.RDB$RELATION_NAME;
    N = C.N;
    SUSPEND;
    -- move 3 records forward (N = 7)
    FETCH RELATIVE 3 FROM C;
    RNAME = C.RDB$RELATION_NAME;
    N = C.N;
    SUSPEND;
    -- move back 5 records (N = 2)
    FETCH RELATIVE -5 FROM C;
    RNAME = C.RDB$RELATION_NAME;
    N = C.N;
    SUSPEND;
    -- move to the first record (N = 1)
    FETCH FIRST FROM C;
    RNAME = C.RDB$RELATION_NAME;
    N = C.N;
    SUSPEND;
    -- move to the last entry
    FETCH LAST FROM C;
```
CLOSE (cursor_name);

**Table 112. CLOSE Statement Parameter**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>cursor_name</td>
<td>Cursor name. A cursor with this name must be previously declared with a DECLARE … CURSOR statement and opened by an OPEN statement</td>
</tr>
</tbody>
</table>

A CLOSE statement closes an open cursor. Only a cursor that was declared with DECLARE .. CURSOR can be closed with a CLOSE statement. Any cursors that are still open will be automatically closed after the module code completes execution.

**CLOSE Examples**

See **FETCH Examples**

See also

DECLARE .. CURSOR, OPEN, FETCH

**7.7.21. IN AUTONOMOUS TRANSACTION**

Executes a statement or a block of statements in an autonomous transaction

**Syntax**

```
IN AUTONOMOUS TRANSACTION DO <compound_statement>
```

**Table 113. IN AUTONOMOUS TRANSACTION Statement Parameter**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>compound_statement</td>
<td>A single statement, or statements wrapped in BEGIN … END</td>
</tr>
</tbody>
</table>

The IN AUTONOMOUS TRANSACTION statement enables execution of a statement or a block of statements
in an autonomous transaction. Code running in an autonomous transaction will be committed right after its successful execution, regardless of the status of its parent transaction. This can be used when certain operations must not be rolled back, even if an error occurs in the parent transaction.

An autonomous transaction has the same isolation level as its parent transaction. Any exception that is thrown in the block of the autonomous transaction code will result in the autonomous transaction being rolled back and all changes made will be undone. If the code executes successfully, the autonomous transaction will be committed.

**IN AUTONOMOUS TRANSACTION Examples**

Using an autonomous transaction in a trigger for the database ON CONNECT event, to log all connection attempts, including those that failed:

```sql
CREATE TRIGGER TR_CONNECT ON CONNECT
AS
BEGIN
  -- Logging all attempts to connect to the database
  IN AUTONOMOUS TRANSACTION DO
    INSERT INTO LOG(MSG)
    VALUES ('USER ' || CURRENT_USER || ' CONNECTS.);
    IF (EXISTS(SELECT *
       FROM BLOCKED_USERS
       WHERE USERNAME = CURRENT_USER)) THEN
      BEGIN
        -- Logging that the attempt to connect -- to the database failed and sending -- a message about the event
        IN AUTONOMOUS TRANSACTION DO
          BEGIN
            INSERT INTO LOG(MSG)
            VALUES ('USER ' || CURRENT_USER || ' REFUSED.');
            POST_EVENT 'CONNECTION ATTEMPT BY BLOCKED USER!';
          END
      END
    END
  END
END
```

*See also*

**Transaction Control**

**7.7.22. POST_EVENT**

Posts an event for notification to registered clients on commit
Syntax

```sql
POST_EVENT event_name;
```

**Table 114. POST_EVENT Statement Parameter**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>event_name</td>
<td>Event name (message) limited to 127 bytes</td>
</tr>
</tbody>
</table>

The `POST_EVENT` statement notifies the event manager about the event, which saves it to an event table. When the transaction is committed, the event manager notifies applications that have registered their interest in the event.

The event name can be a code, or a short message: the choice is open as it is a string of up to 127 bytes. Keep in mind that the application listening for an event must use the exact event name when registering.

The content of the string can be a string literal, a variable or any valid SQL expression that resolves to a string.

**POST_EVENT Examples**

Notifying the listening applications about inserting a record into the `SALES` table:

```sql
CREATE TRIGGER POST_NEW_ORDER FOR SALES
ACTIVE AFTER INSERT POSITION 0
AS
BEGIN
  POST_EVENT 'new_order';
END
```

**7.7.23. RETURN**

Returns a value from a stored function

**Syntax**

```sql
RETURN value;
```

**Table 115. RETURN Statement Parameter**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>Expression with the value to return; Can be any expression type-compatible with the return type of the function</td>
</tr>
</tbody>
</table>

The `RETURN` statement ends the execution of a function and returns the value of the expression `value`.
RETURN can only be used in PSQL functions (stored functions and local sub-functions).

**Examples**

See `CREATE FUNCTION Examples`

### 7.8. Trapping and Handling Errors

Firebird has a useful lexicon of PSQL statements and resources for trapping errors in modules and for handling them. Firebird uses built-in exceptions that are raised for errors occurring when working DML and DDL statements.

In PSQL code, exceptions are handled by means of the `WHEN` statement. Handling an exception in the code involves either fixing the problem in situ, or stepping past it; either solution allows execution to continue without returning an exception message to the client.

An exception results in execution being terminated in the current block. Instead of passing the execution to the `END` statement, the procedure moves outward through levels of nested blocks, starting from the block where the exception is caught, searching for the code of the handler that "knows" about this exception. It stops searching when it finds the first `WHEN` statement that can handle this exception.

#### 7.8.1. System Exceptions

An exception is a message that is generated when an error occurs.

All exceptions handled by Firebird have predefined numeric values for context variables (symbols) and text messages associated with them. Error messages are output in English by default. Localized Firebird builds are available, where error messages are translated into other languages.

Complete listings of the system exceptions can be found in *Appendix B, Exception Codes and Messages*:

- SQLSTATE Error Codes and Descriptions
- "GDSCODE Error Codes, SQLCODEs and Descriptions"

#### 7.8.2. Custom Exceptions

Custom exceptions can be declared in the database as persistent objects and called in PSQL code to signal specific errors; for example, to enforce certain business rules. A custom exception consists of an identifier, and a default message of 1021 bytes. For details, see `CREATE EXCEPTION`.

#### 7.8.3. EXCEPTION

Throws a user-defined exception or rethrows an exception

**Syntax**

```sql
EXCEPTION [ 
```
The EXCEPTION statement with `exception_name` throws the user-defined exception with the specified name. An alternative message text of up to 1,021 bytes can optionally override the exception's default message text.

The default exception message can contain slots for parameters that can be filled when throwing an exception. To pass parameter values to an exception, use the `USING` clause. Considering, in left-to-right order, each parameter passed in the exception-raising statement as “the Nth”, with N starting at 1:

- If the Nth parameter is not passed, its slot is not replaced
- If a NULL parameter is passed, the slot will be replaced with the string “*** null ***”
- If more parameters are passed than are defined in the exception message, the surplus ones are ignored
- The maximum number of parameters is 9
- The maximum message length, including parameter values, is 1053 bytes

The status vector is generated this code combination `isc_except, <exception number>, isc_formatted_exception, <formatted exception message>, <exception parameters>`. The error code used (`isc_formatted_exception`) was introduced in Firebird 3.0, so the client must be at least version 3.0, or at least use the `firebird.msg` from version 3.0 or higher, to translate the status vector to a string.

If the `message` contains a parameter slot number that is greater than 9, the second and subsequent digits will be treated as literal text. For example `@10` will be interpreted as slot 1 followed by a literal ‘0’.

As an example:
CREATE EXCEPTION ex1
'something wrong in @1@2@3@4@5@6@7@8@9@10@11';
SET TERM ^;
EXECUTE BLOCK AS
BEGIN
  EXCEPTION ex1 USING ('a', 'b', 'c', 'd', 'e', 'f', 'g', 'h', 'i');
END^

This will produce the following output

Statement failed, SQLSTATE = HY000
exception 1
-EX1
-something wrong in abcdefghia0a1

Exceptions can be handled in a WHEN … DO statement. If an exception is not handled in a module, then the effects of the actions executed inside this module are cancelled, and the caller program receives the exception (either the default text, or the custom text).

Within the exception-handling block — and only within it — the caught exception can be re-thrown by executing the EXCEPTION statement without parameters. If located outside the block, the re-thrown EXCEPTION call has no effect.

Custom exceptions are stored in the system table RDB$EXCEPTIONS.

**EXCEPTION Examples**

1. Throwing an exception upon a condition in the SHIP_ORDER stored procedure:

```sql
CREATE OR ALTER PROCEDURE SHIP_ORDER (PO_NUM CHAR(8))
AS
  DECLARE VARIABLE ord_stat CHAR(7);
  DECLARE VARIABLE hold_stat CHAR(1);
  DECLARE VARIABLE cust_no INTEGER;
  DECLARE VARIABLE any_po CHAR(8);
BEGIN
  SELECT
    s.order_status,
    c.on_hold,
    c.cust_no
  FROM
    sales s, customer c
  WHERE
    po_number = :po_num AND
    s.cust_no = c.cust_no
  INTO :ord_stat,
    :hold_stat,
```
2. Throwing an exception upon a condition and replacing the original message with an alternative message:

```
CREATE OR ALTER PROCEDURE SHIP_ORDER (
    PO_NUM CHAR(8))
AS
    DECLARE VARIABLE ord_stat  CHAR(7);
    DECLARE VARIABLE hold_stat CHAR(1);
    DECLARE VARIABLE cust_no   INTEGER;
    DECLARE VARIABLE any_po    CHAR(8);
    BEGIN
        SELECT
            s.order_status,
            c.on_hold,
            c.cust_no
        FROM
            sales s, customer c
        WHERE
            po_number = :po_num AND
            s.cust_no = c.cust_no
        INTO :ord_stat,
            :hold_stat,
            :cust_no;

        IF (ord_stat = 'shipped') THEN
            EXCEPTION order_already_shipped
        'Order status is "' || ord_stat || '"';
        /* Other statements */
    END
```

3. Using a parameterized exception:

```
CREATE EXCEPTION EX_BAD_SP_NAME
'Name of procedures must start with '@ 1': '@ 2' ';
...
CREATE TRIGGER TRG_SP_CREATE BEFORE CREATE PROCEDURE
AS
    DECLARE SP_NAME VARCHAR(255);
    BEGIN
        SP_NAME = RDB$GET_CONTEXT ('DDL_TRIGGER', 'OBJECT_NAME');
        IF (SP_NAME NOT STARTING 'SP_') THEN
            EXCEPTION EX_BAD_SP_NAME USING ('SP_', SP_NAME);
```
4. Logging an error and re-throwing it in the WHEN block:

```sql
CREATE PROCEDURE ADD_COUNTRY ( 
    ACountryName COUNTRYNAME, 
    ACurrency VARCHAR(10))
AS
BEGIN
    INSERT INTO country (country, currency)
    VALUES (:ACountryName, :ACurrency);
    WHEN ANY DO
    BEGIN
        -- write an error in log
        IN AUTONOMOUS TRANSACTION DO
            INSERT INTO ERROR_LOG (PSQL_MODULE, GDS_CODE, SQL_CODE, SQL_STATE)
            VALUES ('ADD_COUNTRY', GDSCODE, SQLCODE, SQLSTATE);
        -- Re-throw exception
        EXCEPTION;
    END
END
```

See also

CREATE EXCEPTION, WHEN ... DO

7.8.4. WHEN ... DO

Catches an exception for error handling

Syntax

```sql
WHEN {<error> [, <error> ...] | ANY} DO <compound_statement>

<error> ::= 
{ EXCEPTION exception_name 
| SQLCODE number 
| GDSCODE errcode 
| SQLSTATE sqlstate_code }
```
The **WHEN … DO** statement handles Firebird errors and user-defined exceptions. The statement catches all errors and user-defined exceptions listed after the keyword **WHEN** keyword. If **WHEN** is followed by the keyword **ANY**, the statement catches any error or user-defined exception, even if they have already been handled in a **WHEN** block located higher up.

The **WHEN … DO** statements must be located at the end of a block of statements, before the block's **END** statement, and after any other statement.

The keyword **DO** is followed by a single statement, or statements wrapped in a **BEGIN … END** block, that handles the exception. The **SQLCODE**, **GDSCODE**, and **SQLSTATE** context variables are available in the context of this statement or block. Use the **RDB$ERROR** function to obtain the **SQLCODE**, **GDSCODE**, **SQLSTATE**, custom exception name and exception message. The **EXCEPTION** statement, without parameters, can also be used in this context to re-throw the error or exception.

### Targeting GDSCODE

The argument for the **WHEN GDSCODE** clause is the symbolic name associated with the internally-defined exception, such as **grant_obj_notfound** for GDS error 335544551.

In a statement or block of statements of the **DO** clause, a **GDSCODE** context variable, containing the numeric code, becomes available. That numeric code is required if you want to compare a **GDSCODE** exception with a targeted error. To compare it with a specific error, you need to use a numeric values, for example 335544551 for **grant_obj_notfound**.

Similar context variables are available for **SQLCODE** and **SQLSTATE**.

The **WHEN … DO** statement or block is only executed when one of the events targeted by its conditions occurs at run-time. If the **WHEN … DO** statement is executed, even if it does nothing, execution will continue as if no error occurred: the error or user-defined exception neither terminates nor rolls back the operations of the trigger or stored procedure.

However, if the **WHEN … DO** statement or block does nothing to handle or resolve the error, the DML statement (SELECT, INSERT, UPDATE, DELETE, MERGE) that caused the error will be rolled back and none of the statements below it in the same block of statements are executed.

1. If the error is not caused by one of the DML statements (SELECT, INSERT, UPDATE, DELETE, MERGE), the entire block of statements will be rolled back, not only the one that caused an error. Any operations in the **WHEN … DO** statement will be
rolled back as well. The same limitation applies to the `EXECUTE PROCEDURE` statement. Read an interesting discussion of the phenomenon in Firebird Tracker ticket [firebird#4803](https://tracker.firebirdsql.org/tracker/?atid=400533&func=detail&aid=4803).

2. In selectable stored procedures, output rows that were already passed to the client in previous iterations of a `FOR SELECT … DO … SUSPEND` loop remain available to the client if an exception is thrown subsequently in the process of retrieving rows.

### Scope of a `WHEN … DO` Statement

A `WHEN … DO` statement catches errors and exceptions in the current block of statements. It also catches exceptions from nested blocks, if those exceptions have not been handled in those blocks.

All changes made before the statement that caused the error are visible to a `WHEN … DO` statement. However, if you try to log them in an autonomous transaction, those changes are unavailable, because the transaction where the changes took place is not committed at the point when the autonomous transaction is started. Example 4, below, demonstrates this behaviour.

When handling exceptions, it is sometimes desirable to handle the exception by writing a log message to mark the fault and having execution continue past the faulty record. Logs can be written to regular tables, but there is a problem with that: the log records will “disappear” if an unhandled error causes the module to stop executing, and a rollback is performed. Use of **external tables** can be useful here, as data written to them is transaction-independent. The date inserted into a linked external file will still be there, regardless of whether the overall process succeeds or not.

### Examples using `WHEN…DO`

1. Replacing the standard error with a custom one:

```sql
CREATE EXCEPTION COUNTRY_EXIST ''; 
SET TERM ^; 
CREATE PROCEDURE ADD_COUNTRY ( 
   ACountryName COUNTRYNAME, 
   ACurrency VARCHAR(10) ) 
AS 
BEGIN 
   INSERT INTO country (country, currency) 
      VALUES (:ACountryName, :ACurrency); 
   WHEN SQLCODE -803 DO 
      EXCEPTION COUNTRY_EXIST 'Country already exists!'; 
END^ 
SET TERM ^; 
```

2. Logging an error and re-throwing it in the `WHEN` block:
CREATE PROCEDURE ADD_COUNTRY (
    ACountryName COUNTRYNAME,
    ACurrency VARCHAR(10) )
AS
BEGIN
    INSERT INTO country (country,
                         currency)
    VALUES (:ACountryName,
             :ACurrency);
    WHEN ANY DO
    BEGIN
        -- write an error in log
        IN AUTONOMOUS TRANSACTION DO
            INSERT INTO ERROR_LOG (PSQL_MODULE,
                                    GDS_CODE,
                                    SQL_CODE,
                                    SQL_STATE,
                                    MESSAGE)
            VALUES ('ADD_COUNTRY',
                     GDS_CODE,
                     SQLCODE,
                     SQLSTATE,
                     RDB$ERROR(MESSAGE));
        -- Re-throw exception
        EXCEPTION;
    END
END

3. Handling several errors in one WHEN block

... WHEN GDSCODE GRANT_OBJ_NOTFOUND,
      GDSCODE GRANT_FLD_NOTFOUND,
      GDSCODE GRANT_NOPRIV,
      GDSCODE GRANT_NOPRIV_ON_BASE
DO
BEGIN
    EXECUTE PROCEDURE LOG_GRANT_ERROR(GDSCODE,
                                        RDB$ERROR(MESSAGE);
    EXIT;
END
... 

4. Catching errors using the SQLSTATE code

EXECUTE BLOCK
AS
    DECLARE VARIABLE I INT;
BEGIN
BEGIN
    I = 1/0;
    WHEN SQLSTATE '22003' DO
        EXCEPTION E_CUSTOM_EXCEPTION
        'Numeric value out of range.';
    WHEN SQLSTATE '22012' DO
        EXCEPTION E_CUSTOM_EXCEPTION
        'Division by zero.';
    WHEN SQLSTATE '23000' DO
        EXCEPTION E_CUSTOM_EXCEPTION
        'Integrity constraint violation.';
END
END

See also
exception, create exception, sqlcode and gdscode error codes and message texts and sqlstate codes and message texts, gdscode, sqlcode, sqlstate, rdb$error()
Chapter 8. Built-in Scalar Functions

Unless explicitly mentioned otherwise in an “Available in” section, functions are available in DSQL and PSQL. Availability of built-in functions in ESQL is not tracked by this Language Reference.

8.1. Context Functions

8.1.1. RDB$GET_CONTEXT()

Retrieves the value of a context variable from a namespace

Result type
VARCHAR(255)

Syntax

```
RDB$GET_CONTEXT ('<namespace>', <varname>)
```

- `<namespace>` ::= SYSTEM | USER_SESSION | USER_TRANSACTION | DDL_TRIGGER
- `<varname>` ::= A case-sensitive quoted string of max. 80 characters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>namespace</td>
<td>Namespace</td>
</tr>
<tr>
<td>varname</td>
<td>Variable name; case-sensitive with a maximum length of 80 characters</td>
</tr>
</tbody>
</table>

The namespaces

The USER_SESSION and USER_TRANSACTION namespaces are initially empty. A user can create and set variables with RDB$SET_CONTEXT() and retrieve them with RDB$GET_CONTEXT(). The SYSTEM namespace is read-only. The DDL_TRIGGER namespace is only valid in DDL triggers, and is read-only. The SYSTEM and DDL_TRIGGER namespaces contain a number of predefined variables, shown below.

Return values and error behaviour

If the polled variable exists in the given namespace, its value will be returned as a string of max. 255 characters. If the namespace doesn't exist or if you try to access a non-existing variable in the SYSTEM or DDL_TRIGGER namespace, an error is raised. If you request a non-existing variable in one of the user namespaces, NULL is returned. Both namespace and variable names must be given as single-quoted, case-sensitive, non-NULL strings.

The SYSTEM Namespace

Context variables in the SYSTEM namespace

CLIENT_ADDRESS

For TCP, this is the IP address. For XNET, the local process ID. For all other protocols this variable is NULL.
CLIENT_HOST
The wire protocol host name of remote client. Value is returned for all supported protocols.

CLIENT_PID
Process ID of remote client application.

CLIENT_PROCESS
Process name of remote client application.

CURRENT_ROLE
Same as global CURRENT_ROLE variable.

CURRENT_USER
Same as global CURRENT_USER variable.

DB_FILE_ID
Unique filesystem-level ID of the current database.

DB_GUID
GUID of the current database.

DB_NAME
Canonical name of current database; either the full path to the database or—if connecting via the path is disallowed—it’s alias.

DECFLOAT_ROUND
Rounding mode of the current connection used in operations with DECFLOAT values. See also SET DECFLOAT.

DECFLOAT_TRAPS
Exceptional conditions for the current connection in operations with DECFLOAT values that cause a trap. See also SET DECFLOAT.

EFFECTIVE_USER
Effective user at the point RDB$GET_CONTEXT is called; indicates privileges of which user is currently used to execute a function, procedure, trigger.

ENGINE_VERSION
The Firebird engine (server) version.

EXT_CONN_POOL_ACTIVE_COUNT
Count of active connections associated with the external connection pool.

EXT_CONN_POOL_IDLE_COUNT
Count of currently inactive connections available in the connection pool.

EXT_CONN_POOL_LIFETIME
External connection pool idle connection lifetime, in seconds.
EXT_CONN_POOL_SIZE
   External connection pool size.

GLOBAL_CN
   Most current value of global Commit Number counter.

ISOLATION_LEVEL
   The isolation level of the current transaction: 'READ COMMITTED', 'SNAPSHOT' or 'CONSISTENCY'.

LOCK_TIMEOUT
   Lock timeout of the current transaction.

NETWORK_PROTOCOL
   The protocol used for the connection: 'TCPv4', 'TCPv6', 'XNET' or NULL.

PARALLEL_WORKERS
   The maximum number of parallel workers of the connection.

READ_ONLY
   Returns 'TRUE' if current transaction is read-only and 'FALSE' otherwise.

REPLICA_MODE
   Replica mode of the database: 'READ-ONLY', 'READ-WRITE' and NULL.

REPLICATION_SEQUENCE
   Current replication sequence (number of the latest segment written to the replication journal).

SESSION_ID
   Same as global CURRENT_CONNECTION variable.

SESSION_IDLE_TIMEOUT
   Connection-level idle timeout, or 0 if no timeout was set. When 0 is reported the database ConnectionIdleTimeout from databases.conf or firebird.conf applies.

SESSION_TIMEZONE
   Current session time zone.

SNAPSHOT_NUMBER
   Current snapshot number for the transaction executing this statement. For SNAPSHOT and SNAPSHOT TABLE STABILITY, this number is stable for the duration of the transaction; for READ COMMITTED this number will change (increment) as concurrent transactions are committed.

STATEMENT_TIMEOUT
   Connection-level statement timeout, or 0 if no timeout was set. When 0 is reported the database StatementTimeout from databases.conf or firebird.conf applies.

TRANSACTION_ID
   Same as global CURRENT_TRANSACTION variable.
**WIRE_COMPRESSED**
Compression status of the current connection. If the connection is compressed, returns TRUE; if it is not compressed, returns FALSE. Returns NULL if the connection is embedded.

**WIRE_CRYPT_PLUGIN**
If connection is encrypted - returns name of current plugin, otherwise NULL.

**WIRE_ENCRYPTED**
Encryption status of the current connection. If the connection is encrypted, returns TRUE; if it is not encrypted, returns FALSE. Returns NULL if the connection is embedded.

**The DDL_TRIGGER Namespace**
The DDL_TRIGGER namespace is valid only when a DDL trigger is running. Its use is also valid in stored procedures and functions when called by DDL triggers.

The DDL_TRIGGER context works like a stack. Before a DDL trigger is fired, the values relative to the executed command are pushed onto this stack. After the trigger finishes, the values are popped. So in the case of cascade DDL statements, when a user DDL command fires a DDL trigger and this trigger executes another DDL command with EXECUTE STATEMENT, the values of the DDL_TRIGGER namespace are the ones relative to the command that fired the last DDL trigger on the call stack.

*Context variables in the DDL_TRIGGER namespace*

**EVENT_TYPE**
event type (CREATE, ALTER, DROP)

**OBJECT_TYPE**
object type (TABLE, VIEW, etc)

**DDL_EVENT**
event name (<ddl event item>), where <ddl event item> is EVENT_TYPE || ' ' || OBJECT_TYPE

**OBJECT_NAME**
metadata object name

**OLD_OBJECT_NAME**
for tracking the renaming of a domain (see note)

**NEW_OBJECT_NAME**
for tracking the renaming of a domain (see note)

**SQL_TEXT**
sql statement text

**ALTER DOMAIN old-name TO new-name** sets OLD_OBJECT_NAME and NEW_OBJECT_NAME in both BEFORE and AFTER triggers. For this command, OBJECT_NAME will have the old object name in BEFORE triggers, and the new object name in AFTER triggers.
Examples

```sql
select rdb$get_context('SYSTEM', 'DB_NAME') from rdb$database

New.UserAddr = rdb$get_context('SYSTEM', 'CLIENT_ADDRESS');

insert into MyTable (TestField)
values (rdb$get_context('USER_SESSION', 'MyVar'))
```

See also

RDB$SET_CONTEXT()

8.1.2. RDB$SET_CONTEXT()

Creates, sets or clears a variable in one of the user-writable namespaces

Result type

INTEGER

Syntax

```sql
RDB$SET_CONTEXT ("<namespace>", <varname>, <value> | NULL)
```

| <namespace> | USER_SESSION | USER_TRANSACTION |
| <varname>   | A case-sensitive quoted string of max. 80 characters |
| <value>     | A value of any type, as long as it's castable to a VARCHAR(255) |

Table 119. RDB$SET_CONTEXT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>namespace</td>
<td>Namespace</td>
</tr>
<tr>
<td>varname</td>
<td>Variable name. Case-sensitive. Maximum length is 80 characters</td>
</tr>
<tr>
<td>value</td>
<td>Data of any type provided it can be cast to VARCHAR(255)</td>
</tr>
</tbody>
</table>

The namespaces

The USER_SESSION and USER_TRANSACTION namespaces are initially empty. A user can create and set variables with RDB$SET_CONTEXT() and retrieve them with RDB$get_context(). The USER_SESSION context is bound to the current connection, the USER_TRANSACTION context to the current transaction.

Lifecycle

- When a transaction ends, its USER_TRANSACTION context is cleared.
- When a connection is closed, its USER_SESSION context is cleared.
- When a connection is reset using ALTER SESSION RESET, the USER_TRANSACTION and USER_SESSION contexts are cleared.

Return values and error behaviour
The function returns 1 when the variable already existed before the call and 0 when it didn't. To remove a variable from a context, set it to NULL. If the given namespace doesn't exist, an error is raised. Both namespace and variable names must be entered as single-quoted, case-sensitive, non-NULL strings.

- The maximum number of variables in any single context is 1000.
- All USER_TRANSACTION variables survive a ROLLBACK RETAIN (see ROLLBACK Options) or ROLLBACK TO SAVEPOINT unaltered, no matter at which point during the transaction they were set.
- Due to its UDF-like nature, RDB$SET_CONTEXT can — in PSQL only — be called like a void function, without assigning the result, as in the second example above. Regular internal functions don't allow this type of use.
- ALTER SESSION RESET clears both USER_TRANSACTION and USER_SESSION contexts.

Examples

```sql
select rdb$set_context('USER_SESSION', 'MyVar', 493) from rdb$database

rdb$set_context('USER_SESSION', 'RecordsFound', RecCounter);

select rdb$set_context('USER_TRANSACTION', 'Savepoints', 'Yes')
     from rdb$database
```

See also

RDB$GET_CONTEXT()

8.2. Mathematical Functions

8.2.1. ABS()

Absolute value

Result type
Numerical, matching input type

Syntax

```sql
ABS (number)
```

Table 120. ABS Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>
8.2.2. **ACOS()**

Arc cosine

*Result type*
DOUBLE PRECISION

*Syntax*

```
ACOS (number)
```

*Table 121. ACOS Function Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type within the range ([-1, 1])</td>
</tr>
</tbody>
</table>

- The result is an angle in the range \([0, \pi]\).

*See also*

COS(), ASIN(), ATAN()

8.2.3. **ACOSH()**

Inverse hyperbolic cosine

*Result type*
DOUBLE PRECISION

*Syntax*

```
ACOSH (number)
```

*Table 122. ACOSH Function Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any non-NULL value in the range ([1, \infty]).</td>
</tr>
</tbody>
</table>

The result is in the range \([0, \infty]\).

*See also*

COSH(), ASINH(), ATANH()

8.2.4. **ASIN()**

Arc sine

*Result type*
DOUBLE PRECISION
Syntax

ASIN (number)

Table 123. ASIN Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type within the range [-1, 1]</td>
</tr>
</tbody>
</table>

The result is an angle in the range [-pi/2, pi/2].

See also

SIN(), ACOS(), ATAN()

8.2.5. ASINH()

Inverse hyperbolic sine

Result type

DOUBLE PRECISION

Syntax

ASINH (number)

Table 124. ASINH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any non-NULL value in the range [-INF, INF].</td>
</tr>
</tbody>
</table>

The result is in the range [-INF, INF].

See also

SINH(), ACOSH(), ATANH()

8.2.6. ATAN()

Arc tangent

Result type

DOUBLE PRECISION

Syntax

ATAN (number)

Table 125. ATAN Function Parameter
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

The result is an angle in the range $\langle -\pi/2, \pi/2 \rangle$.

See also

ATAN2(), TAN(), ACOS(), ASIN()

### 8.2.7. ATAN2()

Two-argument arc tangent

**Result type**

DOUBLE PRECISION

**Syntax**

ATAN2 ($y$, $x$)

<table>
<thead>
<tr>
<th>Table 126. ATAN2 Function Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>$y$</td>
</tr>
<tr>
<td>$x$</td>
</tr>
</tbody>
</table>

Returns the angle whose sine-to-cosine *ratio* is given by the two arguments, and whose sine and cosine *signs* correspond to the signs of the arguments. This allows results across the entire circle, including the angles $-\pi/2$ and $\pi/2$.

- The result is an angle in the range $[-\pi, \pi]$.
- If $x$ is negative, the result is $\pi$ if $y$ is 0, and $-\pi$ if $y$ is -0.
- If both $y$ and $x$ are 0, the result is meaningless. An error will be raised if both arguments are 0.

- A fully equivalent description of this function is the following: $\text{ATAN2}(y, x)$ is the angle between the positive X-axis and the line from the origin to the point $(x, y)$. This also makes it obvious that $\text{ATAN2}(0, 0)$ is undefined.
- If $x$ is greater than 0, $\text{ATAN2}(y, x)$ is the same as $\text{ATAN}(y/x)$.
- If both sine and cosine of the angle are already known, $\text{ATAN2}(\sin, \cos)$ gives the angle.

### 8.2.8. ATANH()

Inverse hyperbolic tangent

**Result type**

DOUBLE PRECISION
Syntax

```
ATANH (number)
```

### Table 127. ATANH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>Any non-NULL value in the range &lt;-1, 1&gt;.</td>
</tr>
</tbody>
</table>

The result is a number in the range [-INF, INF].

See also

TANH(), ACOSH(), ASINH()

#### 8.2.9. CEIL(), CEILING()

Ceiling of a number

**Result type**

BIGINT or INT128 for exact numeric `number`, or DOUBLE PRECISION or DECFLOAT for floating point `number`

**Syntax**

```
CEIL[ING] (number)
```

### Table 128. CEIL[ING] Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the smallest whole number greater than or equal to the argument.

See also

FLOOR(), ROUND(), TRUNC()

#### 8.2.10. COS()

Cosine

**Result type**

DOUBLE PRECISION

**Syntax**

```
COS (angle)
```

**Table 129. COS Function Parameter**
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>An angle in radians</td>
</tr>
</tbody>
</table>

The result is in the range [-1, 1].

*See also*

ACOS(), COT(), SIN(), TAN()

### 8.2.11. COSH()

Hyperbolic cosine

**Result type**

DOUBLE PRECISION

**Syntax**

```
COSH (number)
```

*Table 130. COSH Function Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of a numeric type</td>
</tr>
</tbody>
</table>

The result is in the range [1, INF].

*See also*

ACOSH(), SINH(), TANH()

### 8.2.12. COT()

Cotangent

**Result type**

DOUBLE PRECISION

**Syntax**

```
COT (angle)
```

*Table 131. COT Function Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>An angle in radians</td>
</tr>
</tbody>
</table>

*See also*

COS(), SIN(), TAN()
8.2.13. EXP()

Natural exponent

Result type
DOUBLE PRECISION

Syntax

```
exp (number)
```

Table 132. EXP Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of a numeric type</td>
</tr>
</tbody>
</table>

Returns the natural exponential, $e^{\text{number}}$.

See also
LN()

8.2.14. FLOOR()

Floor of a number

Result type
BIGINT or INT128 for exact numeric \text{number}, or DOUBLE PRECISION or DECFLOAT for floating point \text{number}

Syntax

```
floor (number)
```

Table 133. FLOOR Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the largest whole number smaller than or equal to the argument.

See also
CEIL(), CEILING(), ROUND(), TRUNC()

8.2.15. LN()

Natural logarithm

Result type
DOUBLE PRECISION
8.2.16. **LOG()**

Logarithm with variable base

**Result type**
DOUBLE PRECISION

**Syntax**

\[
\text{LOG}(x, y)
\]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>Base. An expression of a numeric type</td>
</tr>
<tr>
<td>y</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the \( x \)-based logarithm of \( y \).

- If either argument is 0 or below, an error is raised.
- If both arguments are 1, NaN is returned.
- If \( x = 1 \) and \( y < 1 \), -INF is returned.
- If \( x = 1 \) and \( y > 1 \), INF is returned.

**See also**

POWER(), LN(), LOG10()
Syntax

\[
\text{LOG10 (number)}
\]

Table 136. LOG10 Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

An error is raised if the argument is negative or 0.

See also

POWER(), LN(), LOG()

8.2.18. MOD()  

Remainder  

Result type  

SMALLINT, INTEGER or BIGINT depending on the type of \( a \). If \( a \) is a floating-point type, the result is a BIGINT.

Syntax

\[
\text{MOD (a, b)}
\]

Table 137. MOD Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>An expression of a numeric type</td>
</tr>
<tr>
<td>b</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns the remainder of an integer division.

- Non-integer arguments are rounded before the division takes place. So, \( \text{mod(7.5, 2.5)} \) gives 2 (\( \text{mod(8, 3)} \)), not 0.
- Do not confuse MOD() with the mathematical modulus operator; e.g. mathematically, \( -21 \mod 4 \) is 3, while Firebird's \( \text{MOD(-21, 4)} \) is -1. In other words, MOD() behaves as \% in languages like C and Java.

8.2.19. PI()  

Approximation of \( pi \).

Result type  

DOUBLE PRECISION
8.2.20. **POWER()**

Power

*Result type*
DOUBLE PRECISION

**Syntax**

```
POWER (x, y)
```

**Table 138. POWER Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>An expression of a numeric type</td>
</tr>
<tr>
<td>y</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Returns x to the power of y ($x^y$).

*See also*

**EXP(), LOG(), LOG10(), SQRT()**

8.2.21. **RAND()**

Generates a random number

*Result type*
DOUBLE PRECISION

**Syntax**

```
RAND ()
```

Returns a random number between 0 and 1.

8.2.22. **ROUND()**

*Result type*

single argument: integer type, DOUBLE PRECISION or DECFLOAT;
two arguments: numerical, matching first argument
Syntax

```
ROUND (number [, scale])
```

Table 139. ROUND Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>
| scale     | An integer specifying the number of decimal places toward which rounding is to be performed, e.g.:
|           | - 2 for rounding to the nearest multiple of 0.01 |
|           | - 1 for rounding to the nearest multiple of 0.1 |
|           | 0 for rounding to the nearest whole number |
|           | -1 for rounding to the nearest multiple of 10 |
|           | -2 for rounding to the nearest multiple of 100 |

Rounds a number to the nearest integer. If the fractional part is exactly 0.5, rounding is upward for positive numbers and downward for negative numbers. With the optional `scale` argument, the number can be rounded to powers-of-ten multiples (tens, hundreds, tenths, hundredths, etc.).

If you are used to the behaviour of the external function `ROUND`, please notice that the internal function always rounds halves away from zero, i.e. downward for negative numbers.

**ROUND Examples**

If the `scale` argument is present, the result usually has the same scale as the first argument:

```
ROUND(123.654, 1) -- returns 123.700 (not 123.7)
ROUND(8341.7, -3) -- returns 8000.0 (not 8000)
ROUND(45.1212, 0) -- returns 45.0000 (not 45)
```

Otherwise, the result scale is 0:

```
ROUND(45.1212) -- returns 45
```

See also

`CEIL()`, `CEILING()`, `FLOOR()`, `TRUNC()`

**8.2.23. SIGN()**

Sign or signum

*Result type*
### 8.2.24. `SIN()`

**Sine**

**Result type**
DOUBLE PRECISION

**Syntax**

```sql
SIN (angle)
```

**Table 141. SIN Function Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>An angle, in radians</td>
</tr>
</tbody>
</table>

The result is in the range [-1, 1].

See also

`ASIN()`, `COS()`, `COT()`, `TAN()`

### 8.2.25. `SINH()`

**Hyperbolic sine**

**Result type**
DOUBLE PRECISION

**Syntax**

```sql
SINH (number)
```

See also

`ASINH()`, `COSH()`, `TANH()`
Table 142. SINH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

See also

ASINH(), COSH(), TANH()

8.2.26. SQRT()

Square root

Result type
DOUBLE PRECISION

Syntax

SQRT (number)

Table 143. SQRT Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

If number is negative, an error is raised.

See also

POWER()

8.2.27. TAN()

Tangent

Result type
DOUBLE PRECISION

Syntax

TAN (angle)

Table 144. TAN Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>angle</td>
<td>An angle, in radians</td>
</tr>
</tbody>
</table>

See also

ATAN(), ATAN2(), COS(), COT(), SIN(), TAN()
### 8.2.28. TANH()

Hyperbolic tangent

**Result type**

DOUBLE PRECISION

**Syntax**

\[ \text{TANH}( \text{number} ) \]

**Table 145. TANH Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
</tbody>
</table>

Due to rounding, the result is in the range \([-1, 1]\) (mathematically, it's \(<-1, 1>\)).

**See also**

ATANH(), COSH(), TANH()

### 8.2.29. TRUNC()

Truncate number

**Result type**

single argument: integer type, DOUBLE PRECISION or DECFLOAT;
two arguments: numerical, matching first argument

**Syntax**

\[ \text{TRUNC}( \text{number [, scale]} ) \]

**Table 146. TRUNC Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>An expression of a numeric type</td>
</tr>
<tr>
<td>scale</td>
<td>An integer specifying the number of decimal places toward which truncating is to be performed, e.g.:</td>
</tr>
<tr>
<td></td>
<td>• 2 for truncating to the nearest multiple of 0.01</td>
</tr>
<tr>
<td></td>
<td>• 1 for truncating to the nearest multiple of 0.1</td>
</tr>
<tr>
<td></td>
<td>• 0 for truncating to the nearest whole number</td>
</tr>
<tr>
<td></td>
<td>• -1 for truncating to the nearest multiple of 10</td>
</tr>
<tr>
<td></td>
<td>• -2 for truncating to the nearest multiple of 100</td>
</tr>
</tbody>
</table>

The single argument variant returns the integer part of a number. With the optional `scale`
argument, the number can be truncated to powers-of-ten multiples (tens, hundreds, tenths, hundredths, etc.).

- If the scale argument is present, the result usually has the same scale as the first argument, e.g.
  - TRUNC(789.2225, 2) returns 789.2200 (not 789.22)
  - TRUNC(345.4, -2) returns 300.0 (not 300)
  - TRUNC(-163.41, 0) returns -163.00 (not -163)
- Otherwise, the result scale is 0:
  - TRUNC(-163.41) returns -163

If you are used to the behaviour of the external function TRUNCATE, please notice that the internal function TRUNC always truncates toward zero, i.e. upward for negative numbers.

See also
CEIL(), CEILING(), FLOOR(), ROUND()

8.3. String and Binary Functions

8.3.1. ASCII_CHAR()

Character from ASCII code

Result type
CHAR(1) CHARACTER SET NONE

Syntax

    ASCII_CHAR (code)

Table 147. ASCII_CHAR Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>code</td>
<td>An integer within the range from 0 to 255</td>
</tr>
</tbody>
</table>

Returns the ASCII character corresponding to the number passed in the argument.

- If you are used to the behaviour of the ASCII_CHAR UDF, which returns an empty string if the argument is 0, please notice that the internal function returns a character with ASCII code 0 (character NUL) here.

See also
ASCII_VAL(), UNICODE_CHAR()
8.3.2. ASCII_VAL()

ASCII code from string

Result type
SMALLINT

Syntax

```
ASCII_VAL (ch)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ch</td>
<td>A string of the [VAR]CHAR data type or a text BLOB with the maximum size of 32,767 bytes</td>
</tr>
</tbody>
</table>

Returns the ASCII code of the character passed in.

- If the argument is a string with more than one character, the ASCII code of the first character is returned.
- If the argument is an empty string, 0 is returned.
- If the argument is NULL, NULL is returned.
- If the first character of the argument string is multi-byte, an error is raised.

See also
ASCII_CHAR(), UNICODE_VAL()

8.3.3. BASE64_DECODE()

Decodes a base64 string to binary

Result type
VARBINARY or BLOB

Syntax

```
BASE64_DECODE (base64_data)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>base64_data</td>
<td>Base64 encoded data, padded with = to multiples of 4</td>
</tr>
</tbody>
</table>

BASE64_DECODE decodes a string with base64-encoded data, and returns the decoded value as VARBINARY or BLOB as appropriate for the input. If the length of the type of base64_data is not a multiple of 4, an error is raised at prepare time. If the length of the value of base64_data is not a multiple of 4, an error is raised at execution time.
When the input is not BLOB, the length of the resulting type is calculated as \( \text{type\_length} \times 3 / 4 \), where \( \text{type\_length} \) is the maximum length in characters of the input type.

**Example of BASE64_DECODE**

```sql
select cast(base64_decode('VGVzdCBiYXNlNjQ=') as varchar(12))
from rdb$database;
```

CAST  

Test base64

See also

BASE64_ENCODE(), HEX_DECODE()

**8.3.4. BASE64_ENCODE()**

Encodes a (binary) value to a base64 string

*Result type*

VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII

*Syntax*

```sql
BASE64_ENCODE (binary_data)
```

*Table 150. BASE64_ENCODE Function Parameter*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>binary_data</td>
<td>Binary data (or otherwise convertible to binary) to encode</td>
</tr>
</tbody>
</table>

BASE64_ENCODE encodes \( \text{binary\_data} \) with base64, and returns the encoded value as a VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII as appropriate for the input. The returned value is padded with '=' so its length is a multiple of 4.

When the input is not BLOB, the length of the resulting type is calculated as \( \text{type\_length} \times 4 / 3 \) rounded up to a multiple of four, where \( \text{type\_length} \) is the maximum length in bytes of the input type. If this length exceeds the maximum length of VARCHAR, the function returns a BLOB.

**Example of BASE64_ENCODE**

```sql
select base64_encode('Test base64')
from rdb$database;
```

BASE64_ENCODE

=ＶＧＶｚｄＣＢｉＹＸＮｌＮｊＱ=
**8.3.5. BIT_LENGTH()**

String or binary length in bits

**Result type**

INTEGER, or BIGINT for BLOB

**Syntax**

```sql
BIT_LENGTH (string)
```

**Table 151. BIT_LENGTH Function Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Gives the length in bits of the input string. For multi-byte character sets, this may be less than the number of characters times 8 times the “formal” number of bytes per character as found in RDB$CHARACTER_SETS.

With arguments of type CHAR, this function takes the entire formal string length (i.e. the declared length of a field or variable) into account. If you want to obtain the “logical” bit length, not counting the trailing spaces, right-TRIM the argument before passing it to BIT_LENGTH.

**BIT_LENGTH Examples**

```sql
select bit_length('Hello!') from rdb$database
-- returns 48

select bit_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 64: ü and ß take up one byte each in ISO8859_1

select bit_length( cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 80: ü and ß take up two bytes each in UTF8

select bit_length( cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 208: all 24 CHAR positions count, and two of them are 16-bit
```

See also

**BASE64_DECODE(), HEX_ENCODE()**
OCTET_LENGTH(), CHAR_LENGTH(), CHARACTER_LENGTH()

8.3.6. BLOB_APPEND()

Efficient concatenation of blobs

Result type
BLOB

Syntax

\[
\text{BLOB_APPEND(} \, \text{expr}_1, \, \text{expr}_2 \, [\, , \text{expr}_N \, ... \, ]\text{)}
\]

Table 152. BLOB_APPEND Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exprN</td>
<td>An expression of a type convertible to BLOB</td>
</tr>
</tbody>
</table>

The BLOB_APPEND function concatenates blobs without creating intermediate BLOBs, avoiding excessive memory consumption and growth of the database file. The BLOB_APPEND function takes two or more arguments and adds them to a BLOB which remains open for further modification by a subsequent BLOB_APPEND call.

The resulting BLOB is left open for writing instead of being closed when the function returns. In other words, the BLOB can be appended as many times as required. The engine marks the BLOB returned by BLOB_APPEND with an internal flag, BLB_close_on_read, and closes it automatically when needed.

The first argument determines the behaviour of the function:

1. **NULL**: new, empty BLOB SUB_TYPE TEXT is created, using the connection character set as the character set
2. permanent BLOB (from a table) or temporary BLOB which was already closed: new BLOB is created with the same subtype and, if subtype is TEXT the same character set, populated with the content of the original BLOB.
3. temporary unclosed BLOB with the BLB_close_on_read flag (e.g. created by another call to BLOB_APPEND): used as-is, remaining arguments are appended to this BLOB
4. other data types: a new BLOB SUB_TYPE TEXT is created, populated with the original argument converted to string. If the original value is a character type, its character set is used (for string literals, the connection character set), otherwise the connection character set.

Other arguments can be of any type. The following behavior is defined for them:

1. **NULLs** are ignored (behave as empty string)
2. BLOBs, if necessary, are transliterated to the character set of the first argument and their contents are appended to the result
3. other data types are converted to strings (as usual) and appended to the result
The BLOB_APPEND function returns a temporary unclosed BLOB with the BLB_close_on_read flag. If the first argument is such a temporary unclosed BLOB (e.g. created by a previous call to BLOB_APPEND), it will be used as-is, otherwise a new BLOB is created. Thus, a series of operations like blob = BLOB_APPEND (blob, ...) will result in the creation of at most one BLOB (unless you try to append a BLOB to itself). This blob will be automatically closed by the engine when the client reads it, assigns it to a table, or uses it in other expressions that require reading the content.

**Important caveats for BLOB_APPEND**

1. The NULL behaviour of BLOB_APPEND is different from normal concatenation (using ||). Occurrence of NULL will behave as if an empty string was used. In other words, NULL is effectively ignored.

In normal concatenation, concatenating with NULL results in NULL.

Testing a blob for NULL using the IS [NOT] NULL operator does not read it and therefore a temporary blob with the BLB_close_on_read flag will not be closed after such a test.

Use LIST or BLOB_APPEND functions to concatenate blobs. This reduces memory consumption and disk I/O, and also prevents database growth due to the creation of many temporary blobs when using the concatenation operator.

**BLOB_APPEND Examples**

execute block
returns (b blob sub_type text)
as
begin
    -- creates a new temporary not closed BLOB
    -- and writes the string from the 2nd argument into it
    b = blob_append(null, 'Hello ');

    -- adds two strings to the temporary BLOB without closing it
    b = blob_append(b, 'World', '!' );

    -- comparing a BLOB with a string will close it, because the BLOB needs to be read
    if (b = 'Hello World!') then
        begin
            -- ...
        end

    -- creates a temporary closed BLOB by adding a string to it
    b = b || 'Close';

    suspend;
end
See also
Concatenation Operator, LIST(), RDB$BLOB_UTIL

8.3.7. CHAR_LENGTH(), CHARACTER_LENGTH()

String length in characters

Result type
INTEGER, or BIGINT for BLOB

Syntax

```
CHAR_LENGTH (string)
| CHARACTER_LENGTH (string)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Gives the length in characters of the input string.

- With arguments of type CHAR, this function returns the formal string length (i.e. the declared length of a field or variable). If you want to obtain the “logical” length, not counting the trailing spaces, right-TRIM the argument before passing it to CHAR[ACTER]_LENGTH.
- This function fully supports text BLOBs of any length and character set.

**CHAR_LENGTH Examples**

```
select char_length('Hello!') from rdb$database
-- returns 6

select char_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 8

select char_length(cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 8; the fact that ü and ß take up two bytes each is irrelevant

select char_length(cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 24: all 24 CHAR positions count
```

See also
8.3.8. CRYPTO_HASH()

Cryptographic hash

Result type
VARBINARY

Syntax

CRYPTO_HASH (value USING <hash>)

<hash> ::= MD5 | SHA1 | SHA256 | SHA512

Table 154. CRYPTO_HASH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>Expression of value of any type; non-string or non-binary types are converted to string</td>
</tr>
<tr>
<td>hash</td>
<td>Cryptographic hash algorithm to apply</td>
</tr>
</tbody>
</table>

CRYPTO_HASH returns a cryptographic hash calculated from the input argument using the specified algorithm. If the input argument is not a string or binary type, it is converted to string before hashing.

This function returns a VARBINARY with the length depending on the specified algorithm.

- The MD5 and SHA1 algorithms are not recommended for security purposes due to known attacks to generate hash collisions. These two algorithms are provided for backward-compatibility only.
- When hashing string or binary values, take into account the effects of trailing blanks (spaces or NULs). The value 'ab' in a CHAR(5) (3 trailing spaces) has a different hash than if it is stored in a VARCHAR(5) (no trailing spaces) or CHAR(6) (4 trailing spaces).

To avoid this, make sure you always use a variable length data type, or the same fixed length data type, or normalize values before hashing, for example using TRIM(TRAILING FROM value).

Examples of CRYPTO_HASH

Hashing x with the SHA512 algorithm

select crypt_hash(x using sha512) from y;

See also
HASH()
8.3.9. HASH()

Non-cryptographic hash

Result type
INTEGER, BIGINT

Syntax

\[
\text{HASH (value [USING } \text{<hash>])}
\]

<hash> ::= CRC32

Table 155. HASH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>Expression of value of any type; non-string or non-binary types are converted to string</td>
</tr>
<tr>
<td>hash</td>
<td>Non-cryptographic hash algorithm to apply</td>
</tr>
</tbody>
</table>

HASH returns a hash value for the input argument. If the input argument is not a string or binary type, it is converted to string before hashing.

The optional USING clause specifies the non-cryptographic hash algorithm to apply. When the USING clause is absent, the legacy PJW algorithm is applied; this is identical to its behaviour in previous Firebird versions.

This function fully supports text BLOBs of any length and character set.

Supported algorithms
not specified

When no algorithm is specified, Firebird applies the 64-bit variant of the non-cryptographic PJW hash function (also known as ELF64). This is a fast algorithm for general purposes (hash tables, etc.), but its collision quality is suboptimal. Other hash functions — specified explicitly in the USING clause, or cryptographic hashes through CRYPT_HASH() — should be used for more reliable hashing.

The HASH function returns BIGINT for this algorithm

CRC32

With CRC32, Firebird applies the CRC32 algorithm using the polynomial 0x04C11DB7.

The HASH function returns INTEGER for this algorithm.

Examples of HASH

1. Hashing x with the CRC32 algorithm
2. Hashing x with the legacy PJW algorithm

```sql
select hash(x using crc32) from y;
```

See also

CRYPT_HASH()

### 8.3.10. HEX_DECODE()

Decode a hexadecimal string to binary

**Result type**

VARBINARY or BLOB

**Syntax**

```sql
HEX_DECODE (hex_data)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>hex_data</td>
<td>Hex encoded data</td>
</tr>
</tbody>
</table>

HEX_DECODE decodes a string with hex-encoded data, and returns the decoded value as VARBINARY or BLOB as appropriate for the input. If the length of the type of `hex_data` is not a multiple of 2, an error is raised at prepare time. If the length of the value of `hex_data` is not a multiple of 2, an error is raised at execution time.

When the input is not BLOB, the length of the resulting type is calculated as `type_length / 2`, where `type_length` is the maximum length in characters of the input type.

**Example of HEX_DECODE**

```sql
select cast(hex_decode('48657861646563696D616C') as varchar(12))
from rdb$database;
```

CAST

```
Hexadecimal
```

See also

HEX_ENCODE(), BASE64_DECODE()
8.3.11. HEX_ENCODE()

Encodes a (binary) value to a hexadecimal string

**Result type**

VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII

**Syntax**

```
HEX_ENCODE (binary_data)
```

**Table 157. HEX_ENCODE Function Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>binary_data</td>
<td>Binary data (or otherwise convertible to binary) to encode</td>
</tr>
</tbody>
</table>

HEX_ENCODE encodes `binary_data` with hex, and returns the encoded value as a VARCHAR CHARACTER SET ASCII or BLOB SUB_TYPE TEXT CHARACTER SET ASCII as appropriate for the input.

When the input is not BLOB, the length of the resulting type is calculated as `type_length * 2`, where `type_length` is the maximum length in bytes of the input type. If this length exceeds the maximum length of VARCHAR, the function returns a BLOB.

**Example of HEX_ENCODE**

```
select hex_encode('Hexadecimal')
from rdb$database;
```

```
HEX_ENCODE
======================
4865786164656D616C
```

See also

HEX_DECODE(), BASE64_ENCODE()

8.3.12. LEFT()

Extracts the leftmost part of a string

**Result type**

VARCHAR or BLOB

**Syntax**

```
LEFT (string, length)
```

**Table 158. LEFT Function Parameters**
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>length</td>
<td>Integer expression. The number of characters to return</td>
</tr>
</tbody>
</table>

- This function fully supports text BLOBs of any length, including those with a multi-byte character set.
- If `string` is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with n the length of the input string.
- If the `length` argument exceeds the string length, the input string is returned unchanged.
- If the `length` argument is not a whole number, bankers’ rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

See also
RIGHT()

**8.3.13. LOWER()**

Converts a string to lowercase

**Result type**

(VAR)CHAR, (VAR)BINARY or BLOB

**Syntax**

```
LOWER (string)
```

**Table 159. LOWER Function ParameterS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Returns the lowercase equivalent of the input string. The exact result depends on the character set. With ASCII or NONE for instance, only ASCII characters are lowercased; with character set OCTETS/(VAR)BINARY, the entire string is returned unchanged.

**LOWER Examples**

```
select Sheriff from Towns
  where lower(Name) = 'cooper''s valley'
```

See also
UPPER()
8.3.14. LPAD()

Left-pads a string

Result type
VARCHAR or BLOB

Syntax

LPAD (str, endlen [, padstr])

Table 160. LPAD Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>endlen</td>
<td>Output string length</td>
</tr>
<tr>
<td>padstr</td>
<td>The character or string to be used to pad the source string up to the specified length. Default is space (&quot; &quot;)</td>
</tr>
</tbody>
</table>

Left-pads a string with spaces or with a user-supplied string until a given length is reached.

- This function fully supports text BLOBs of any length and character set.
- If str is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(endlen).
- If padstr is given and equal to '' (empty string), no padding takes place.
- If endlen is less than the current string length, the string is truncated to endlen, even if padstr is the empty string.

When used on a BLOB, this function may need to load the entire object into memory. Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

LPAD Examples

lpad ('Hello', 12)               -- returns '       Hello'
lpad ('Hello', 12, '-')          -- returns '-------Hello'
lpad ('Hello', 12, '')           -- returns 'Hello'
lpad ('Hello', 12, 'abc')        -- returns 'abcabcaHello'
lpad ('Hello', 12, 'abcdefghij') -- returns 'abcdefgHello'
lpad ('Hello', 2)                -- returns 'He'
lpad ('Hello', 2, '-')           -- returns 'He'
lpad ('Hello', 2, '')            -- returns 'He'

See also
RPAD()
8.3.15. OCTET_LENGTH()

Length in bytes (octets) of a string or binary value

Result type
INTEGER, or BIGINT for BLOB

Syntax

```
OCTET_LENGTH (string)
```

Table 161. OCTET_LENGTH Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Gives the length in bytes (octets) of the input string. For multi-byte character sets, this may be less than the number of characters times the “formal” number of bytes per character as found in RDB$CHARACTER_SETS.

With arguments of type CHAR or BINARY, this function takes the entire formal string length (i.e. the declared length of a field or variable) into account. If you want to obtain the “logical” byte length, not counting the trailing spaces, right-TRIM the argument before passing it to OCTET_LENGTH.

OCTET_LENGTH Examples

```
select octet_length('Hello!') from rdb$database
-- returns 6

select octet_length(_iso8859_1 'Grüß di!') from rdb$database
-- returns 8: ü and ß take up one byte each in ISO8859_1

select octet_length
  (cast (_iso8859_1 'Grüß di!' as varchar(24) character set utf8))
from rdb$database
-- returns 10: ü and ß take up two bytes each in UTF8

select octet_length
  (cast (_iso8859_1 'Grüß di!' as char(24) character set utf8))
from rdb$database
-- returns 26: all 24 CHAR positions count, and two of them are 2-byte
```

See also

BIT_LENGTH(), CHAR_LENGTH(), CHARACTER_LENGTH()
8.3.16. OVERLAY()

Overwrites part of, or inserts into, a string

Result type
VARCHAR or BLOB

Syntax

OVERLAY (string PLACING replacement FROM pos [FOR length])

Table 162. OVERLAY Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>The string into which the replacement takes place</td>
</tr>
<tr>
<td>replacement</td>
<td>Replacement string</td>
</tr>
<tr>
<td>pos</td>
<td>The position from which replacement takes place (starting position)</td>
</tr>
<tr>
<td>length</td>
<td>The number of characters that are to be overwritten</td>
</tr>
</tbody>
</table>

By default, the number of characters removed from (overwritten in) the host string equals the length of the replacement string. With the optional fourth argument, a different number of characters can be specified for removal.

- This function supports BLOBs of any length.
- If string or replacement is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with n the sum of the lengths of string and replacement.
- As usual in SQL string functions, pos is 1-based.
- If pos is beyond the end of string, replacement is placed directly after string.
- If the number of characters from pos to the end of string is smaller than the length of replacement (or than the length argument, if present), string is truncated at pos and replacement placed after it.
- The effect of a “FOR 0” clause is that replacement is inserted into string.
- If any argument is NULL, the result is NULL.
- If pos or length is not a whole number, bankers' rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

⚠️ When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

OVERLAY Examples

overlay ('Goodbye' placing 'Hello' from 2)   -- returns 'GHelloe'
overlay ('Goodbye' placing 'Hello' from 5)   -- returns 'GoodHello'
overlay ('Goodbye' placing 'Hello' from 8)   -- returns 'GoodbyeHello'
overlay ('Goodbye' placing 'Hello' from 20) -- returns 'GoodbyeHello'
overlay ('Goodbye' placing 'Hello' from 2 for 0) -- r. 'GHellooodbye'
overlay ('Goodbye' placing 'Hello' from 2 for 3) -- r. 'GHellobye'
overlay ('Goodbye' placing 'Hello' from 2 for 6) -- r. 'GHello'
overlay ('Goodbye' placing 'Hello' from 2 for 9) -- r. 'GHello'

overlay ('Goodbye' placing '' from 4)        -- returns 'Goodbye'
overlay ('Goodbye' placing '' from 4 for 3)  -- returns 'Gooe'
overlay ('Goodbye' placing '' from 4 for 20) -- returns 'Goo'

overlay ('' placing 'Hello' from 4)          -- returns 'Hello'
overlay ('' placing 'Hello' from 4 for 0)    -- returns 'Hello'
overlay ('' placing 'Hello' from 4 for 20)   -- returns 'Hello'

See also
REPLACE()

8.3.17. POSITION()

Finds the position of the first or next occurrence of a substring in a string

Result type
INTEGER

Syntax

<table>
<thead>
<tr>
<th>POSITION (substr IN string)</th>
</tr>
</thead>
<tbody>
<tr>
<td>POSITION (substr, string [, startPos])</td>
</tr>
</tbody>
</table>

Table 163. POSITION Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>substr</td>
<td>The substring whose position is to be searched for</td>
</tr>
<tr>
<td>string</td>
<td>The string which is to be searched</td>
</tr>
<tr>
<td>startPos</td>
<td>The position in string where the search is to start</td>
</tr>
</tbody>
</table>

Returns the (1-based) position of the first occurrence of a substring in a host string. With the optional third argument, the search starts at a given offset, disregarding any matches that may occur earlier in the string. If no match is found, the result is 0.

- The optional third argument is only supported in the second syntax (comma syntax).
- The empty string is considered a substring of every string. Therefore, if substr is '' (empty string) and string is not NULL, the result is:
  - 1 if startPos is not given;
• startpos if startpos lies within string;
• 0 if startpos lies beyond the end of string.

• This function fully supports text BLOBs of any size and character set.

When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

**POSITION Examples**

```plaintext
position ('be' in 'To be or not to be')   -- returns 4
position ('be', 'To be or not to be')     -- returns 4
position ('be', 'To be or not to be', 4) -- returns 4
position ('be', 'To be or not to be', 8)  -- returns 17
position ('be', 'To be or not to be', 18) -- returns 0
position ('be' in 'Alas, poor Yorick!')  -- returns 0
```

See also

**SUBSTRING()**

### 8.3.18. REPLACE()

Replaces all occurrences of a substring in a string

**Result type**

VARCHAR or BLOB

**Syntax**

```plaintext
REPLACE (str, find, repl)
```

**Table 164. REPLACE Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>The string in which the replacement is to take place</td>
</tr>
<tr>
<td>find</td>
<td>The string to search for</td>
</tr>
<tr>
<td>repl</td>
<td>The replacement string</td>
</tr>
</tbody>
</table>

• This function fully supports text BLOBs of any length and character set.

• If any argument is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(n) with n calculated from the lengths of str, find and repl in such a way that even the maximum possible number of replacements won't overflow the field.

• If find is the empty string, str is returned unchanged.

• If repl is the empty string, all occurrences of find are deleted from str.

• If any argument is NULL, the result is always NULL, even if nothing would have been replaced.
When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

**REPLACE Examples**

- `replace ('Billy Wilder', 'il', 'oog') -- returns 'Boogly Woogder'`
- `replace ('Billy Wilder', 'il', '') -- returns 'Bly Wder'`
- `replace ('Billy Wilder', null, 'oog') -- returns 'NULL'`
- `replace ('Billy Wilder', 'il', null) -- returns 'NULL (!)'`
- `replace ('Billy Wilder', 'xyz', 'abc') -- returns 'Billy Wilder'`
- `replace ('Billy Wilder', '', 'abc') -- returns 'Billy Wilder'`

See also

OVERLAY(), SUBSTRING(), POSITION(), CHAR_LENGTH(), CHARACTER_LENGTH()

### 8.3.19. REVERSE()

Reverses a string

**Result type**

VARCHAR

**Syntax**

```sql
REVERSE (string)
```

**Table 165. REVERSE Function Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

**REVERSE Examples**

- `reverse ('spoonful') -- returns 'lufnoops'`
- `reverse ('Was it a cat I saw?') -- returns '?was I tac a ti saW'`

This function is useful if you want to group, search or order on string endings, e.g. when dealing with domain names or email addresses:

```sql
create index ix_people_email on people
computed by (reverse(email));

select * from people
where reverse(email) starting with reverse('.br');
```
8.3.20. RIGHT()

Extracts the rightmost part of a string

Result type
VARCHAR or BLOB

Syntax

\[
\text{RIGHT} (\text{string}, \text{length})
\]

Table 166. RIGHT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>string</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>length</td>
<td>Integer. The number of characters to return</td>
</tr>
</tbody>
</table>

- This function supports text BLOBs of any length.
- If \text{string} is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(\text{n}) with \text{n} the length of the input string.
- If the \text{length} argument exceeds the string length, the input string is returned unchanged.
- If the \text{length} argument is not a whole number, bankers' rounding (round-to-even) is applied, i.e. 0.5 becomes 0, 1.5 becomes 2, 2.5 becomes 2, 3.5 becomes 4, etc.

⚠️ When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

See also
LEFT(), SUBSTRING()

8.3.21. RPAD()

Right-pads a string

Result type
VARCHAR or BLOB

Syntax

\[
\text{RPAD} (\text{str}, \text{endlen} [, \text{padstr}])
\]

Table 167. RPAD Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>endlenden</td>
<td>Output string length</td>
</tr>
</tbody>
</table>
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>endlen</td>
<td>The character or string to be used to pad the source string up to the specified length. Default is space (' ')</td>
</tr>
</tbody>
</table>

Right-pads a string with spaces or with a user-supplied string until a given length is reached.

- This function fully supports text BLOBs of any length and character set.
- If `str` is a BLOB, the result is a BLOB. Otherwise, the result is a VARCHAR(`endlen`).
- If `padstr` is given and equals '' (empty string), no padding takes place.
- If `endlen` is less than the current string length, the string is truncated to `endlen`, even if `padstr` is the empty string.

⚠️ When used on a BLOB, this function may need to load the entire object into memory. Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

#### RPAD Examples

```sql
rpad ('Hello', 12)               -- returns 'Hello       '
rpad ('Hello', 12, '-')          -- returns 'Hello-------'
rpad ('Hello', 12, '')           -- returns 'Hello'
rpad ('Hello', 12, 'abc')        -- returns 'Helloabcabca'
rpad ('Hello', 12, 'abcdefghij') -- returns 'Helloabcdefg'
rpad ('Hello', 2)                -- returns 'He'
rpad ('Hello', 2, '-')           -- returns 'He'
rpad ('Hello', 2, '')            -- returns 'He'
```

See also

LPAD()

### 8.3.22. SUBSTRING()

Extracts a substring by position and length, or by SQL regular expression

#### Result types

VARCHAR or BLOB

#### Syntax

```
SUBSTRING ( <substring-args> )

<substring-args> ::=  
  str FROM startpos [FOR length]  
  | str SIMILAR <similar-pattern> ESCAPE <escape>

<similar-pattern> ::=  
  <similar-pattern-R1>
```
Table 168. SUBSTRING Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>startpos</td>
<td>Integer expression, the position from which to start retrieving the substring</td>
</tr>
<tr>
<td>length</td>
<td>The number of characters to retrieve after the startpos</td>
</tr>
<tr>
<td>similar-pattern</td>
<td>SQL regular expression pattern to search for the substring</td>
</tr>
<tr>
<td>escape</td>
<td>Escape character</td>
</tr>
</tbody>
</table>

Returns a string's substring starting at the given position, either to the end of the string or with a given length, or extracts a substring using an SQL regular expression pattern.

If any argument is NULL, the result is also NULL.

When used on a BLOB, this function may need to load the entire object into memory. Although it does try to limit memory consumption, this may affect performance if huge BLOBs are involved.

**Positional SUBSTRING**

In its simple, positional form (with FROM), this function returns the substring starting at character position startpos (the first character being 1). Without the FOR argument, it returns all the remaining characters in the string. With FOR, it returns length characters or the remainder of the string, whichever is shorter.

When startpos is smaller than 1, substring behaves as if the string has 1 - startpos extra positions before the actual first character at position 1. The length is considered from this imaginary start of the string, so the resulting string could be shorter than the specified length, or even empty.

The function fully supports binary and text BLOBs of any length, and with any character set. If str is a BLOB, the result is also a BLOB. For any other argument type, the result is a VARCHAR.

For non-BLOB arguments, the width of the result field is always equal to the length of str, regardless of startpos and length. So, substring('pinhead' from 4 for 2) will return a VARCHAR(7) containing the string 'he'.

**Example**

```sql
insert into AbbrNames(AbbrName)
    select substring(LongName from 1 for 3) from LongNames;

select substring('abcdef' from 1 for 2) from rdb$database;
-- result: 'ab'
```
Regular Expression SUBSTRING

In the regular expression form (with SIMILAR), the SUBSTRING function returns part of the string matching an SQL regular expression pattern. If no match is found, NULL is returned.

The SIMILAR pattern is formed from three SQL regular expression patterns, \( R_1 \), \( R_2 \) and \( R_3 \). The entire pattern takes the form of \( R_1 \mid \mid \text{<escape>}'' \mid \mid R_2 \mid \mid \text{<escape>}'' \mid \mid R_3 \), where \text{<escape>} is the escape character defined in the ESCAPE clause. \( R_2 \) is the pattern that matches the substring to extract, and is enclosed between escaped double quotes (\text{<escape>'}, e.g. ``#'' with escape character ‘#’). \( R_1 \) matches the prefix of the string, and \( R_3 \) the suffix of the string. Both \( R_1 \) and \( R_3 \) are optional (they can be empty), but the pattern must match the entire string. In other words, it is not sufficient to specify a pattern that only finds the substring to extract.

The escaped double quotes around \( R_2 \) can be compared to defining a single capture group in more common regular expression syntax like PCRE. That is, the full pattern is equivalent to \( R_1(R_2)R_3 \), which must match the entire input string, and the capture group is the substring to be returned.

If any one of \( R_1 \), \( R_2 \), or \( R_3 \) is not a zero-length string and does not have the format of an SQL regular expression, then an exception is raised.

The full SQL regular expression format is described in Syntax: SQL Regular Expressions

Examples

```
substring('abcabc' similar 'a"#"c' escape '#' ) -- bcab
substring('abcabc' similar 'a"%"c' escape '#' ) -- bcab
substring('abcabc' similar '_"%"_' escape '#' ) -- bcab
substring('abcabc' similar '#(abc)*#' escape '#' ) -- abcabc
substring('abcabc' similar '#abc#' escape '#' ) -- <null>
```

See also

POSITION(), LEFT(), RIGHT(), CHAR_LENGTH(), CHARACTER_LENGTH(), SIMILAR TO

8.3.23. TRIM()

Trims leading and/or trailing spaces or other substrings from a string
**Result type**

VARCHAR or BLOB

**Syntax**

```
TRIM ([<adjust>] str)
```

```
<adjust> ::= {} FROM

<where> ::= BOTH | LEADING | TRAILING
```

**Table 169. TRIM Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
<tr>
<td>where</td>
<td>The position the substring is to be removed from — BOTH</td>
</tr>
<tr>
<td>what</td>
<td>The substring that should be removed (multiple times if there are several matches) from the beginning, the end, or both sides of the input string str. By default, it is space (’ ’)</td>
</tr>
</tbody>
</table>

Removes leading and/or trailing spaces (or optionally other strings) from the input string.

- If `str` is a BLOB, the result is a BLOB. Otherwise, it is a VARCHAR(n) with `n` the formal length of `str`.

- When used on a BLOB, this function may need to load the entire object into memory. This may affect performance if huge BLOBs are involved.

**TRIM Examples**

```
select trim (' Waste no space ') from rdb$database
-- returns 'Waste no space'

select trim (leading from ' Waste no space ') from rdb$database
-- returns 'Waste no space '

select trim (leading '.' from ' Waste no space ') from rdb$database
-- returns ' Waste no space '

select trim (trailing '!' from 'Help!!!!') from rdb$database
-- returns 'Help'

select trim ('la' from 'lalala I love you Ella') from rdb$database
-- returns ' I love you El'

select trim ('la' from 'Lalala I love you Ella') from rdb$database
```

452
-- returns 'Lalala I love you El'

### 8.3.24. UNICODE_CHAR()

Character from Unicode code point

*Result type*

CHAR(1) CHARACTER SET UTF8

*Syntax*

```
UNICODE_CHAR (code)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>code</td>
<td>The Unicode code point (range 0...0x10FFFF)</td>
</tr>
</tbody>
</table>

Returns the character corresponding to the Unicode code point passed in the argument.

*See also*

UNICODE_VAL(), ASCII_CHAR()

### 8.3.25. UNICODE_VAL()

Unicode code point from string

*Result type*

INTEGER

*Syntax*

```
UNICODE_VAL (ch)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ch</td>
<td>A string of the [VAR]CHAR data type or a text BLOB</td>
</tr>
</tbody>
</table>

Returns the Unicode code point (range 0...0x10FFFF) of the character passed in.

- If the argument is a string with more than one character, the Unicode code point of the first character is returned.
- If the argument is an empty string, 0 is returned.
- If the argument is NULL, NULL is returned.

*See also*

UNICODE_CHAR(), ASCII_VAL()
8.3.26. UPPER()

Converts a string to uppercase

**Result type**

(VAR)CHAR, (VAR)BINARY or BLOB

**Syntax**

```
UPPER (str)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>str</td>
<td>An expression of a string type</td>
</tr>
</tbody>
</table>

Returns the uppercase equivalent of the input string. The exact result depends on the character set. With ASCII or NONE for instance, only ASCII characters are uppercased; with character set OCTETS /(VAR)BINARY, the entire string is returned unchanged.

**UPPER Examples**

```
select upper(_iso8859_1 'Débâcle')
from rdb$database
-- returns 'DÉBÂCLE'

select upper(_iso8859_1 'Débâcle' collate fr_fr)
from rdb$database
-- returns 'DEBACLE', following French uppecasing rules
```

See also

LOWER()

8.4. Date and Time Functions

8.4.1. DATEADD()

Adds or subtracts datetime units from a datetime value

**Result type**

DATE, TIME or TIMESTAMP

**Syntax**

```
DATEADD (<args>)
```

<args> ::= 

  <amount> <unit> TO <datetime>
Table 173. DATEADD Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>amount</td>
<td>An integer expression of the SMALLINT, INTEGER or BIGINT type. For unit MILLISECOND, the type is NUMERIC(18, 1). A negative value is subtracted.</td>
</tr>
<tr>
<td>unit</td>
<td>Date/time unit</td>
</tr>
<tr>
<td>datetime</td>
<td>An expression of the DATE, TIME or TIMESTAMP type</td>
</tr>
</tbody>
</table>

Adds the specified number of years, months, weeks, days, hours, minutes, seconds or milliseconds to a date/time value.

- The result type is determined by the third argument.
- With TIMESTAMP and DATE arguments, all units can be used.
- With TIME arguments, only HOUR, MINUTE, SECOND and MILLISECOND can be used.

Examples of DATEADD

dateadd (28 day to current_date)
dateadd (-6 hour to current_time)
dateadd (month, 9, DateOfConception)
dateadd (-38 week to DateOfBirth)
dateadd (minute, 90, cast('now' as time))
dateadd (? year to date '11-Sep-1973')

```sql
select cast(dateadd(-1 * extract(millisecond from ts) millisecond to ts) as varchar(30)) as t,
       extract(millisecond from ts) as ms
from (select timestamp '2014-06-09 13:50:17.4971' as ts
       from rdb$database
     ) a
```

<table>
<thead>
<tr>
<th>T</th>
<th>MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014-06-09 13:50:17.0000</td>
<td>497.1</td>
</tr>
</tbody>
</table>
See also
DATEDIFF(), Operations Using Date and Time Values

8.4.2. DATEDIFF()

Difference between two datetime values in a datetime unit

Result type
BIGINT, or NUMERIC(18,1) for MILLISECOND

Syntax

DATEDIFF (<args>)

<args> ::= 
   <unit> FROM <moment1> TO <moment2>
   | <unit>, <moment1>, <moment2>

<unit> ::= 
   YEAR | MONTH | WEEK | DAY
   | HOUR | MINUTE | SECOND | MILLISECOND

Table 174. DATEDIFF Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>unit</td>
<td>Date/time unit</td>
</tr>
<tr>
<td>moment1</td>
<td>An expression of the DATE, TIME or TIMESTAMP type</td>
</tr>
<tr>
<td>moment2</td>
<td>An expression of the DATE, TIME or TIMESTAMP type</td>
</tr>
</tbody>
</table>

Returns the number of years, months, weeks, days, hours, minutes, seconds or milliseonds elapsed between two date/time values.

- DATE and TIMESTAMP arguments can be combined. No other mixes are allowed.
- With TIMESTAMP and DATE arguments, all units can be used.
- With TIME arguments, only HOUR, MINUTE, SECOND and MILLISECOND can be used.

Computation

- DATEDIFF doesn't look at any smaller units than the one specified in the first argument. As a result,
  - datediff (year, date '1-Jan-2009', date '31-Dec-2009') returns 0, but
  - datediff (year, date '31-Dec-2009', date '1-Jan-2010') returns 1
- It does, however, look at all the bigger units. So:
  - datediff (day, date '26-Jun-1908', date '11-Sep-1973') returns 23818
- A negative result value indicates that moment2 lies before moment1.
**DATEDIFF Examples**

datediff (hour from current_timestamp to timestamp '12-Jun-2059 06:00')
datediff (minute from time '0:00' to current_time)
datediff (month, current_date, date '1-1-1900')
datediff (day from current_date to cast(? as date))

See also

**DATEADD()**, **Operations Using Date and Time Values**

**8.4.3. EXTRACT()**

Extracts a datetime unit from a datetime value

*Result type*

SMALLINT or NUMERIC

*Syntax*

```
EXTRACT (<part> FROM <datetime>)
```

- `<part>` :=
  - YEAR | MONTH | QUARTER | WEEK
  - | DAY | WEEKDAY | YEARDAY
  - | HOUR | MINUTE | SECOND | MILLISECOND
  - | TIMEZONE_HOUR | TIMEZONE_MINUTE
- `<datetime>` := a DATE, TIME or TIMESTAMP expression

*Table 175. EXTRACT Function Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>part</td>
<td>Date/time unit</td>
</tr>
<tr>
<td>datetime</td>
<td>An expression of the DATE, TIME or TIMESTAMP type</td>
</tr>
</tbody>
</table>

Extracts and returns an element from a DATE, TIME or TIMESTAMP expression.

*Returned Data Types and Ranges*

The returned data types and possible ranges are shown in the table below. If you try to extract a part that isn’t present in the date/time argument (e.g. SECOND from a DATE or YEAR from a TIME), an error occurs.

*Table 176. Types and ranges of EXTRACT results*

<table>
<thead>
<tr>
<th>Part</th>
<th>Type</th>
<th>Range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>YEAR</td>
<td>SMALLINT</td>
<td>1-9999</td>
<td></td>
</tr>
<tr>
<td>MONTH</td>
<td>SMALLINT</td>
<td>1-12</td>
<td></td>
</tr>
</tbody>
</table>
### PART

<table>
<thead>
<tr>
<th>Part</th>
<th>Type</th>
<th>Range</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUARTER</td>
<td>SMALLINT</td>
<td>1-4</td>
<td></td>
</tr>
<tr>
<td>WEEK</td>
<td>SMALLINT</td>
<td>1-53</td>
<td></td>
</tr>
<tr>
<td>DAY</td>
<td>SMALLINT</td>
<td>1-31</td>
<td></td>
</tr>
<tr>
<td>WEEKDAY</td>
<td>SMALLINT</td>
<td>0-6</td>
<td>0 = Sunday</td>
</tr>
<tr>
<td>YEARDAY</td>
<td>SMALLINT</td>
<td>0-365</td>
<td>0 = January 1</td>
</tr>
<tr>
<td>HOUR</td>
<td>SMALLINT</td>
<td>0-23</td>
<td></td>
</tr>
<tr>
<td>MINUTE</td>
<td>SMALLINT</td>
<td>0-59</td>
<td></td>
</tr>
<tr>
<td>SECOND</td>
<td>NUMERIC(9,4)</td>
<td>0.0000-59.9999</td>
<td>includes millisecond as fraction</td>
</tr>
<tr>
<td>MILLISECOND</td>
<td>NUMERIC(9,1)</td>
<td>0.0-999.9</td>
<td></td>
</tr>
<tr>
<td>TIMEZONE_HOUR</td>
<td>SMALLINT</td>
<td>-23 - +23</td>
<td></td>
</tr>
<tr>
<td>TIMEZONE_MINUTE</td>
<td>SMALLINT</td>
<td>-59 - +59</td>
<td></td>
</tr>
</tbody>
</table>

### MILLISECOND

Extracts the millisecond value from a `TIME` or `TIMESTAMP`. The data type returned is `NUMERIC(9,1)`.

If you extract the millisecond from `CURRENT_TIME`, be aware that this variable defaults to seconds precision, so the result will always be 0. Extract from `CURRENT_TIME(3)` or `CURRENT_TIMESTAMP` to get milliseconds precision.

### WEEK

Extracts the ISO-8601 week number from a `DATE` or `TIMESTAMP`. ISO-8601 weeks start on a Monday and always have the full seven days. Week 1 is the first week that has a majority (at least 4) of its days in the new year. The first 1-3 days of the year may belong to the last week (52 or 53) of the previous year. Likewise, a year's final 1-3 days may belong to week 1 of the following year.

Be careful when combining `WEEK` and `YEAR` results. For instance, 30 December 2008 lies in week 1 of 2009, so `extract(week from date '30 Dec 2008')` returns 1. However, extracting `YEAR` always gives the calendar year, which is 2008. In this case, `WEEK` and `YEAR` are at odds with each other. The same happens when the first days of January belong to the last week of the previous year.

Please also notice that `WEEKDAY` is **not** ISO-8601 compliant: it returns 0 for Sunday, whereas ISO-8601 specifies 7.

**See also**

[Data Types for Dates and Times](#)

#### 8.4.4. FIRST_DAY()

Returns the first day of a time period containing a datetime value

**Result Type**
DATE, TIMESTAMP (with or without time zone)

Syntax

```
FIRST_DAY(OF <period> FROM date_or_timestamp)
```

<period> ::= YEAR | MONTH | QUARTER | WEEK

**Table 177. FIRST_DAY Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>date_or_timestamp</td>
<td>Expression of type DATE, TIMESTAMP WITHOUT TIME ZONE or TIMESTAMP WITH TIME ZONE</td>
</tr>
</tbody>
</table>

FIRST_DAY returns a date or timestamp (same as the type of `date_or_timestamp`) with the first day of the year, month or week of a given date or timestamp value.

- The first day of the week is considered as Sunday, following the same rules as for `EXTRACT()` with `WEEKDAY`.
- When a timestamp is passed, the return value preserves the time part.

**Examples of FIRST_DAY**

```sql
select
    first_day(of month from current_date),
    first_day(of year from current_timestamp),
    first_day(of week from date '2017-11-01'),
    first_day(of quarter from date '2017-11-01')
from rdb$database;
```

### 8.4.5. LAST_DAY()

Returns the last day of a time period containing a datetime value

**Result Type**

DATE, TIMESTAMP (with or without time zone)

**Syntax**

```
LAST_DAY(OF <period> FROM date_or_timestamp)
```

<period> ::= YEAR | MONTH | QUARTER | WEEK

**Table 178. LAST_DAY Function Parameters**
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>date_or_timestamp</td>
<td>Expression of type DATE, TIMESTAMP WITHOUT TIME ZONE or TIMESTAMP WITH TIME ZONE</td>
</tr>
</tbody>
</table>

LAST_DAY returns a date or timestamp (same as the type of `date_or_timestamp`) with the last day of the year, month or week of a given date or timestamp value.

- The last day of the week is considered as Saturday, following the same rules as for `EXTRACT()` with WEEKDAY.
- When a timestamp is passed, the return value preserves the time part.

**Examples of LAST_DAY**

```sql
select
    last_day(of month from current_date),
    last_day(of year from current_timestamp),
    last_day(of week from date '2017-11-01'),
    last_day(of quarter from date '2017-11-01')
from rdb$database;
```

## 8.5. Type Casting Functions

### 8.5.1. CAST()

Converts a value from one data type to another

**Result type**

As specified by `target_type`

**Syntax**

```sql
CAST (<expression> AS <target_type>)
```

- `<target_type>` ::= `<domain_or_non_array_type>` | `<array_datatype>`

- `<domain_or_non_array_type>` ::= ! See Scalar Data Types Syntax !

- `<array_datatype>` ::= ! See Array Data Types Syntax !
CAST converts an expression to the desired data type or domain. If the conversion is not possible, an error is raised.

**“Shorthand” Syntax**

Alternative syntax, supported only when casting a string literal to a DATE, TIME or TIMESTAMP:

```
datatype 'date/timestring'
```

This syntax was already available in InterBase, but was never properly documented. In the SQL standard, this feature is called “datetime literals”.

Since Firebird 4.0, the use of 'NOW', 'YESTERDAY' and 'TOMORROW' in the shorthand cast is no longer allowed; only literals defining a fixed moment in time are supported.

**Allowed Type Conversions**

The following table shows the type conversions possible with CAST.

<table>
<thead>
<tr>
<th>From</th>
<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numeric types</td>
<td>Numeric types</td>
</tr>
<tr>
<td>[VAR]CHAR</td>
<td>Blob</td>
</tr>
<tr>
<td>[VAR]CHAR</td>
<td>CHAR</td>
</tr>
<tr>
<td>BLOB</td>
<td>Date</td>
</tr>
<tr>
<td></td>
<td>Time</td>
</tr>
<tr>
<td></td>
<td>Timestamp</td>
</tr>
</tbody>
</table>

Keep in mind that sometimes information is lost, for instance when you cast a TIMESTAMP to a DATE. Also, the fact that types are CAST-compatible is in itself no guarantee that a conversion will succeed. “CAST(123456789 as SMALLINT)” will definitely result in an error, as will “CAST('Judgement Day' as DATE)".
Casting Parameters

You can also cast statement parameters to a data type:

```sql
cast (?) as integer
```

This gives you control over the type of the parameter set up by the engine. Please notice that with statement parameters, you always need a full-syntax cast — shorthand casts are not supported.

Casting to a Domain or its Type

Casting to a domain or its base type are supported. When casting to a domain, any constraints (NOT NULL and/or CHECK) declared for the domain must be satisfied, or the cast will fail. Please be aware that a CHECK passes if it evaluates to TRUE or NULL! So, given the following statements:

```sql
create domain quint as int check (value >= 5000);
select cast (2000 as quint) from rdb$database;  ①
select cast (8000 as quint) from rdb$database;  ②
select cast (null as quint) from rdb$database;  ③
```

only cast number ① will result in an error.

When the `TYPE OF` modifier is used, the expression is cast to the base type of the domain, ignoring any constraints. With domain `quint` defined as above, the following two casts are equivalent and will both succeed:

```sql
select cast (2000 as type of quint) from rdb$database;
select cast (2000 as int) from rdb$database;
```

If `TYPE OF` is used with a (VAR)CHAR type, its character set and collation are retained:

```sql
create domain iso20 varchar(20) character set iso8859_1;
create domain dunl20 varchar(20) character set iso8859_1 collate du_nl;
create table zinnen (zin varchar(20));
commit;
insert into zinnen values ('Deze');
insert into zinnen values ('Die');
insert into zinnen values ('die');
insert into zinnen values ('deze');
select cast(zin as type of iso20) from zinnen order by 1;
-- returns Deze -> Die -> deze -> die
select cast(zin as type of dunl20) from zinnen order by 1;
-- returns deze -> Deze -> die -> Die
```
If a domain's definition is changed, existing CASTs to that domain or its type may become invalid. If these CASTs occur in PSQL modules, their invalidation may be detected. See the note *The RDB$VALID_BLR field*, in Appendix A.

**Casting to a Column's Type**

It is also possible to cast expressions to the type of an existing table or view column. Only the type itself is used; in the case of string types, this includes the character set but not the collation. Constraints and default values of the source column are not applied.

```sql
create table ttt (  
  s varchar(40) character set utf8 collate unicode_ci_ai  
);  
commit;

select cast ('Jag har många vänner' as type of column ttt.s) from rdb$database;
```

**Warnings**

If a column's definition is altered, existing CASTs to that column's type may become invalid. If these CASTs occur in PSQL modules, their invalidation may be detected. See the note *The RDB$VALID_BLR field*, in Appendix A.

**Cast Examples**

A full-syntax cast:

```sql
select cast ('12' || '-June-' || '1959' as date) from rdb$database
```

A shorthand string-to-date cast:

```sql
update People set AgeCat = 'Old'  
where BirthDate < date '1-Jan-1943'
```

Notice that you can drop even the shorthand cast from the example above, as the engine will understand from the context (comparison to a DATE field) how to interpret the string:

```sql
update People set AgeCat = 'Old'  
where BirthDate < '1-Jan-1943'
```

However, this is not always possible. The cast below cannot be dropped, otherwise the engine would find itself with an integer to be subtracted from a string:
8.6. Bitwise Functions

8.6.1. BIN_AND()

Bitwise AND

Result type

integer type (the widest type of the arguments)

> SMALLINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC(n, 0) with n <= 4; otherwise small integers return an INTEGER result.

Syntax

BIN_AND (number, number [, number ...])

Table 181. BIN_AND Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of an integer type</td>
</tr>
</tbody>
</table>

Returns the result of the bitwise AND operation on the argument(s).

See also

BIN_OR(), BIN_XOR()

8.6.2. BIN_NOT()

Bitwise NOT

Result type

integer type matching the argument

> SMALLINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC(n, 0) with n <= 4; otherwise small integers return an INTEGER result.

Syntax

BIN_NOT (number)

Table 182. BIN_NOT Function Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of an integer type</td>
</tr>
</tbody>
</table>
Returns the result of the bitwise NOT operation on the argument, i.e. one’s complement.

See also
BIN_OR(), BIN_XOR() and others in this set.

8.6.3. BIN_OR()

Bitwise OR

Result type
integer type (the widest type of the arguments)

\[
\text{SMALLINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC(n, 0) with } n \leq 4; \text{ otherwise small integers return an INTEGER result.}
\]

Syntax

\[
\text{BIN\_OR (number, number[, number ...])}
\]

Table 183. BIN_OR Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of an integer type</td>
</tr>
</tbody>
</table>

Returns the result of the bitwise OR operation on the argument(s).

See also
BIN_AND(), BIN_XOR()

8.6.4. BIN_SHL()

Bitwise left-shift

Result type
BIGINT or INT128 depending on the first argument

Syntax

\[
\text{BIN\_SHL (number, shift)}
\]

Table 184. BIN_SHL Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of an integer type</td>
</tr>
<tr>
<td>shift</td>
<td>The number of bits the number value is shifted by</td>
</tr>
</tbody>
</table>

Returns the first argument bitwise left-shifted by the second argument, i.e. \( a \ll b \) or \( a \cdot 2^b \).
8.6.5. BIN_SHR()

Bitwise right-shift with sign extension

Result type
BIGINT or INT128 depending on the first argument

Syntax

```
BIN_SHR (number, shift)
```

Table 185. BIN_SHR Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of an integer type</td>
</tr>
<tr>
<td>shift</td>
<td>The number of bits the number value is shifted by</td>
</tr>
</tbody>
</table>

Returns the first argument bitwise right-shifted by the second argument, i.e. \( a \gg b \) or \( a/2^b \).

The operation performed is an arithmetic right shift (x86 SAR), meaning that the sign of the first operand is always preserved.

See also

BIN_SHL()

8.6.6. BIN_XOR()

Bitwise XOR

Result type
integer type (the widest type of the arguments)

SmallINT result is returned only if all the arguments are explicit SMALLINTs or NUMERIC\((n, 0)\) with \( n \leq 4 \); otherwise small integers return an INTEGER result.

Syntax

```
BIN_XOR (number, number [, number ...])
```

Table 186. BIN_XOR Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number</td>
<td>A number of an integer type</td>
</tr>
</tbody>
</table>

Returns the result of the bitwise XOR operation on the argument(s).
8.7. UUID Functions

8.7.1. CHAR_TO_UUID()

Converts a string UUID to its binary representation

Result type
BINARY(16)

Syntax

```sql
CHAR_TO_UUID (ascii_uuid)
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ascii_uuid</td>
<td>A 36-character representation of UUID. ‘-’ (hyphen) in positions 9, 14, 19</td>
</tr>
<tr>
<td></td>
<td>and 24; valid hexadecimal digits in any other positions, e.g. 'A0BF4E45-</td>
</tr>
<tr>
<td></td>
<td>3029-2A44-D493-4998c9b439A3'</td>
</tr>
</tbody>
</table>

Converts a human-readable 36-char UUID string to the corresponding 16-byte UUID.

**CHAR_TO_UUID Examples**

```sql
select char_to_uuid('A0BF4E45-3029-2A44-D493-4998c9b439A3') from rdb$database
-- returns A0BF4E4530292A44D4934998C9B439A3 (16-byte string)

select char_to_uuid('A0bf4E45-3029-2A44-X493-4998c9b439A3') from rdb$database
-- error: -Human readable UUID argument for CHAR_TO_UUID must
-- have hex digit at position 20 instead of "X (ASCII 88)"
```

See also
UUID_TO_CHAR(), GEN_UUID()

8.7.2. GEN_UUID()

Generates a random binary UUID

Result type
BINARY(16)

Syntax

```sql
GEN_UUID ()
```
Returns a universally unique ID as a 16-byte character string.

**GEN_UUID Example**

```
select gen_uuid() from rdb$database
-- returns e.g. 017347BFE212B2479C00FA4323B36320 (16-byte string)
```

See also

**UUID_TO_CHAR(), CHAR_TO_UUID()**

### 8.7.3. UUID_TO_CHAR()

Converts a binary UUID to its string representation

**Result type**

CHAR(36)

**Syntax**

```
UUID_TO_CHAR (uuid)
```

**Table 188. UUID_TO_CHAR Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>uuid</td>
<td>16-byte UUID</td>
</tr>
</tbody>
</table>

Converts a 16-byte UUID to its 36-character, human-readable ASCII representation.

**UUID_TO_CHAR Examples**

```
select uuid_to_char('876C45F4569B320DBCB4735AC3509E5F') from rdb$database
-- returns '876C45F4-569B-320D-BCB4-735AC3509E5F'

select uuid_to_char(gen_uuid()) from rdb$database
-- returns e.g. '680D946B-45FF-DB4E-B103-BB5711529B86'

select uuid_to_char('Firebird swings!') from rdb$database
-- returns '46697265-6269-7264-2073-77696E677321'
```

See also

**CHAR_TO_UUID(), GEN_UUID()**

### 8.8. Functions for Sequences (Generators)
8.8.1. GEN_ID()

Increments a sequence (generator) value and returns its new value

Result type
BIGINT — dialect 2 and 3
INTEGER — dialect 1

Syntax

```
GEN_ID (generator-name, step)
```

Table 189. GEN_ID Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>generator-name</td>
<td>Identifier name of a generator (sequence)</td>
</tr>
<tr>
<td>step</td>
<td>An integer expression of the increment</td>
</tr>
</tbody>
</table>

If step equals 0, the function will leave the value of the generator unchanged and return its current value.

The SQL-compliant `NEXT VALUE FOR` syntax is preferred, except when an increment other than the configured increment of the sequence is needed.

- If the value of the step parameter is less than zero, it will decrease the value of the generator. You should be cautious with such manipulations in the database, as they could compromise data integrity (meaning, subsequent insert statements could fail due to generating of duplicate id values).

- In dialect 1, the result type is INTEGER, in dialect 2 and 3 it is BIGINT.

GEN_ID Example

```
new.rec_id = gen_id(gen_recnum, 1);
```

See also

`NEXT VALUE FOR`, `CREATE SEQUENCE (GENERATOR)`

8.9. Conditional Functions

8.9.1. COALESCE()

Returns the first non-NULL argument

Result type
Depends on input
Syntax

COALESCE (<exp1>, <exp2> [, <expN> ... ])

Table 190. COALESCE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exp1, exp2 ... expN</td>
<td>A list of expressions of compatible types</td>
</tr>
</tbody>
</table>

The COALESCE function takes two or more arguments and returns the value of the first non-NULL argument. If all the arguments evaluate to NULL, the result is NULL.

**COALESCE Examples**

This example picks the Nickname from the Persons table. If it happens to be NULL, it goes on to FirstName. If that too is NULL, “Mr./Mrs.” is used. Finally, it adds the family name. All in all, it tries to use the available data to compose a full name that is as informal as possible. This scheme only works if absent nicknames and first names are NULL: if one of them is an empty string, COALESCE will happily return that to the caller. That problem can be fixed by using NULLIF().

```sql
select coalesce (Nickname, FirstName, 'Mr./Mrs.') || ' ' || LastName
    as FullName
from Persons
```

See also

IIF(), NULLIF(), CASE

8.9.2. DECODE()

Shorthand “simple CASE”-equivalent function

Result type

Depends on input

Syntax

DECODE(<testexpr>,
        <expr1>, <result1>
        [<expr2>, <result2> ...]
        [, <defaultresult>])

Table 191. DECODE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>testexpr</td>
<td>An expression of any compatible type that is compared to the expressions expr1, expr2 ... exprN</td>
</tr>
</tbody>
</table>
DECODE is a shorthand for the so-called "simple CASE" construct, in which a given expression is compared to a number of other expressions until a match is found. The result is determined by the value listed after the matching expression. If no match is found, the default result is returned, if present, otherwise NULL is returned.

The equivalent CASE construct:

```
CASE <testexpr>
  WHEN <expr1> THEN <result1>
  [WHEN <expr2> THEN <result2> ...]
  [ELSE <defaultresult>]
END
```

Matching is done with the '=' operator, so if testexpr is NULL, it won't match any of the exprs, not even those that are NULL.

**DECODE Examples**

```sql
select name, age, 
  decode(upper(sex),
    'M', 'Male',
    'F', 'Female',
    'Unknown'),
  religion
from people
```

*See also*

**CASE, Simple CASE**

### 8.9.3. IIF()**

Ternary conditional function

*Result type*

Depends on input
### Syntax

\[
\text{IIF (condition, ResultT, ResultF)}
\]

### Table 192. IIF Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>condition</td>
<td>A true</td>
</tr>
<tr>
<td>resultT</td>
<td>The value returned if the condition is true</td>
</tr>
<tr>
<td>resultF</td>
<td>The value returned if the condition is false</td>
</tr>
</tbody>
</table>

IIF takes three arguments. If the first evaluates to true, the second argument is returned; otherwise the third is returned.

IIF could be likened to the ternary “\text{<condition> ? resultT : resultF}” operator in C-like languages.

\[
\text{IIF<condition>, resultT, resultF> is a shorthand for “CASE WHEN <condition> THEN resultT ELSE resultF END”.
}\]

### IIF Examples

```sql
select iif( sex = 'M', 'Sir', 'Madam' ) from Customers
```

### See also

\text{CASE, DECODE()}

### 8.9.4. \text{MAXVALUE()}

Returns the maximum value of its arguments

### Result type

Varies according to input—result will be of the same data type as the first expression in the list (expr1).

### Syntax

\[
\text{MAXVALUE (expr1 [, ... , exprN ])}
\]

### Table 193. MAXVALUE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr1 ... exprN</td>
<td>List of expressions of compatible types</td>
</tr>
</tbody>
</table>

Returns the maximum value from a list of numerical, string, or date/time expressions. This function fully supports text BLOBs of any length and character set.
If one or more expressions resolve to NULL, MAXVALUE returns NULL. This behaviour differs from the aggregate function MAX.

**MAXVALUE Examples**

```
SELECT MAXVALUE(PRICE_1, PRICE_2) AS PRICE
FROM PRICELIST
```

*See also*

**MINVALUE()**

### 8.9.5. MINVALUE()

Returns the minimum value of its arguments

**Result type**

Varies according to input — result will be of the same data type as the first expression in the list (expr1).

**Syntax**

```
MINVALUE (<expr1> [, ... , <exprN> ])
```

**Table 194. MINVALUE Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr1 ... exprN</td>
<td>List of expressions of compatible types</td>
</tr>
</tbody>
</table>

Returns the minimum value from a list of numerical, string, or date/time expressions. This function fully supports text BLOBs of any length and character set.

If one or more expressions resolve to NULL, MINVALUE returns NULL. This behaviour differs from the aggregate function MIN.

**MINVALUE Examples**

```
SELECT MINVALUE(PRICE_1, PRICE_2) AS PRICE
FROM PRICELIST
```

*See also*

**MAXVALUE()**

### 8.9.6. NULLIF()

Conditional NULL function

**Result type**
Depends on input

**Syntax**

```sql
NULLIF (<exp1>, <exp2>)
```

**Table 195. NULLIF Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exp1</td>
<td>An expression</td>
</tr>
<tr>
<td>exp2</td>
<td>Another expression of a data type compatible with exp1</td>
</tr>
</tbody>
</table>

NULLIF returns the value of the first argument, unless it is equal to the second. In that case, NULL is returned.

**NULLIF Example**

```sql
select avg( nullif(Weight, -1) ) from FatPeople
```

This will return the average weight of the persons listed in FatPeople, excluding those having a weight of -1, since `AVG` skips NULL data. Presumably, -1 indicates “weight unknown” in this table. A plain `AVG(Weight)` would include the -1 weights, thus skewing the result.

*See also*

`COALESCE()`, `DECODE()`, `IIF()`, `CASE`

## 8.10. Special Functions for DECFLOAT

### 8.10.1. COMPARE_DECFLOAT()

Compares two DECFLOAT values to be equal, different or unordered

**Result type**

`SMALLINT`

**Syntax**

```sql
COMPARE_DECFLOAT (decfloat1, decfloat2)
```

**Table 196. COMPARE_DECFLOAT Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>decfloatn</td>
<td>Value or expression of type DECFLOAT, or cast-compatible with DECFLOAT</td>
</tr>
</tbody>
</table>

The result is a `SMALLINT` value, as follows:
Values are equal

First value is less than second

First value is greater than second

Values are unordered, i.e. one or both is NaN/sNaN

Unlike the comparison operators ('<', '=', '>', etc.), comparison is exact: `COMPARE_DECFLOAT(2.17, 2.170)` returns 2 not 0.

See also

TOTALORDER()

8.10.2. NORMALIZE_DECFLOAT()

Returns the simplest, normalized form of a DECFLOAT

Result type

DECFLOAT

Syntax

NORMALIZE_DECFLOAT (decfloat_value)

Table 197. NORMALIZE_DECFLOAT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>decfloat_value</td>
<td>Value or expression of type DECFLOAT, or cast-compatible with DECFLOAT</td>
</tr>
</tbody>
</table>

For any non-zero value, trailing zeroes are removed with appropriate correction of the exponent.

Examples of NORMALIZE_DECFLOAT

```
-- will return 12
select normalize_decfloat(12.00)
from rdb$database;

-- will return 1.2E+2
select normalize_decfloat(120)
from rdb$database;
```

8.10.3. QUANTIZE()

Returns a value that is equal in value — except for rounding — to the first argument, but with the same exponent as the second argument

Result type

DECFLOAT
Syntax

QUANTIZE (decfloat_value, exp_value)

Table 198. QUANTIZE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>decfloat_value</td>
<td>Value or expression to quantize; needs to be of type DECFL OAT, or cast-compatible with DECFL OAT</td>
</tr>
<tr>
<td>exp_value</td>
<td>Value or expression to use for its exponent; needs to be of type DECFL OAT, or cast-compatible with DECFL OAT</td>
</tr>
</tbody>
</table>

QUANTIZE returns a DECFL OAT value that is equal in value and sign (except for rounding) to decfloat_value, and that has an exponent equal to the exponent of exp_value. The type of the return value is DECFL OAT(16) if both arguments are DECFL OAT(16), otherwise the result type is DECFL OAT(34).

The target exponent is the exponent used in the Decimal64 or Decimal128 storage format of DECFL OAT of exp_value. This is not necessarily the same as the exponent displayed in tools like isql. For example, the value 1.23E+2 is coefficient 123 and exponent 0, while 1.2 is coefficient 12 and exponent -1.

If the exponent of decfloat_value is greater than the one of exp_value, the coefficient of decfloat_value is multiplied by a power of ten, and its exponent decreased. If the exponent is smaller, then its coefficient is rounded using the current decfloat rounding mode, and its exponent is increased.

When it is not possible to achieve the target exponent because the coefficient would exceed the target precision (16 or 34 decimal digits), either a “Decfloat float invalid operation” error is raised or NaN is returned (depending on the current decfloat traps configuration).

There are almost no restrictions on the exp_value. However, in almost all usages, NaN/sNaN/Infinity will produce an exception (unless allowed by the current decfloat traps configuration), NULL will make the function return NULL, and so on.

Examples of QUANTIZE

```sql
select v, pic, quantize(v, pic) from examples;

<table>
<thead>
<tr>
<th>V</th>
<th>PIC</th>
<th>QUANTIZE</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.16</td>
<td>0.01</td>
<td>3.160</td>
</tr>
<tr>
<td>3.16</td>
<td>0.01</td>
<td>3.16</td>
</tr>
<tr>
<td>3.16</td>
<td>0.1</td>
<td>3.2</td>
</tr>
<tr>
<td>3.16</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>3.16</td>
<td>1E+1</td>
<td>0E+1</td>
</tr>
<tr>
<td>-0.1</td>
<td>1</td>
<td>-0</td>
</tr>
<tr>
<td>0</td>
<td>1E+5</td>
<td>0E+5</td>
</tr>
<tr>
<td>316</td>
<td>0.1</td>
<td>316.0</td>
</tr>
</tbody>
</table>
```
8.10.4. TOTALORDER()

Determines the total or linear order of its arguments

Result type
SMALLINT

Syntax

TOTALORDER (decfloat1, decfloat2)

Table 199. TOTALORDER Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>decfloatn</td>
<td>Value or expression of type DECFLOAT, or cast-compatible with DECFLOAT</td>
</tr>
</tbody>
</table>

TOTALORDER compares two DECFLOAT values including any special values. The comparison is exact, and returns a SMALLINT, one of:

-1     First value is less than second

0      Values are equal

1      First value is greater than second.

For TOTALORDER comparisons, DECFLOAT values are ordered as follows:

-NaN < -sNaN < -INF < -0.1 < -0.10 < -0 < 0 < 0.10 < 0.1 < INF < sNaN < NaN

See also

COMPARE_DECFLOAT()

8.11. Cryptographic Functions

8.11.1. DECrypt()

Decrypts data using a symmetric cipher

Result type
VARBINARY or BLOB

Syntax

DECrypt ( encrypted_input
USING <algorithm> [MODE <mode>]  
KEY key  
[IV iv] [<ctr_type>] [CTR_LENGTH ctr_length]  
[COUNTER initial_counter] 

!! See syntax of <<fblangref50-scalarfuncs-encrypt,ENCRYPT>> for further rules !!

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>encrypted_input</td>
<td>Encrypted input as a blob or (binary) string</td>
</tr>
</tbody>
</table>

See ENCRYPT Function Parameters for other parameters

- Sizes of data strings (like `encrypted_input`, `key` and `iv`) must meet the requirements of the selected algorithm and mode.
- This function returns BLOB SUB_TYPE BINARY when the first argument is a BLOB, and VARBINARY for all other text and binary types.
- When the encrypted data was text, it must be explicitly cast to a string type of appropriate character set.
- The ins and outs of the various algorithms are considered beyond the scope of this language reference. We recommend searching the internet for further details on the algorithms.

**DECRIPT Examples**

```sql
select decrypt(x'0154090759DF' using sober128 key 'AbcdAbcdAbcdAbcd' iv '01234567')
from rdb$database;
select decrypt(secret_field using aes mode ofb key '0123456701234567' iv init_vector)
from secure_table;
```

See also

ENCRYPT(), RSA_DECRYPT()

### 8.11.2. ENCRYPT()

Encrypts data using a symmetric cipher

**Result type**

VARBINARY or BLOB

**Syntax**

```sql
ENCRYPT ( input
    USING <algorithm> [MODE <mode>]
    KEY key
    [IV iv] [<ctr_type>] [CTR_LENGTH ctr_length]
```

478
<algorithm> ::= <block_cipher> | <stream_cipher>

<block_cipher> ::= AES | ANUBIS | BLOWFISH | KHAZAD | RC5
| RC6 | SAFER+ | TWOFSH | XTEA

<stream_cipher> ::= CHACHA20 | RC4 | SOBER128

<mode> ::= CBC | CFB | CTR | ECB | OFB

<ctr_type> ::= CTR_BIG_ENDIAN | CTR_LITTLE_ENDIAN

Table 201. ENCRYPT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>input</td>
<td>Input to encrypt as a blob or (binary) string</td>
</tr>
<tr>
<td>algorithm</td>
<td>The algorithm to use for decryption</td>
</tr>
<tr>
<td>mode</td>
<td>The algorithm mode; only for block ciphers</td>
</tr>
<tr>
<td>key</td>
<td>The encryption/decryption key</td>
</tr>
<tr>
<td>iv</td>
<td>Initialization vector or nonce; should be specified for block ciphers in all modes except ECB, and all stream ciphers except RC4</td>
</tr>
<tr>
<td>ctr_type</td>
<td>Endianness of the counter; only for CTR mode. Default is CTR_LITTLE_ENDIAN.</td>
</tr>
<tr>
<td>ctr_length</td>
<td>Counter length; only for CTR mode. Default is size of iv.</td>
</tr>
<tr>
<td>initial_counter</td>
<td>Initial counter value; only for CHACHA20. Default is 0.</td>
</tr>
</tbody>
</table>

- This function returns BLOB_SUBTYPE_BINARY when the first argument is a BLOB, and VARBINARY for all other text and binary types.
- Sizes of data strings (like key and iv) must meet the requirements of the selected algorithm and mode, see table Encryption Algorithm Requirements.
  - In general, the size of iv must match the block size of the algorithm
  - For ECB and CBC mode, input must be multiples of the block size, you will need to manually pad with zeroes or spaces as appropriate.
- The ins and outs of the various algorithms and modes are considered beyond the scope of this language reference. We recommend searching the internet for further details on the algorithms.
- Although specified as separate options in this Language Reference, in the actual syntax CTR_LENGTH and COUNTER are aliases.

Table 202. Encryption Algorithm Requirements
<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Key size (bytes)</th>
<th>Block size (bytes)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Block Ciphers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AES</td>
<td>16, 24, 32</td>
<td>16</td>
<td>Key size determines the AES variant:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>16 bytes → AES-128</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>24 bytes → AES-192</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>32 bytes → AES-256</td>
</tr>
<tr>
<td>ANUBIS</td>
<td>16 - 40, in steps of 4 (4x)</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>BLOWFISH</td>
<td>8 - 56</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>KHAZAD</td>
<td>16</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>RC5</td>
<td>8 - 128</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>RC6</td>
<td>8 - 128</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>SAFER+</td>
<td>16, 24, 32</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>TWOFISH</td>
<td>16, 24, 32</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>XTEA</td>
<td>16</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Stream Ciphers</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CHACHA20</td>
<td>16, 32</td>
<td>1</td>
<td>Nonce size (IV) is 8 or 12 bytes. For nonce size 8, initial_counter is a 64-bit integer, for size 12, 32-bit.</td>
</tr>
<tr>
<td>RC4</td>
<td>5 - 256</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SOBER128</td>
<td>4x</td>
<td>1</td>
<td>Nonce size (IV) is 4y bytes, the length is independent of key size.</td>
</tr>
</tbody>
</table>

**ENCRYPT Examples**

```sql
select encrypt('897897' using sober128 key 'AbcdAbcdAbcdAbcd' iv '01234567')
from rdb$database;
```

See also

DECRYPT(), RSA_ENCRYPT()

**8.11.3. RSA_DECRYPT()**

Decrypts data using an RSA private key and removes OAEP or PKCS 1.5 padding

*Result type*

VARBINARY
Syntax

\[
\text{RSA\_DECRYPT (encrypted\_input \hspace{1em} KEY \hspace{1em} private\_key}
\]
\[
[\text{LPARAM tag\_string} \hspace{1em} \text{[HASH <hash>] [PKCS\_1\_5]}]
\]
\[
<\text{hash}> ::= \text{MD5} \mid \text{SHA1} \mid \text{SHA256} \mid \text{SHA512}
\]

Table 203. RSA\_DECRYPT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>encrypted_input</td>
<td>Input data to decrypt</td>
</tr>
<tr>
<td>private_key</td>
<td>Private key to apply, PKCS#1 format</td>
</tr>
<tr>
<td>tag_string</td>
<td>An additional system-specific tag to identify which system encrypted the message; default is NULL. If the tag does not match what was used during encryption, RSA_DECRYPT will not decrypt the data.</td>
</tr>
<tr>
<td>hash</td>
<td>The hash used for OAEP padding; default is SHA256.</td>
</tr>
</tbody>
</table>

RSA\_DECRYPT decrypts \textit{encrypted\_input} using the RSA private key and then removes padding from the resulting data.

By default, OAEP padding is used. The \text{PKCS\_1\_5} option will switch to the less secure PKCS 1.5 padding.

- The \text{PKCS\_1\_5} option is only for backward compatibility with systems applying PKCS 1.5 padding. For security reasons, it should \textbf{not} be used in new projects.

- This function returns \text{VARBINARY}.

- When the encrypted data was text, it must be explicitly cast to a string type of appropriate character set.

\textbf{RSA\_DECRYPT Examples}

- Run the examples of the \text{RSA\_PRIVATE} and \text{RSA\_PUBLIC, RSA\_ENCRYPT} functions first.

```sql
select cast(rsa\_decrypt(rdb\$get\_context('USER\_SESSION', 'msg')
key rdb\$get\_context('USER\_SESSION', 'private\_key')) as varchar(128))
from rdb\$database;
```

\textit{See also}

\text{RSA\_ENCRYPT()}, \text{RSA\_PRIVATE()}, \text{DECRYPT()}

\textbf{8.11.4. RSA\_ENCRYPT()}

Pads data using OAEP or PKCS 1.5 and then encrypts it with an RSA public key
Result type
VARBINARY

Syntax

```
RSA_ENCRYPT (input KEY public_key
             [LPARAM tag_string] [HASH <hash>] [PKCS_1_5])

<hash> ::= MD5 | SHA1 | SHA256 | SHA512
```

Table 204. RSA_ENCRYPT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>input</td>
<td>Input data to encrypt</td>
</tr>
<tr>
<td>public_key</td>
<td>Public key to apply, PKCS#1 format</td>
</tr>
<tr>
<td>tag_string</td>
<td>An additional system-specific tag to identify which system encrypted the message; default is NULL.</td>
</tr>
<tr>
<td>hash</td>
<td>The hash used for OAEP padding; default is SHA256.</td>
</tr>
</tbody>
</table>

RSA_ENCRYPT pads input using the OAEP or PKCS 1.5 padding scheme and then encrypts it using the specified RSA public key. This function is normally used to encrypt short symmetric keys which are then used in block ciphers to encrypt a message.

By default, OAEP padding is used. The PKCS_1_5 option will switch to the less secure PKCS 1.5 padding.

The PKCS_1_5 option is only for backward compatibility with systems applying PKCS 1.5 padding. For security reasons, it should not be used in new projects.

RSA_ENCRYPT Examples

Run the examples of the RSA_PRIVATE and RSA_PUBLIC functions first.

```
select rdb$set_context('USER_SESSION', 'msg', rsa_encrypt('Some message' key rdb$get_context('USER_SESSION', 'public_key'))) from rdb$database;
```

See also
RSA_DECRYPT(), RSA_PUBLIC(), ENCRYPT()

8.11.5. RSA_PRIVATE()

Generates an RSA private key

Result type
VARBINARY
Syntax

`RSA_PRIVATE (key_length)`

Table 205. RSA_PRIVATE Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>key_length</td>
<td>Key length in bytes; minimum 4, maximum 1024. A size of 256 bytes (2048 bits) or larger is recommended.</td>
</tr>
</tbody>
</table>

RSA_PRIVATE generates an RSA private key of the specified length (in bytes) in PKCS#1 format.

![Info]

The larger the length specified, the longer it takes for the function to generate a private key.

RSA_PRIVATE Examples

```sql
select rdb$set_context('USER_SESSION', 'private_key', rsa_private(256))
from rdb$database;
```

![Warning]

Putting private keys in the context variables is not secure; we’re doing it here for demonstration purposes. SYSDBA and users with the role RDB$ADMIN or the system privilege MONITOR_ANY_ATTACHMENT can see all context variables from all attachments.

See also

`RSA_PUBLIC()`, `RSA_DECRYPT()`

8.11.6. RSA_PUBLIC()

Generates an RSA public key

Result type

VARBINARY

Syntax

`RSA_PUBLIC (private_key)`

Table 206. RSA_PUBLIC Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>private_key</td>
<td>RSA private key in PKCS#1 format</td>
</tr>
</tbody>
</table>

RSA_PUBLIC returns the RSA public key in PKCS#1 format for the provided RSA private key (also PKCS#1 format).
8.11.7. RSA_SIGN_HASH()

PSS encodes a message hash and signs it with an RSA private key

**Result type**
VARBINARY

**Syntax**

```sql
RSA_SIGN_HASH (message_digest
 KEY private_key
 [HASH <hash>] [SALT_LENGTH salt_length]
 [PKCS_1_5])
```

<hash> ::= MD5 | SHA1 | SHA256 | SHA512

**Table 207. RSA_SIGN_HASH Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>message_digest</td>
<td>Hash of message to sign. The hash algorithm used should match hash</td>
</tr>
<tr>
<td>private_key</td>
<td>RSA private key in PKCS#1 format</td>
</tr>
<tr>
<td>hash</td>
<td>Hash to generate PSS encoding; default is SHA256. This should be the same hash as used to generate message_digest.</td>
</tr>
<tr>
<td>salt_length</td>
<td>Length of the desired salt in bytes; default is 8; minimum 1, maximum 32. The recommended value is between 8 and 16.</td>
</tr>
</tbody>
</table>

RSA_SIGN_HASH performs PSS encoding of the message_digest to be signed, and signs using the RSA private key.

By default, OAEP padding is used. The PKCS_1_5 option will switch to the less secure PKCS 1.5 padding.

- The PKCS_1_5 option is only for backward compatibility with systems applying PKCS 1.5 padding. For security reasons, it should not be used in new projects.
- This function expects the hash of a message (or message digest), not the actual
message. The \textit{hash} argument should specify the algorithm that was used to generate that hash.

A function that accepts the actual message to hash might be introduced in a future version of Firebird.

### PSS encoding

Probabilistic Signature Scheme (PSS) is a cryptographic signature scheme specifically developed to allow modern methods of security analysis to prove that its security directly relates to that of the RSA problem. There is no such proof for the traditional PKCS#1 v1.5 scheme.

#### RSA\_SIGN\_HASH Examples

Run the example of the \texttt{RSA\_PRIVATE} function first.

```sql
select rdb$set_context('USER\_SESSION', 'msg',
    rsa_sign_hash(crypt_hash('Test message' using sha256)
    key rdb$get_context('USER\_SESSION', 'private\_key'))) from rdb$database;
```

See also

\texttt{RSA\_VERIFY\_HASH()}, \texttt{RSA\_PRIVATE()}, \texttt{CRYPT\_HASH()}

### 8.11.8. RSA\_VERIFY\_HASH()

Verifies a message hash against a signature using an RSA public key

**Result type**

\texttt{BOOLEAN}

**Syntax**

\begin{verbatim}
RSA\_VERIFY\_HASH (message\_digest SIGNATURE signature KEY public\_key
[HASH <hash>] [SALT\_LENGTH salt\_length]
[PKCS\_1\_5])
\end{verbatim}

\texttt{<hash>} ::= MD5 \mid SHA1 \mid SHA256 \mid SHA512

**Table 208. RSA\_VERIFY Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>message_digest</td>
<td>Hash of message to verify. The hash algorithm used should match \textit{hash}</td>
</tr>
<tr>
<td>signature</td>
<td>Expected signature of \textit{input} generated by RSA_SIGN_HASH</td>
</tr>
</tbody>
</table>

485
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>public_key</td>
<td>RSA public key in PKCS#1 format matching the private key used to sign</td>
</tr>
<tr>
<td>hash</td>
<td>Hash to use for the message digest; default is SHA256. This should be the same hash as used to generate message_digest, and as used in RSA_SIGN_HASH</td>
</tr>
<tr>
<td>salt_length</td>
<td>Length of the salt in bytes; default is 8; minimum 1, maximum 32. Value must match the length used in RSA_SIGN_HASH.</td>
</tr>
</tbody>
</table>

**RSA_VERIFY_HASH** performs PSS encoding of the *message_digest* to be verified, and verifies the digital signature using the provided RSA public key.

By default, OAEP padding is used. The **PKCS_1_5** option will switch to the less secure PKCS 1.5 padding.

| ![Icon] | The PKCS_1_5 option is only for backward compatibility with systems applying PKCS 1.5 padding. For security reasons, it should **not** be used in new projects. |
| ![Icon] | This function expects the hash of a message (or message digest), not the actual message. The *hash* argument should specify the algorithm that was used to generate that hash. |
| ![Icon] | A function that accepts the actual message to hash might be introduced in a future version of Firebird. |

**RSA_VERIFY_HASH Examples**

Run the examples of the **RSA_PRIVATE**, **RSA_PUBLIC** and **RSA_SIGN_HASH** functions first.

```sql
select rsa_verify_hash(
    crypt_hash('Test message' using sha256)
    signature rdb$get_context('USER_SESSION', 'msg')
    key rdb$get_context('USER_SESSION', 'public_key'))
from rdb$database
```

*See also*

**RSA_SIGN_HASH()**, **RSA_PUBLIC()**, **CRYPT_HASH()**

### 8.12. Other Functions

Functions that don’t fit in any other category.

#### 8.12.1. MAKE_DBKEY()

Creates a DBKEY value

*Result type*
Syntax

```
MAKE_DBKEY (relation, recnum [, dpnum [, ppnum]])
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>relation</td>
<td>Relation name or relation id</td>
</tr>
<tr>
<td>recnum</td>
<td>Record number. Either absolute (if dpnum and ppnum are absent), or relative (if dpnum present)</td>
</tr>
<tr>
<td>dpnum</td>
<td>Data page number. Either absolute (if ppnum is absent) or relative (if ppnum present)</td>
</tr>
<tr>
<td>ppnum</td>
<td>Pointer page number.</td>
</tr>
</tbody>
</table>

**Table 209. RDB$GET_TRANSACTION_CN Function Parameters**

**MAKE_DBKEY** creates a DBKEY value using a relation name or ID, record number, and (optionally) logical numbers of data page and pointer page.

1. If `relation` is a string expression or literal, then it is treated as a relation name, and the engine searches for the corresponding relation ID. The search is case-sensitive. In the case of string literal, relation ID is evaluated at query preparation time. In the case of expression, relation ID is evaluated at execution time. If the relation cannot be found, then error **isc_relnotdef** is raised.

2. If `relation` is a numeric expression or literal, then it is treated as a relation ID and used “as is”, without verification against existing relations. If the argument value is negative or greater than the maximum allowed relation ID (65535 currently), then **NULL** is returned.

3. Argument `recnum` represents an absolute record number in the relation (if the next arguments `dpnum` and `ppnum` are missing), or a record number relative to the first record, specified by the next arguments.

4. Argument `dpnum` is a logical number of data page in the relation (if the next argument `ppnum` is missing), or number of data pages relative to the first data page addressed by the given `ppnum`.

5. Argument `ppnum` is a logical number of pointer page in the relation.

6. All numbers are zero-based. Maximum allowed value for `dpnum` and `ppnum` is $2^{32}$ (4294967296). If `dpnum` is specified, then `recnum` can be negative. If `dpnum` is missing and `recnum` is negative, then **NULL** is returned. If `ppnum` is specified, then `dpnum` can be negative. If `ppnum` is missing and `dpnum` is negative, then **NULL** is returned.

7. If any of specified arguments is **NULL**, the result is also **NULL**.

8. Argument `relation` is described as **INTEGER** during query preparation, but it can be overridden by a client application as **VARCHAR** or **CHAR**. Arguments `recnum`,
$dpnum$ and $ppnum$ are described as BIGINT.

**Examples of **$MAKE\_DBKEY$

1. Select record using relation name (note that relation name is uppercase)

   ```sql
   select *
   from rdb$relations
   where rdb$db_key = make_dbkey('RDB$RELATIONS', 0)
   ```

2. Select record using relation ID

   ```sql
   select *
   from rdb$relations
   where rdb$db_key = make_dbkey(6, 0)
   ```

3. Select all records physically residing on the first data page

   ```sql
   select *
   from rdb$relations
   where rdb$db_key >= make_dbkey(6, 0, 0)
   and rdb$db_key < make_dbkey(6, 0, 1)
   ```

4. Select all records physically residing on the first data page of 6th pointer page

   ```sql
   select *
   from SOMETABLE
   where rdb$db_key >= make_dbkey('SOMETABLE', 0, 0, 5)
   and rdb$db_key < make_dbkey('SOMETABLE', 0, 1, 5)
   ```

**8.12.2. RDB$ERROR()**

Returns PSQL error information inside a WHEN ... DO block

*Available in*  
PSQL

*Result type*  
Varies (see table below)

*Syntax*

```
RDB$ERROR (<context>)
```

<context> ::=
Table 210. Contexts

<table>
<thead>
<tr>
<th>Context</th>
<th>Result type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDSCODE</td>
<td>INTEGER</td>
<td>Firebird error code, see also GDSCODE</td>
</tr>
<tr>
<td>SQLCODE</td>
<td>INTEGER</td>
<td>(deprecated) SQL code, see also SQLCODE</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>CHAR(5) CHARACTER SET ASCII</td>
<td>SQLstate, see also SQLSTATE</td>
</tr>
<tr>
<td>EXCEPTION</td>
<td>VARCHAR(63) CHARACTER SET UTF8</td>
<td>Name of the active user-defined exception or NULL if the active exception is a system exception</td>
</tr>
<tr>
<td>MESSAGE</td>
<td>VARCHAR(1024) CHARACTER SET UTF8</td>
<td>Message text of the active exception</td>
</tr>
</tbody>
</table>

RDB$ERROR returns data of the specified context about the active PSQL exception. Its scope is confined to exception-handling blocks in PSQL (WHEN … DO). Outside the exception handling blocks, RDB$ERROR always returns NULL. This function cannot be called from DSQL.

Example of RDB$ERROR

```
BEGIN
  ...
  WHEN ANY DO
    EXECUTE PROCEDURE P_LOG_EXCEPTION(RDB$ERROR(MESSAGE));
END
```

See also
Trapping and Handling Errors, GDSCODE, SQLCODE, SQLSTATE

8.12.3. RDB$GET_TRANSACTION_CN()

Returns the commit number (“CN”) of a transaction

Result type
BIGINT

Syntax

```
RDB$GET_TRANSACTION_CN (transaction_id)
```

Table 211. RDB$GET_TRANSACTION_CN Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>transaction_id</td>
<td>Transaction id</td>
</tr>
</tbody>
</table>

If the return value is greater than 1, it is the actual CN of the transaction if it was committed after
the database was started.

The function can also return one of the following results, indicating the commit status of the transaction:

-2  Transaction is dead (rolled back)
-1  Transaction is in limbo
0   Transaction is still active
1   Transaction committed before the database started or less than the Oldest Interesting Transaction for the database
NULL Transaction number supplied is NULL or greater than Next Transaction for the database

For more information about CN, consult the *Firebird 4.0 Release Notes*.

**RDB$GET_TRANSACTION_CN Examples**

```
select rdb$get_transaction_cn(current_transaction) from rdb$database;
select rdb$get_transaction_cn(123) from rdb$database;
```

### 8.12.4. RDB$ROLE_IN_USE()

Checks if a role is active for the current connection

**Result type**

BOOLEAN

**Syntax**

```
RDB$ROLE_IN_USE (role_name)
```

**Table 212. RDB$ROLE_IN_USE Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>role_name</td>
<td>String expression for the role to check. Case-sensitive, must match the role name as stored in RDB$ROLES</td>
</tr>
</tbody>
</table>

RDB$ROLE_IN_USE returns TRUE if the specified role is active for the current connection, and FALSE otherwise. Contrary to `CURRENT_ROLE`—which only returns the explicitly specified role—this function can be used to check for roles that are active by default, or cumulative roles activated by an explicitly specified role.

**RDB$ROLE_IN_USE Examples**
List currently active roles

```sql
select rdb$role_name
from rdb$roles
where rdb$role_in_use(rdb$role_name);
```

See also

CURRENT_ROLE

### 8.12.5. RDB$SYSTEM_PRIVILEGE()

Checks if the authorization of the current connection has a system privilege

**Result type**

BOOLEAN

**Syntax**

```sql
RDB$SYSTEM_PRIVILEGE (<sys_privilege>)
```

<sys_privilege> ::= 

!! See CREATE ROLE !!

**Table 213. RDB$SYSTEM_PRIVILEGE Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sys_privilege</td>
<td>System privilege</td>
</tr>
</tbody>
</table>

RDB$SYSTEM_PRIVILEGE accepts a system privilege name and returns TRUE if the current connection has the given system privilege, and FALSE otherwise.

The authorization of the current connection is determined by privileges of the current user, the user PUBLIC, and the currently active roles (explicitly set or activated by default).

**RDB$SYSTEM_PRIVILEGE Examples**

```sql
select rdb$system_privilege(user_management) from rdb$database;
```

See also

Fine-grained System Privileges
Chapter 9. Aggregate Functions

Aggregate functions operate on groups of records, rather than on individual records or variables. They are often used in combination with a `GROUP BY` clause.

**Syntax**

```
<aggregate_function> ::=  
aggregate_function ([<expr> [, <expr> ...]]) 
[FILTER (WHERE <condition>)]
```

The aggregate functions can also be used as window functions with the `OVER()` clause. See Window (Analytical) Functions for more information.

Aggregate functions are available in DSQL and PSQL. Availability in ESQL is not tracked by this Language Reference.

### 9.1. FILTER Clause for Aggregate Functions

The `FILTER` clause extends aggregate functions (SUM, AVG, COUNT, etc.) with an additional `WHERE` clause. This limits the rows processed by the aggregate functions to the rows that satisfy the conditions of both the main `WHERE` clause and those inside the `FILTER` clause.

It can be thought of as a more explicit form of using an aggregate function with a condition (DECODE, CASE, IIF, NULLIF) to ignore some values that would otherwise be considered by the aggregation.

The `FILTER` clause can be used with any aggregate functions in aggregate or windowed (OVER) statements, but not with window-only functions like DENSE_RANK.

**Example of FILTER**

Suppose you need a query to count the rows with `status = 'A'` and the row with `status = 'E'` as different columns. The old way to do it would be:

```
select count(decode(status, 'A', 1)) status_a,
       count(decode(status, 'E', 1)) status_e
from data;
```

The `FILTER` clause lets you express those conditions more explicitly:

```
select count(*) filter (where status = 'A') status_a,
       count(*) filter (where status = 'E') status_e
from data;
```

You can use more than one `FILTER` modifier in an aggregate query. You could, for example, use 12 filters on totals aggregating sales for a year to produce monthly...
9.2. General-purpose Aggregate Functions

9.2.1. AVG()

Average

Result type
Depends on the input type

Syntax

\[
\text{AVG} ([\text{ALL} \mid \text{DISTINCT}] <\text{expr}>)
\]

Table 214. AVG Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{expr}</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns a numeric data type. Aggregate functions are not allowed as expressions</td>
</tr>
</tbody>
</table>

AVG returns the average argument value in the group. NULL is ignored.

- Parameter \text{ALL} (the default) applies the aggregate function to all values.
- Parameter \text{DISTINCT} directs the AVG function to consider only one instance of each unique value, no matter how many times this value occurs.
- If the set of retrieved records is empty or contains only NULL, the result will be NULL.

The result type of AVG depends on the input type:

\[
\begin{align*}
\text{FLOAT, DOUBLE PRECISION} &\quad \text{DOUBLE PRECISION} \\
\text{SMALLINT, INTEGER, BIGINT} &\quad \text{BIGINT} \\
\text{INT128} &\quad \text{INT128} \\
\text{DECIMAL/NUMERIC}(p, n) \text{ with } p < 19 &\quad \text{DECIMAL/NUMERIC}(18, n) \\
\text{DECIMAL/NUMERIC}(p, n) \text{ with } p \geq 19 &\quad \text{DECIMAL/NUMERIC}(38, n) \\
\text{DECFLOAT}(16) &\quad \text{DECFLOAT}(16) \\
\text{DECFLOAT}(34) &\quad \text{DECFLOAT}(34)
\end{align*}
\]

AVG Examples

\[
\begin{align*}
\text{SELECT} \\
&\quad \text{dept\_no}, \\
&\quad \text{AVG(salary)} \\
\text{FROM employee}
\end{align*}
\]
GROUP BY dept_no

See also
SELECT

9.2.2. COUNT()

Counts non-NULL values

Result type
BIGINT

Syntax
COUNT ([ALL | DISTINCT] <expr> | *)

Table 215. COUNT Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns a numeric data type. Aggregate functions are not allowed as expressions</td>
</tr>
</tbody>
</table>

COUNT returns the number of non-null values in a group.

- ALL is the default: it counts all values in the set that are not NULL.
- If DISTINCT is specified, duplicates are excluded from the counted set.
- If COUNT (*) is specified instead of the expression expr, all rows will be counted. COUNT (*) —
  - does not accept parameters
  - cannot be used with the keyword DISTINCT
  - does not take an expr argument, since its context is column-unspecific by definition
  - counts each row separately and returns the number of rows in the specified table or group without omitting duplicate rows
  - counts rows containing NULL
- If the result set is empty or contains only NULL in the specified column(s), the returned count is zero.

COUNT Examples

```sql
SELECT dept_no,
       COUNT(*) AS cnt,
       COUNT(DISTINCT name) AS cnt_name
FROM employee
```
GROUP BY dept_no

See also

SELECT.

9.2.3. LIST()

Concatenates values into a string list

Result type
BLOB

Syntax

\[
\text{LIST ([ALL | DISTINCT] <expr> [, separator])}
\]

Table 216. LIST Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF that returns the string data type or a BLOB. Fields of numeric and date/time types are converted to strings. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>separator</td>
<td>Optional alternative separator, a string expression. Comma is the default separator</td>
</tr>
</tbody>
</table>

LIST returns a string consisting of the non-NULL argument values in the group, separated either by a comma or by a user-supplied separator. If there are no non-NULL values (this includes the case where the group is empty), NULL is returned.

- ALL (the default) results in all non-NULL values being listed. With DISTINCT, duplicates are removed, except if expr is a BLOB.
- The optional separator argument may be any string expression. This makes it possible to specify e.g. ascii_char(13) as a separator.
- The expr and separator arguments support BLOBs of any size and character set.
- Datetime and numeric arguments are implicitly converted to strings before concatenation.
- The result is a text BLOB, except when expr is a BLOB of another subtype.
- The ordering of the list values is undefined — the order in which the strings are concatenated is determined by read order from the source set which, in tables, is not generally defined. If ordering is important, the source data can be pre-sorted using a derived table or similar.

This is a trick/workaround, and it depends on implementation details of the optimizer/execucion order. This trick doesn't always work, and it is not guaranteed to work across versions.

Some reports indicate this no longer works in Firebird 5.0, or only in more
limited circumstances than in previous versions.

**LIST Examples**

1. Retrieving the list, order undefined:

   ```sql
   SELECT LIST (display_name, '; ') FROM GR_WORK;
   ```

2. Retrieving the list in alphabetical order, using a derived table:

   ```sql
   SELECT LIST (display_name, '; ') 
   FROM (SELECT display_name 
     FROM GR_WORK 
     ORDER BY display_name);
   ```

**See also**

**SELECT**

### 9.2.4. MAX()

Maximum

**Result type**

Returns a result of the same data type the input expression.

**Syntax**

```sql
MAX ([ALL | DISTINCT] <expr>)
```  

**Table 217. MAX Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

MAX returns the maximum non-NULL element in the result set.

- If the group is empty or contains only NULLs, the result is NULL.
- If the input argument is a string, the function will return the value that will be sorted last if COLLATE is used.
- This function fully supports text BLOBs of any size and character set.

The DISTINCT parameter makes no sense if used with MAX() as it doesn't change the result; it is implemented only for compliance with the standard.
Max Examples

```
SELECT
department,
MAX(salary)
FROM employee
GROUP BY department
```

See also

**MIN(), SELECT**

9.2.5. **MIN()**

Minimum

**Result type**

Returns a result of the same data type the input expression.

**Syntax**

```
MIN ([ALL | DISTINCT] <expr>)
```

**Table 218. MIN Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

**MIN** returns the minimum non-NULL element in the result set.

- If the group is empty or contains only NULLs, the result is NULL.
- If the input argument is a string, the function will return the value that will be sorted first if COLLATE is used.
- This function fully supports text BLOBs of any size and character set.

<table>
<thead>
<tr>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>The DISTINCT parameter makes no sense if used with MIN() as it doesn't change the result; it is implemented only for compliance with the standard.</td>
</tr>
</tbody>
</table>

Min Examples

```
SELECT
department,
MIN(salary)
FROM employee
GROUP BY department
```
See also
MAX(), SELECT

9.2.6. SUM()

Sum

Result type
Depends on the input type

Syntax

```
SUM ([ALL | DISTINCT] <expr>)
```

Table 219. SUM Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

SUM calculates and returns the sum of non-NULL values in the group.

- If the group is empty or contains only NULLs, the result is NULL.
- ALL is the default option — all values in the set that are not NULL are processed. If DISTINCT is specified, duplicates are removed from the set and the SUM evaluation is done afterward.

The result type of SUM depends on the input type:

- FLOAT, DOUBLE PRECISION  →  DOUBLE PRECISION
- SMALLINT, INTEGER  →  BIGINT
- BIGINT, INT128  →  INT128
- DECIMAL/NUMERIC($p$, $n$) with $p < 10$  →  DECIMAL/NUMERIC($18$, $n$)
- DECIMAL/NUMERIC($p$, $n$) with $p \geq 10$  →  DECIMAL/NUMERIC($38$, $n$)
- DECFLOAT(16), DECFLOAT(34)  →  DECFLOAT(34)

SUM Examples

```
SELECT
  dept_no,
  SUM(salary),
FROM employee
GROUP BY dept_no

See also
SELECT
```
9.3. Statistical Aggregate Functions

9.3.1. CORR()

Correlation coefficient

Result type
DOUBLE PRECISION

Syntax

CORR ( <expr1>, <expr2> )

Table 220. CORR Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exprN</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The CORR function return the correlation coefficient for a pair of numerical expressions.

The function CORR(<expr1>, <expr2>) is equivalent to

\[
\text{COVAR\_POP}(\text{expr1}, \text{expr2}) / (\text{STDDEV\_POP}(\text{expr2}) \times \text{STDDEV\_POP}(\text{expr1}))
\]

This is also known as the Pearson correlation coefficient.

In a statistical sense, correlation is the degree to which a pair of variables are linearly related. A linear relation between variables means that the value of one variable can to a certain extent predict the value of the other. The correlation coefficient represents the degree of correlation as a number ranging from -1 (high inverse correlation) to 1 (high correlation). A value of 0 corresponds to no correlation.

If the group or window is empty, or contains only NULL values, the result will be NULL.

CORR Examples

```
select corr(alength, aheight) AS c_corr from measure
```

See also
COVAR\_POP\(), STDDEV\_POP\()
9.3.2. COVAR_POP()

Population covariance

Result type
DOUBLE PRECISION

Syntax

COVAR_POP( <expr1>, <expr2> )

Table 221. COVAR_POP Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>exprN</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function COVAR_POP returns the population covariance for a pair of numerical expressions.

The function COVAR_POP(<expr1>, <expr2>) is equivalent to

\[(\text{SUM}(\text{expr1} \times \text{expr2}) - \text{SUM}(\text{expr1}) \times \text{SUM}(\text{expr2}) / \text{COUNT}(*)) / \text{COUNT}(*)\]

If the group or window is empty, or contains only NULL values, the result will be NULL.

COVAR_POP Examples

```sql
select
    covar_pop(alength, aheight) AS c_covar_pop
from measure
```

See also
COVAR_SAMP(), SUM(), COUNT()

9.3.3. COVAR_SAMP()

Sample covariance

Result type
DOUBLE PRECISION

Syntax

COVAR_SAMP( <expr1>, <expr2> )

Table 222. COVAR_SAMP Function Parameters
The function `COVAR_SAMP` returns the sample covariance for a pair of numerical expressions.

The function `COVAR_SAMP(<expr1>, <expr2>)` is equivalent to

\[
\frac{(\text{SUM}(<\text{expr1}> * <\text{expr2}>) - \text{SUM}(<\text{expr1}>) \times \text{SUM}(<\text{expr2}>))}{\text{COUNT}(*) - 1}
\]

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.

**COVAR_SAMP Examples**

```sql
select 
  covar_samp(alength, aheight) AS c_covar_samp 
from measure
```

See also

`COVAR_POP()`, `SUM()`, `COUNT()`

### 9.3.4. STDDEV_POP()

Population standard deviation

**Result type**

DOUBLE PRECISION or NUMERIC depending on the type of `expr`

**Syntax**

```sql
STDDEV_POP ( <expr> )
```

**Table 223. STDDEV_POP Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `STDDEV_POP` returns the population standard deviation for a group or window. NULL values are skipped.

The function `STDDEV_POP(<expr>)` is equivalent to
If the group or window is empty, or contains only NULL values, the result will be NULL.

**STDDEV_POP Examples**

```sql
select
deat_no,
stddev_pop(salary)
from employee
group by dept_no
```

*See also*

STDDEV_SAMP(), VAR_POP(), SQRT

**9.3.5. STDDEV_SAMP()**

Sample standard deviation

**Result type**

DOUBLE PRECISION or NUMERIC depending on the type of `expr`

**Syntax**

```sql
STDDEV_POP ( <expr> )
```

*Table 224. STDDEV_SAMP Function Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>expr</code></td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `STDDEV_SAMP` returns the sample standard deviation for a group or window. NULL values are skipped.

The function `STDDEV_SAMP(<expr>)` is equivalent to

```sql
SQRT(VAR_SAMP(<expr>))
```

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.

**STDDEV_SAMP Examples**
select
department_number
standard_deviation_samp(salary)
from employee
group by department_number

See also
STDDEV_POP(), VAR_SAMP(), SQRT

9.3.6. VAR_POP()

Population variance

Result type
DOUBLE PRECISION or NUMERIC depending on the type of expr

Syntax

VAR_POP ( <expr> )

Table 225. VAR_POP Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function VAR_POP returns the population variance for a group or window. NULL values are skipped.

The function VAR_POP(<expr>) is equivalent to

\[
(SUM(<expr> * <expr>) - SUM(<expr>) * SUM(<expr>) / COUNT(<expr>)) / COUNT(<expr>)
\]

If the group or window is empty, or contains only NULL values, the result will be NULL.

VAR_POP Examples

    select
department_number
var_pop(salary)
from employee
group by department_number

See also
9.3.7. VAR_SAMP()

Sample variance

Result type
DOUBLE PRECISION or NUMERIC depending on the type of expr

Syntax

VAR_SAMP ( <expr> )

Table 226. VAR_SAMP Function Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Numeric expression. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function VAR_POP returns the sample variance for a group or window. NULL values are skipped.

The function VAR_SAMP(<expr>) is equivalent to

\[
\frac{(\text{SUM}(\text{expr} * \text{expr}) - \text{SUM}(\text{expr}) * \text{SUM}(\text{expr})) / \text{COUNT}(\text{expr}))}{(\text{COUNT}(\text{expr}) - 1)}
\]

If the group or window is empty, contains only 1 row, or contains only NULL values, the result will be NULL.

**VAR_SAMP Examples**

```sql
select
department
var_samp(salary)
from employee
group by department
```

See also

VAR_POP(), SUM(), COUNT()

9.4. Linear Regression Aggregate Functions

Linear regression functions are useful for trend line continuation. The trend or regression line is usually a pattern followed by a set of values. Linear regression is useful to predict future values. To continue the regression line, you need to know the slope and the point of intersection with the y-
axis. As a set of linear functions can be used for calculating these values.

In the function syntax, \( y \) is interpreted as an \( x \)-dependent variable.

The linear regression aggregate functions take a pair of arguments, the dependent variable expression (\( y \)) and the independent variable expression (\( x \)), which are both numeric value expressions. Any row in which either argument evaluates to NULL is removed from the rows that qualify. If there are no rows that qualify, then the result of \texttt{REGR\_COUNT} is 0 (zero), and the other linear regression aggregate functions result in NULL.

9.4.1. \texttt{REGR\_AVGX()}

Average of the independent variable of the regression line

\textit{Result type}

\texttt{DOUBLE PRECISION}

\textit{Syntax}

\begin{verbatim}
REGR\_AVGX ( \langle y \rangle, \langle x \rangle )
\end{verbatim}

\begin{table}[h]
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y )</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>( x )</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function \texttt{REGR\_AVGX} calculates the average of the independent variable (\( x \)) of the regression line.

The function \texttt{REGR\_AVGX(\langle y \rangle, \langle x \rangle)} is equivalent to

\begin{verbatim}
SUM(\langle exprX\rangle) / REGR\_COUNT(\langle y \rangle, \langle x \rangle)
\end{verbatim}

\begin{verbatim}
\langle exprX\rangle :=
    CASE WHEN \langle x \rangle IS NOT NULL AND \langle y \rangle IS NOT NULL THEN \langle x \rangle END
\end{verbatim}

\textit{See also}

\texttt{REGR\_AVGY()}, \texttt{REGR\_COUNT()}, \texttt{SUM()}

9.4.2. \texttt{REGR\_AVGY()}

Average of the dependent variable of the regression line

\textit{Result type}

\texttt{DOUBLE PRECISION}
**DOUBLE PRECISION**

**Syntax**

```sql
REGR_AVGY ( <y>, <x> )
```

**Table 228. REGR_AVGY Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `REGR_AVGY` calculates the average of the dependent variable (y) of the regression line.

The function `REGR_AVGY(<y>, <x>)` is equivalent to

```sql
SUM(<exprY>) / REGR_COUNT(<y>, <x>)
```

- `<exprY> :=
  CASE WHEN <x> IS NOT NULL AND <y> IS NOT NULL THEN <y> END

**See also**

`REGR_AVGX()`, `REGR_COUNT()`, `SUM()`

### 9.4.3. REGR_COUNT()

Number of non-empty pairs of the regression line

**Result type**

DOUBLE PRECISION

**Syntax**

```sql
REGR_COUNT ( <y>, <x> )
```

**Table 229. REGR_COUNT Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>
The function `REGR_COUNT` counts the number of non-empty pairs of the regression line.

The function `REGR_COUNT(<y>, <x>)` is equivalent to

```
COUNT(*) FILTER (WHERE <x> IS NOT NULL AND <y> IS NOT NULL)
```

See also
COUNT()

**9.4.4. REGR_INTERCEPT()**

Point of intersection of the regression line with the y-axis

*Result type*
DOUBLE PRECISION

*Syntax*

```
REGR_INTERCEPT (<y>, <x>)
```

*Table 230. REGR_INTERCEPT Function Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `REGR_INTERCEPT` calculates the point of intersection of the regression line with the y-axis.

The function `REGR_INTERCEPT(<y>, <x>)` is equivalent to

```
REGR_AVGY(<y>, <x>) - REGR_SLOPE(<y>, <x>) * REGR_AVGX(<y>, <x>)
```

**REGR_INTERCEPT Examples**

Forecasting sales volume
with recursive years (byyear) as (  
    select 1991  
    from rdb$database  
    union all  
    select byyear + 1  
    from years  
    where byyear < 2020  
  ),

s as (  
    select  
      extract(year from order_date) as byyear,
      sum(total_value) as total_value  
    from sales  
    group by 1  
  ),

regr as (  
    select  
      regr_intercept(total_value, byyear) as intercept,
      regr_slope(total_value, byyear) as slope  
    from s  
  )

select  
  years.byyear as byyear,
  intercept + (slope * years.byyear) as total_value  
from years  
cross join regr

<table>
<thead>
<tr>
<th>BYYEAR</th>
<th>TOTAL_VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1991</td>
<td>118377.35</td>
</tr>
<tr>
<td>1992</td>
<td>414557.62</td>
</tr>
<tr>
<td>1993</td>
<td>710737.89</td>
</tr>
<tr>
<td>1994</td>
<td>1006918.16</td>
</tr>
<tr>
<td>1995</td>
<td>1303098.43</td>
</tr>
<tr>
<td>1996</td>
<td>1599278.69</td>
</tr>
<tr>
<td>1997</td>
<td>1895458.96</td>
</tr>
<tr>
<td>1998</td>
<td>2191639.23</td>
</tr>
<tr>
<td>1999</td>
<td>2487819.50</td>
</tr>
<tr>
<td>2000</td>
<td>2783999.77</td>
</tr>
</tbody>
</table>

...  

See also

REGR_AVGX(), REGR_AVGY(), REGR_SLOPE()

9.4.5. REGR_R2()

Coefficient of determination of the regression line
**Result type**
DOUBLE PRECISION

**Syntax**

```sql
REGR_R2 ( <y>, <x> )
```

<table>
<thead>
<tr>
<th>Table 231. REGR_R2 Function Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>y</td>
</tr>
<tr>
<td>x</td>
</tr>
</tbody>
</table>

The REGR_R2 function calculates the coefficient of determination, or R-squared, of the regression line.

The function `REGR_R2(<y>, <x>)` is equivalent to

```sql
POWER(CORR(<y>, <x>), 2)
```

**See also**

CORR(), POWER

### 9.4.6. REGR_SLOPE()

Slope of the regression line

**Result type**
DOUBLE PRECISION

**Syntax**

```sql
REGR_SLOPE ( <y>, <x> )
```

<table>
<thead>
<tr>
<th>Table 232. REGR_SLOPE Function Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Parameter</strong></td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>y</td>
</tr>
<tr>
<td>x</td>
</tr>
</tbody>
</table>
The function `REGR_SLOPE` calculates the slope of the regression line.

The function `REGR_SLOPE(<y>, <x>)` is equivalent to

\[
\frac{\text{COVAR_POP}(<y>, <x>)}{\text{VAR_POP}(\text{exprX})}
\]

\[
\text{exprX} := \begin{cases} 
\text{CASE WHEN } <x> \text{ IS NOT NULL AND } <y> \text{ IS NOT NULL THEN } <x> \end{cases}
\]

See also

`COVAR_POP()`, `VAR_POP()`

### 9.4.7. `REGR_SXX()`

Sum of squares of the independent variable

**Result type**

DOUBLE PRECISION

**Syntax**

\[
\text{REGR_SXX} ( <y>, <x> )
\]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `REGR_SXX` calculates the sum of squares of the independent expression variable (x).

The function `REGR_SXX(<y>, <x>)` is equivalent to

\[
\text{REGR_COUNT}(<y>, <x>) \times \text{VAR_POP}(\text{exprX})
\]

\[
\text{exprX} := \begin{cases} 
\text{CASE WHEN } <x> \text{ IS NOT NULL AND } <y> \text{ IS NOT NULL THEN } <x> \end{cases}
\]

See also

`REGR_COUNT()`, `VAR_POP()`
### 9.4.8. `REGR_SXY()`

Sum of products of the independent variable and the dependent variable

**Result type**
DOUBLE PRECISION

**Syntax**

```
REGR_SXY ( <y>, <x> )
```

**Table 234. REGR_SXY Function Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>y</td>
<td>Dependent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
<tr>
<td>x</td>
<td>Independent variable of the regression line. It may contain a table column, a constant, a variable, an expression, a non-aggregate function or a UDF. Aggregate functions are not allowed as expressions.</td>
</tr>
</tbody>
</table>

The function `REGR_SXY` calculates the sum of products of independent variable expression (x) times dependent variable expression (y).

The function `REGR_SXY(<y>, <x>)` is equivalent to

```
REGR_COUNT(<y>, <x>) * COVAR_POP(<y>, <x>)
```

**See also**

`COVAR_POP()`, `REGR_COUNT()`

### 9.4.9. `REGR_SYY()`

Sum of squares of the dependent variable

**Result type**
DOUBLE PRECISION

**Syntax**

```
REGR_SYY ( <y>, <x> )
```

**Table 235. REGR_SYY Function Parameters**
The function `REGR_SYY` calculates the sum of squares of the dependent variable (*y*).

The function `REGR_SYY(<y>, <x>)` is equivalent to

\[
REGR_COUNT(<y>, <x>) \times VAR_POP(<exprY>)
\]

\[
<exprY> := \begin{cases} 
\text{CASE WHEN } <x> \text{ IS NOT NULL AND } <y> \text{ IS NOT NULL THEN } <y> \end{cases} \text{ END}
\]

*See also*

`REGR_COUNT()`, `VAR_POP()`
Chapter 10. Window (Analytical) Functions

Window functions (also known as analytical functions) are a kind of aggregation, but one that does not “reduce” a group into a single row. The columns of aggregated data are mixed with the query result set.

The window functions are used with the OVER clause. They may appear only in the SELECT list, or the ORDER BY clause of a query.

Firebird window functions may be partitioned and ordered.

Window functions are available in DSQL and PSQL. Availability in ESQL is not tracked by this Language Reference.

Syntax

\[
\text{<window_function>} ::= \text{<aggregate-function>} \text{ OVER} \text{<window-name-or-spec>} \\
| \text{<window-function-name>} ([\text{<value-expression>} [, \text{<value-expression>} ...]]) \text{ OVER} \text{<window-name-or-spec>}
\]

\[
\text{<aggregate-function>} ::= !\ !\text{ See Aggregate Functions} !\!
\]

\[
\text{<window-name-or-spec>} ::= (\text{<window-specification-details>}) | \text{existing_window_name}
\]

\[
\text{<window-function-name>} ::= \text{<ranking-function>}
| \text{<navigational-function>}
\]

\[
\text{<ranking-function>} ::= \text{RANK} | \text{DENSE_RANK} | \text{PERCENT_RANK} | \text{ROW_NUMBER} \\
| \text{CUME_DIST} | \text{NTILE}
\]

\[
\text{<navigational-function>} \\
\text{LEAD} | \text{LAG} | \text{FIRST_VALUE} | \text{LAST_VALUE} | \text{NTH_VALUE}
\]

\[
\text{<window-specification-details>} ::= [\text{existing-window-name}] \\
[\text{<window-partition-clause>}] \\
[\text{<order-by-clause>}] \\
[\text{<window-frame-clause>}] \\
\]

\[
\text{<window-partition-clause>} ::= \text{PARTITION BY} \text{<value-expression>} [, \text{<value-expression>} ...]
\]

\[
\text{<order-by-clause>} ::= \text{ORDER BY} \text{<sort-specification>} [, \text{<sort-specification>} ...]
\]
Table 236. Window Function Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value-expression</td>
<td>Expression. May contain a table column, constant, variable, expression,</td>
</tr>
<tr>
<td></td>
<td>scalar or aggregate function. Window functions are not allowed as an</td>
</tr>
<tr>
<td></td>
<td>expression.</td>
</tr>
<tr>
<td>aggregate-function</td>
<td>An aggregate function used as a window function</td>
</tr>
<tr>
<td>existing-window-name</td>
<td>A named window defined using the WINDOW clause of the current query</td>
</tr>
<tr>
<td></td>
<td>specification.</td>
</tr>
</tbody>
</table>

### 10.1. Aggregate Functions as Window Functions

All aggregate functions — including FILTER clause — can be used as window functions, by adding the OVER clause.

Imagine a table EMPLOYEE with columns ID, NAME and SALARY, and the need to show each employee with their respective salary and the percentage of their salary over the payroll.

A normal query could achieve this, as follows:
select
    id,
    department,
    salary,
    salary / (select sum(salary) from employee) portion
from employee
order by id;

Results

<table>
<thead>
<tr>
<th>id</th>
<th>department</th>
<th>salary</th>
<th>portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>----------</td>
<td>------</td>
<td>--------</td>
</tr>
<tr>
<td>1</td>
<td>R &amp; D</td>
<td>10.00</td>
<td>0.2040</td>
</tr>
<tr>
<td>2</td>
<td>SALES</td>
<td>12.00</td>
<td>0.2448</td>
</tr>
<tr>
<td>3</td>
<td>SALES</td>
<td>8.00</td>
<td>0.1632</td>
</tr>
<tr>
<td>4</td>
<td>R &amp; D</td>
<td>9.00</td>
<td>0.1836</td>
</tr>
<tr>
<td>5</td>
<td>R &amp; D</td>
<td>10.00</td>
<td>0.2040</td>
</tr>
</tbody>
</table>

The query is repetitive and lengthy to run, especially if EMPLOYEE happens to be a complex view.

The same query could be specified in a much faster and more elegant way using a window function:

select
    id,
    department,
    salary,
    salary / sum(salary) OVER () portion
from employee
order by id;

Here, \( \text{sum(salary) over ()} \) is computed with the sum of all \( \text{SALARY} \) from the query (the EMPLOYEE table).

10.2. Partitioning

Like aggregate functions, that may operate alone or in relation to a group, window functions may also operate on a group, which is called a “partition”.

Syntax

\[
\text{<window function>(...) OVER (PARTITION BY <expr> [, <expr> ...])}
\]

Aggregation over a group could produce more than one row, so the result set generated by a partition is joined with the main query using the same expression list as the partition.

Continuing the EMPLOYEE example, instead of getting the portion of each employee’s salary over the
all-employees total, we would like to get the portion based on the employees in the same department:

```
select
    id,
    department, 
    salary,
    salary / sum(salary) OVER (PARTITION BY department) portion
from employee
order by id;
```

Results

<table>
<thead>
<tr>
<th>id</th>
<th>department</th>
<th>salary</th>
<th>portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>R &amp; D</td>
<td>10.00</td>
<td>0.3448</td>
</tr>
<tr>
<td>2</td>
<td>SALES</td>
<td>12.00</td>
<td>0.6000</td>
</tr>
<tr>
<td>3</td>
<td>SALES</td>
<td>8.00</td>
<td>0.4000</td>
</tr>
<tr>
<td>4</td>
<td>R &amp; D</td>
<td>9.00</td>
<td>0.3103</td>
</tr>
<tr>
<td>5</td>
<td>R &amp; D</td>
<td>10.00</td>
<td>0.3448</td>
</tr>
</tbody>
</table>

10.3. Ordering

The `ORDER BY` sub-clause can be used with or without partitions. The `ORDER BY` clause within `OVER` specifies the order in which the window function will process rows. This order does not have to be the same as the order rows appear in the output.

There is an important concept associated with window functions: for each row there is a set of rows in its partition called the **window frame**. By default, when specifying `ORDER BY`, the frame consists of all rows from the beginning of the partition to the current row and rows equal to the current `ORDER BY` expression. Without `ORDER BY`, the default frame consists of all rows in the partition.

As a result, for standard aggregate functions, the `ORDER BY` clause produces partial aggregation results as rows are processed.

**Example**

```
select
    id, 
    salary, 
    sum(salary) over (order by salary) cumul_salary
from employee
order by salary;
```

Results

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>cumul_salary</th>
</tr>
</thead>
<tbody>
<tr>
<td>--</td>
<td>------</td>
<td>--------------</td>
</tr>
</tbody>
</table>
Then `cumul_salary` returns the partial/accumulated (or running) aggregation (of the `SUM` function). It may appear strange that 37.00 is repeated for the ids 1 and 5, but that is how it should work. The `ORDER BY` keys are grouped together, and the aggregation is computed once (but summing the two 10.00). To avoid this, you can add the `ID` field to the end of the `ORDER BY` clause.

It’s possible to use multiple windows with different orders, and `ORDER BY` parts like `ASC/DESC` and `NULLS FIRST/LAST`.

With a partition, `ORDER BY` works the same way, but at each partition boundary the aggregation is reset.

All aggregation functions can use `ORDER BY`, except for `LIST()`.

### 10.4. Window Frames

A *window frame* specifies which rows to consider for the current row when evaluating the window function.

The frame comprises three pieces: unit, start bound, and end bound. The unit can be `RANGE` or `ROWS`, which defines how the bounds will work.

The bounds are:

- **UNBOUNDED PRECEDING**
- `<expr> PRECEDING`
- `CURRENT ROW`
- `<expr> FOLLOWING`
- **UNBOUNDED FOLLOWING**

- With `RANGE`, the `ORDER BY` should specify exactly one expression, and that expression should be of a numeric, date, time, or timestamp type. For `<expr> PRECEDING`, `expr` is subtracted from the `ORDER BY` expression, and for `<expr> FOLLOWING`, `expr` is added. For `CURRENT ROW`, the expression is used as-is.

  All rows inside the current partition that are between the bounds are considered part of the resulting window frame.

- With `ROWS`, `ORDER BY` expressions are not limited by number or type. For this unit, `<expr> PRECEDING` and `<expr> FOLLOWING` relate to the row position within the current partition, and not the values of the ordering keys.

Both **UNBOUNDED PRECEDING** and **UNBOUNDED FOLLOWING** work identical with `RANGE` and `ROWS`. **UNBOUNDED**
PRECEDING start at the first row of the current partition, and UNBOUNDED FOLLOWING ends at the last row of the current partition.

The frame syntax with \texttt{<window-frame-start>} specifies the start-frame, with the end-frame being CURRENT ROW.

Some window functions discard frames:

- \texttt{ROW\_NUMBER}, \texttt{LAG} and \texttt{LEAD} always work as ROWS BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW
- \texttt{DENSE\_RANK}, \texttt{RANK}, \texttt{PERCENT\_RANK} and \texttt{CUME\_DIST} always work as RANGE BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW
- \texttt{FIRST\_VALUE}, \texttt{LAST\_VALUE} and \texttt{NTH\_VALUE} respect frames, but the RANGE unit behaviour is identical to ROWS.

\textbf{Example Using Frame}

When the ORDER BY clause is used, but a frame clause is omitted, the default considers the partition up to the current row. When combined with \texttt{SUM}, this results in a running total:

\begin{verbatim}
select    
id, 
salary, 
\text{sum(salary) over (order by salary)} \text{sum_salary}
from employee
order by salary;
\end{verbatim}

Result:

\begin{verbatim}
<table>
<thead>
<tr>
<th align="right">id</th>
<th align="right">salary</th>
<th align="right">sum_salary</th>
</tr>
</thead>
<tbody>
<tr>
<td align="right">3</td>
<td align="right">8.00</td>
<td align="right">8.00</td>
</tr>
<tr>
<td align="right">4</td>
<td align="right">9.00</td>
<td align="right">17.00</td>
</tr>
<tr>
<td align="right">1</td>
<td align="right">10.00</td>
<td align="right">37.00</td>
</tr>
<tr>
<td align="right">5</td>
<td align="right">10.00</td>
<td align="right">37.00</td>
</tr>
<tr>
<td align="right">2</td>
<td align="right">12.00</td>
<td align="right">49.00</td>
</tr>
</tbody>
</table>
\end{verbatim}

On the other hand, if we apply a frame for the entire partition, we get the total for the entire partition.

\begin{verbatim}
select    
id, 
salary, 
\text{sum(salary) over (}
  \text{order by salary}
  \text{ROWS BETWEEN UNBOUNDED PRECEDING AND UNBOUNDED FOLLOWING}
\text{)} \text{sum_salary}
from employee
\end{verbatim}
order by salary;

Result:

<table>
<thead>
<tr>
<th align="right">id</th>
<th align="right">salary</th>
<th align="right">sum_salary</th>
</tr>
</thead>
<tbody>
<tr>
<td align="right">3</td>
<td align="right">8.00</td>
<td align="right">49.00</td>
</tr>
<tr>
<td align="right">4</td>
<td align="right">9.00</td>
<td align="right">49.00</td>
</tr>
<tr>
<td align="right">1</td>
<td align="right">10.00</td>
<td align="right">49.00</td>
</tr>
<tr>
<td align="right">5</td>
<td align="right">10.00</td>
<td align="right">49.00</td>
</tr>
<tr>
<td align="right">2</td>
<td align="right">12.00</td>
<td align="right">49.00</td>
</tr>
</tbody>
</table>

This example is to demonstrate how this works; the result of this example would be simpler to produce with `sum(salary) over()`.

We can use a range frame to compute the count of employees with salaries between (an employee's salary - 1) and (their salary + 1) with this query:

```
select
  id,
  salary,
  count(*) over (order by salary RANGE BETWEEN 1 PRECEDING AND 1 FOLLOWING) range_count
from employee
order by salary;
```

Result:

<table>
<thead>
<tr>
<th align="right">id</th>
<th align="right">salary</th>
<th align="right">range_count</th>
</tr>
</thead>
<tbody>
<tr>
<td align="right">3</td>
<td align="right">8.00</td>
<td align="right">2</td>
</tr>
<tr>
<td align="right">4</td>
<td align="right">9.00</td>
<td align="right">4</td>
</tr>
<tr>
<td align="right">1</td>
<td align="right">10.00</td>
<td align="right">3</td>
</tr>
<tr>
<td align="right">5</td>
<td align="right">10.00</td>
<td align="right">3</td>
</tr>
<tr>
<td align="right">2</td>
<td align="right">12.00</td>
<td align="right">1</td>
</tr>
</tbody>
</table>

### 10.5. Named Windows

The `WINDOW clause` can be used to explicitly name a window, for example to avoid repetitive or confusing expressions.

A named window can be used:

a. in the `OVER` clause to reference a window definition, e.g. `OVER window_name`
10.6. Ranking Functions

The ranking functions compute the ordinal rank of a row within the window partition.

These functions can be used with or without partitioning and ordering. However, using them without ordering almost never makes sense.

The ranking functions can be used to create different type of counters. Consider `SUM(1) OVER (ORDER BY SALARY)` as an example of what they can do, each of them differently. Following is an example query, also comparing with the `SUM` behavior.

```
select  
id,  
salary,  
dense_rank() over (order by salary),  
rank() over (order by salary),  
row_number() over (order by salary),  
sum(1) over (order by salary)  
from employee  
order by salary;
```

Results

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>dense_rank</th>
<th>rank</th>
<th>row_number</th>
<th>sum</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

The difference between `DENSE_RANK` and `RANK` is that there is a gap related to duplicate rows (relative to the window ordering) only in `RANK`. `DENSE_RANK` continues assigning sequential numbers after the duplicate salary. On the other hand, `ROW_NUMBER` always assigns sequential numbers, even when there are duplicate values.

10.6.1. `CUME_DIST()`

Relative rank (or, cumulative distribution) of a row within a window partition

*Result type*

DOUBLE PRECISION
Syntax

```
CUME_DIST () OVER <window_name_or_spec>
```

CUME_DIST is calculated as the number of rows preceding or peer of the current row divided by the number of rows in the partition.

In other words, `CUME_DIST() OVER <window_name_or_spec>` is equivalent to `COUNT(*) OVER <window_name_or_spec> / COUNT(*) OVER()`

**CUME_DIST Examples**

```
select
    id,
    salary,
    cume_dist() over (order by salary)
from employee
order by salary;
```

**Result**

```
id  salary  cume_dist
--  ------  ---------
 3   8.00   0.2
 4   9.00   0.4
 1  10.00   0.8
 5  10.00   0.8
 2  12.00   1
```

### 10.6.2. DENSE_RANK()

See also **RANK**, **PERCENT_RANK**

Rank of rows in a partition without gaps

**Result type**

**BIGINT**

**Syntax**

```
DENSE_RANK () OVER <window_name_or_spec>
```

Rows with the same `window_order` values get the same rank within the partition `window_partition`, if specified. The dense rank of a row is equal to the number of different rank values in the partition preceding the current row, plus one.

**DENSE_RANK Examples**
select
  id,
  salary,
  dense_rank() over (order by salary)
from employee
order by salary;

Result

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>dense_rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>4</td>
</tr>
</tbody>
</table>

10.6.3. NTILE()

See also RANK(), ROW_NUMBER()

Distributes the rows of the current window partition into the specified number of tiles (groups)

Result type
BIGINT

Syntax

$$\text{NTILE (number_of_tiles) OVER <window_name_or_spec>}$$

Table 237. Arguments of NTILE

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>number_of_tiles</td>
<td>Number of tiles (groups). Restricted to a positive integer literal, a named parameter (PSQL), or a positional parameter (DSQL).</td>
</tr>
</tbody>
</table>

NTILE Examples

```sql
select
  id,
  salary,
  rank() over (order by salary),
  ntile(3) over (order by salary)
from employee
order by salary;
```
### 10.6.4. PERCENT_RANK()

Relative rank of a row within a window partition.

**Result type**

DOUBLE PRECISION

**Syntax**

```
PERCENT_RANK () OVER <window_name_or_spec>
```

PERCENT_RANK is calculated as the RANK() minus 1 of the current row divided by the number of rows in the partition minus 1.

In other words, PERCENT_RANK() OVER <window_name_or_spec> is equivalent to (RANK() OVER <window_name_or_spec> - 1) / CAST(COUNT(*) OVER() - 1 AS DOUBLE PRECISION)

**PERCENT_RANK Examples**

```sql
select
    id,  
    salary,  
    rank() over (order by salary),  
    percent_rank() over (order by salary)
from employee
order by salary;
```

**Result**

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>rank</th>
<th>percent_rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>2</td>
<td>0.25</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>3</td>
<td>0.5</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>
10.6.5. RANK()

See also RANK(), CUME_DIST()

Rank of each row in a partition

Result type
BIGINT

Syntax

RANK () OVER <window_name_or_spec>

Rows with the same values of window-order get the same rank within the partition window-partition, if specified. The rank of a row is equal to the number of rank values in the partition preceding the current row, plus one.

RANK Examples

```sql
select
  id,
  salary,
  rank() over (order by salary)
from employee
order by salary;
```

Result

```
id salary rank
--- ------ ----
3  8.00     1
4  9.00     2
1 10.00     3
5 10.00     3
2 12.00     5
```

See also
DENSE_RANK(), ROW_NUMBER()

10.6.6. ROW_NUMBER()

Sequential row number in the partition

Result type
BIGINT
Syntax

```
ROW_NUMBER () OVER <window_name_or_spec>
```

Returns the sequential row number in the partition, where 1 is the first row in each of the partitions.

**ROW_NUMBER Examples**

```sql
select
  id,
  salary,
  row_number() over (order by salary)
from employee
order by salary;
```

**Result**

```
id  salary  rank
----- ------ ----
 3    8.00    1
 4    9.00    2
 1   10.00    3
 5   10.00    4
 2   12.00    5
```

**See also**

`DENSE_RANK()`, `RANK()`

### 10.7. Navigational Functions

The navigational functions get the simple (non-aggregated) value of an expression from another row of the query, within the same partition.

```
FIRST_VALUE, LAST_VALUE and NTH_VALUE also operate on a window frame. For navigational functions, Firebird applies a default frame from the first to the current row of the partition, not to the last. In other words, it behaves as if the following frame is specified:
```

```
RANGE BETWEEN UNBOUNDED PRECEDING AND CURRENT ROW
```

This is likely to produce strange or unexpected results for NTH_VALUE and especially LAST_VALUE, so make sure to specify an explicit frame with these functions.
Example of Navigational Functions

```sql
select
    id,
    salary,
    first_value(salary) over (order by salary),
    last_value(salary) over (order by salary),
    nth_value(salary, 2) over (order by salary),
    lag(salary) over (order by salary),
    lead(salary) over (order by salary)
from employee
order by salary;
```

Results

<table>
<thead>
<tr>
<th>id</th>
<th>salary</th>
<th>first_value</th>
<th>last_value</th>
<th>nth_value</th>
<th>lag</th>
<th>lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>9.00</td>
</tr>
<tr>
<td>4</td>
<td>9.00</td>
<td>8.00</td>
<td>9.00</td>
<td>9.00</td>
<td>8.00</td>
<td>10.00</td>
</tr>
<tr>
<td>1</td>
<td>10.00</td>
<td>8.00</td>
<td>10.00</td>
<td>9.00</td>
<td>9.00</td>
<td>10.00</td>
</tr>
<tr>
<td>5</td>
<td>10.00</td>
<td>8.00</td>
<td>10.00</td>
<td>9.00</td>
<td>10.00</td>
<td>12.00</td>
</tr>
<tr>
<td>2</td>
<td>12.00</td>
<td>8.00</td>
<td>12.00</td>
<td>9.00</td>
<td>10.00</td>
<td>&lt;null&gt;</td>
</tr>
</tbody>
</table>

10.7.1. FIRST_VALUE()

First value of the current partition

**Result type**
The same as type as `expr`

**Syntax**

\[
\text{FIRST\_VALUE\(\ (\ <expr>\ )\ \text{OVER\ <window\_name\_or\_spec>}}
\]

**Table 238. Arguments of FIRST_VALUE**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
</tbody>
</table>

See also

LAST_VALUE(), NTH_VALUE()

10.7.2. LAG()

Value from row in the current partition with a given offset before the current row

**Result type**
The same as type as *expr*

**Syntax**

```
LAG ( <expr> [, <offset [, <default>]]))
OVER <window_name_or_spec>
```

**Table 239. Arguments of LAG**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
<tr>
<td>offset</td>
<td>The offset in rows before the current row to get the value identified by <em>expr</em>. If <em>offset</em> is not specified, the default is 1. <em>offset</em> can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to BIGINT. <em>offset</em> cannot be negative (use LEAD instead).</td>
</tr>
<tr>
<td>default</td>
<td>The default value to return if <em>offset</em> points outside the partition. Default is NULL.</td>
</tr>
</tbody>
</table>

The `LAG` function provides access to the row in the current partition with a given *offset* before the current row.

If *offset* points outside the current partition, *default* will be returned, or NULL if no default was specified.

**LAG Examples**

Suppose you have `RATE` table that stores the exchange rate for each day. To trace the change of the exchange rate over the past five days you can use the following query.

```
select bydate, cost,
       cost - lag(cost) over (order by bydate) as change,
       100 * (cost - lag(cost) over (order by bydate)) /  
       lag(cost) over (order by bydate) as percent_change
from rate
where bydate between dateadd(-4 day to current_date)  
and current_date
order by bydate
```

**Result**

<table>
<thead>
<tr>
<th>bydate</th>
<th>cost</th>
<th>change</th>
<th>percent_change</th>
</tr>
</thead>
<tbody>
<tr>
<td>27.10.2014</td>
<td>31.00</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
</tr>
<tr>
<td>28.10.2014</td>
<td>31.53</td>
<td>0.53</td>
<td>1.7096</td>
</tr>
</tbody>
</table>
See also

**10.7.3. LAST_VALUE()**

Last value from the current partition

*Result type*

The same as type as *expr*

*Syntax*

```sql
LAST_VALUE ( <expr> ) OVER <window_name_or_spec>
```

*Table 240. Arguments of LAST_VALUE*

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>expr</em></td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
</tbody>
</table>

See also note on frame for navigational functions.

*See also*

**FIRST_VALUE(), NTH_VALUE()**

**10.7.4. LEAD()**

Value from a row in the current partition with a given *offset* after the current row

*Result type*

The same as type as *expr*

*Syntax*

```sql
LEAD ( <expr> [, <offset [, <default>]]))
OVER <window_name_or_spec>
```

*Table 241. Arguments of LEAD*

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>expr</em></td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
</tbody>
</table>
The **offset** in rows after the current row to get the value identified by *expr*. If *offset* is not specified, the default is 1. *offset* can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to **BIGINT**. *offset* cannot be negative (use **LAG** instead).

**default**

The default value to return if *offset* points outside the partition. Default is **NULL**.

The **LEAD** function provides access to the row in the current partition with a given *offset* after the current row.

If *offset* points outside the current partition, *default* will be returned, or **NULL** if no default was specified.

**See also**

**LAG()**

### 10.7.5. **NTH_VALUE()**

The *N*th value starting from the first or the last row of the current frame

**Result type**

The same as type as *expr*

**Syntax**

```sql
NTH_VALUE ( <expr>, <offset> )
[FROM {FIRST | LAST}]
OVER <window_name_or_spec>
```

**Table 242. Arguments of **NTH_VALUE**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>expr</em></td>
<td>Expression. May contain a table column, constant, variable, expression, scalar function. Aggregate functions are not allowed as an expression.</td>
</tr>
<tr>
<td><em>offset</em></td>
<td>The offset in rows from the start (FROM FIRST), or the last (FROM LAST) to get the value identified by <em>expr</em>. <em>offset</em> can be a column, subquery or other expression that results in a positive integer value, or another type that can be implicitly converted to <strong>BIGINT</strong>. <em>offset</em> cannot be zero or negative.</td>
</tr>
</tbody>
</table>

The **NTH_VALUE** function returns the *N*th value starting from the first (FROM FIRST) or the last (FROM LAST) row of the current frame, see also note on frame for navigational functions. Offset 1 with FROM FIRST is equivalent to **FIRST_VALUE**, and offset 1 with FROM LAST is equivalent to **LAST_VALUE**.

**See also**

**FIRST_VALUE()**, **LAST_VALUE()**
10.8. Aggregate Functions Inside Window Specification

It is possible to use aggregate functions (but not window functions) inside the `OVER` clause. In that case, first the aggregate function is applied to determine the windows, and only then the window functions are applied on those windows.

When using aggregate functions inside `OVER`, all columns not used in aggregate functions must be specified in the `GROUP BY` clause of the `SELECT`.

Using an Aggregate Function in a Window Specification

```sql
select
    code_employee_group,
    avg(salary) as avg_salary,
    rank() over (order by avg(salary)) as salary_rank
from employee
group by code_employee_group
```
Chapter 11. System Packages

System packages provide utility stored functions and stored functions.

List of System Packages

**RDB$BLOB_UTIL**
- Utilities for blob manipulation

**RDB$PROFILER**
- Profiler

**RDB$TIME_ZONE_UTIL**
- Time zone utilities

### 11.1. RDB$BLOB_UTIL

Package of functions and procedures for blob manipulation

#### 11.1.1. Function IS_WRITABLE

**RDB$BLOB_UTIL.IS_WRITABLE** returns TRUE when a BLOB is suitable for data appending using **BLOB_APPEND** without copying.

*Input parameter*
- • **BLOB** type BLOB NOT NULL

*Return type*: BOOLEAN NOT NULL.

#### 11.1.2. Function NEW_BLOB

**RDB$BLOB_UTIL.NEW_BLOB** creates a new BLOB SUB_TYPE BINARY. It returns a BLOB suitable for data appending, similar to **BLOB_APPEND**.

The advantage over **BLOB_APPEND** is that it’s possible to set custom `SEGMENTED` and `TEMP_STORAGE` options.

**BLOB_APPEND** always creates BLOBs in temporary storage, which may not always be the best approach if the created BLOB is going to be stored in a permanent table, as this will require a copy operation.

The BLOB returned from this function, even when `TEMP_STORAGE = FALSE`, may be used with **BLOB_APPEND** for appending data.

*Input parameters*
- • **SEGMENTED** type BOOLEAN NOT NULL
- • **TEMP_STORAGE** type BOOLEAN NOT NULL

*Return type*: BLOB SUB_TYPE BINARY NOT NULL.
11.1.3. Function OPEN_BLOB

RDB$BLOB_UTIL.OPEN_BLOB opens an existing BLOB for reading. It returns a handle (an integer bound to the transaction) suitable for use with other functions of this package, like SEEK, READ_DATA and CLOSE_HANDLE.

Handles which are not explicitly closed are closed automatically when the transaction ends.

Input parameter

• BLOB type BLOB NOT NULL

Return type: INTEGER NOT NULL.

11.1.4. Function READ_DATA

RDB$BLOB_UTIL.READ_DATA reads chunks of data of a BLOB handle opened with RDB$BLOB_UTIL.OPEN_BLOB. When the BLOB is fully read and there is no more data, it returns NULL.

If LENGTH is passed with a positive number, it returns a VARBINARY with its maximum length.

If LENGTH is NULL it returns a segment of the BLOB with a maximum length of 32765.

Input parameters

• HANDLE type INTEGER NOT NULL
• LENGTH type INTEGER

Return type: VARBINARY(32765).

11.1.5. Function SEEK

RDB$BLOB_UTIL.SEEK sets the position for the next READ_DATA, it returns the new position.

MODE may be:

0  from the start
1  from current position
2  from end.

When MODE is 2, OFFSET should be zero or negative.

Input parameters

• HANDLE type INTEGER NOT NULL
• MODE type INTEGER NOT NULL
• OFFSET type INTEGER NOT NULL

Return type: INTEGER NOT NULL.

SEEK only works on stream blobs. Attempting to seek on a segmented blob results
in error “invalid BLOB type for operation”.

### 11.1.6. Procedure CANCEL_BLOB

RDB$BLOB_UTIL.CANCEL_BLOB immediately releases a temporary BLOB, like one created with BLOB_APPEND.

If the same BLOB is used after cancel, an “invalid blob id” error will be raised.

**Input parameter**
- **BLOB** type BLOB

### 11.1.7. Procedure CLOSE_HANDLE

RDB$BLOB_UTIL.CLOSE_HANDLE closes a BLOB handle opened with RDB$BLOB_UTIL.OPEN_BLOB.

Handles which are not explicitly closed are closed automatically when the transaction ends.

**Input parameter**
- **HANDLE** type INTEGER NOT NULL

### 11.1.8. Examples

**Create a BLOB in temporary space and return it in EXECUTE BLOCK**

```sql
execute block returns (b blob) 
as 
begin 
  -- Create a BLOB handle in the temporary space. 
  b = rdb$blob_util.new_blob(false, true);

  -- Add chunks of data. 
  b = blob_append(b, '12345');
  b = blob_append(b, '67');

  suspend;
end
```

**Open a BLOB and return chunks of it with EXECUTE BLOCK**

```sql
execute block returns (s varchar(10)) 
as 
  declare b blob = '1234567';
  declare bhandle integer;
begin 
  -- Open the BLOB and get a BLOB handle. 
  bhandle = rdb$blob_util.open_blob(b);

  -- Get chunks of data as string and return.
```

---

Chapter 11. System Packages

533
s = rdb$blob_util.read_data(bhandle, 3);
suspend;

s = rdb$blob_util.read_data(bhandle, 3);
suspend;

s = rdb$blob_util.read_data(bhandle, 3);
suspend;

-- Here EOF is found, so it returns NULL.
s = rdb$blob_util.read_data(bhandle, 3);
suspend;

-- Close the BLOB handle.
execute procedure rdb$blob_util.close_handle(bhandle);
end

Seek in a blob

set term !;

execute block returns (s varchar(10))
as
   declare b blob;
   declare bhandle integer;
begin
   -- Create a stream BLOB handle.
   b = rdb$blob_util.new_blob(false, true);

   -- Add data.
b = blob_append(b, '0123456789');

   -- Open the BLOB.
bhandle = rdb$blob_util.open_blob(b);

   -- Seek to 5 since the start.
rdb$blob_util.seek(bhandle, 0, 5);
s = rdb$blob_util.read_data(bhandle, 3);
suspend;

   -- Seek to 2 since the start.
rdb$blob_util.seek(bhandle, 0, 2);
s = rdb$blob_util.read_data(bhandle, 3);
suspend;

   -- Advance 2.
rdb$blob_util.seek(bhandle, 1, 2);
s = rdb$blob_util.read_data(bhandle, 3);
suspend;
-- Seek to -1 since the end.
    rdb$blob_util.seek(bhandle, 2, -1);
    s = rdb$blob_util.read_data(bhandle, 3);
    suspend;
end!

set term ;!

Check if blobs are writable

create table t(b blob);
set term !;

execute block returns (bool boolean)
as
    declare b blob;
begin
    b = blob_append(null, 'writable');
    bool = rdb$blob_util.is_writable(b);
    suspend;

    insert into t (b) values ('not writable') returning b into b;
    bool = rdb$blob_util.is_writable(b);
    suspend;
end!

set term ;!

11.2. RDB$PROFILER

A package with functions and procedures to run and control the profiler.

- These profiler controls are standard, but the actual profiler is a plugin. The profiler used depends on the setting of DefaultProfilerPlugin in firebird.conf or databases.conf, or the PLUGIN_NAME parameter of START_SESSION.

  Firebird 5.0 comes with a profiler plugin called Default_Profiler.

- Users are allowed to profile their own connections. Profiling connections from other users requires the PROFILE_ANY_ATTACHMENT system privilege.

11.2.1. Function START_SESSION

RDB$PROFILER.START_SESSION starts a new profiler session, makes it the current session (of the given ATTACHMENT_ID) and returns its identifier.
If FLUSH_INTERVAL is different from NULL, auto-flush is set up in the same way as manually calling RDB$PROFILER.SET_FLUSH_INTERVAL.

If PLUGIN_NAME is NULL (the default), it uses the database configuration DefaultProfilerPlugin.

PLUGIN_OPTIONS are plugin specific options and currently should be NULL for the Default_Profiler plugin.

**Input parameters**

- DESCRIPTION type VARCHAR(255) CHARACTER SET UTF8 default NULL
- FLUSH_INTERVAL type INTEGER default NULL
- ATTACHMENT_ID type BIGINT NOT NULL default CURRENT_CONNECTION
- PLUGIN_NAME type VARCHAR(255) CHARACTER SET UTF8 default NULL
- PLUGIN_OPTIONS type VARCHAR(255) CHARACTER SET UTF8 default NULL

Return type: BIGINT NOT NULL.

### 11.2.2. Procedure CANCEL_SESSION

RDB$PROFILER.CANCEL_SESSION cancels the current profiler session (of the given ATTACHMENT_ID).

All session data present in the profiler plugin is discarded and will not be flushed.

Data already flushed is not deleted automatically.

**Input parameter**

- ATTACHMENT_ID type BIGINT NOT NULL default CURRENT_CONNECTION

### 11.2.3. Procedure DISCARD

RDB$PROFILER.DISCARD removes all sessions (of the given ATTACHMENT_ID) from memory, without flushing them.

If there is an active session, it is cancelled.

**Input parameter**

- ATTACHMENT_ID type BIGINT NOT NULL default CURRENT_CONNECTION

### 11.2.4. Procedure FINISH_SESSION

RDB$PROFILER.FINISH_SESSION finishes the current profiler session (of the given ATTACHMENT_ID).

If FLUSH is TRUE, the snapshot tables are updated with data of the finished session (and old finished sessions not yet present in the snapshot), otherwise data remains only in memory for later update.

Calling RDB$PROFILER.FINISH_SESSION(TRUE) has the same semantics of calling RDB$PROFILER.FINISH_SESSION(FALSE) followed by RDB$PROFILER.FLUSH (using the same ATTACHMENT_ID).

**Input parameters**
11.2.5. Procedure FLUSH

RDB$PROFILER.FLUSH updates the snapshot tables with data from the profile sessions (of the given ATTACHMENT_ID) in memory.

After flushing, the data is stored in tables PLG$PROF_SESSIONS, PLG$PROF_STATEMENTS, PLG$PROF_RECORD_SOURCES, PLG$PROF_REQUESTS, PLG$PROF_PSQL_STATS and PLG$PROF_RECORD_SOURCE_STATS and may be read and analyzed by the user.

Data is updated using an autonomous transaction, so if the procedure is called in a snapshot transaction, data will not be directly readable in the same transaction.

Once flush happens, finished sessions are removed from memory.

Input parameter

• ATTACHMENT_ID type BIGINT NOT NULL default CURRENT_CONNECTION

11.2.6. Procedure PAUSE_SESSION

RDB$PROFILER.PAUSE_SESSION pauses the current profiler session (of the given ATTACHMENT_ID), so the next executed statements statistics are not collected.

If FLUSH is TRUE, the snapshot tables are updated with data up to the current moment, otherwise data remains only in memory for later update.

Calling RDB$PROFILER.PAUSE_SESSION(TRUE) has the same semantics as calling RDB$PROFILER.PAUSE_SESSION(FALSE) followed by RDB$PROFILER.FLUSH (using the same ATTACHMENT_ID).

Input parameters

• FLUSH type BOOLEAN NOT NULL default FALSE
• ATTACHMENT_ID type BIGINT NOT NULL default CURRENT_CONNECTION

11.2.7. Procedure RESUME_SESSION

RDB$PROFILER.RESUME_SESSION resumes the current profiler session (of the given ATTACHMENT_ID), if it was paused, so the next executed statements statistics are collected again.

Input parameter

• ATTACHMENT_ID type BIGINT NOT NULL default CURRENT_CONNECTION

11.2.8. Procedure SET_FLUSH_INTERVAL

RDB$PROFILER.SET_FLUSH_INTERVAL turns periodic auto-flush on (when FLUSH_INTERVAL is greater than 0) or off (when FLUSH_INTERVAL is equal to 0).

FLUSH_INTERVAL is interpreted as number of seconds.
Input parameters

- FLUSH_INTERVAL type INTEGER NOT NULL
- ATTACHMENT_ID type BIGINT NOT NULL default CURRENT_CONNECTION

11.2.9. Example

Below is a sample profile session and queries for data analysis.

1. Preparation — create table and routines that will be analyzed

   ```sql
   create table tab (id integer not null, val integer not null);
   set term !;

   create or alter function mult(p1 integer, p2 integer) returns integer as
   begin
     return p1 * p2;
   end!

   create or alter procedure ins as
   declare n integer = 1;
   begin
     while (n <= 1000) do
       begin
         if (mod(n, 2) = 1) then
           insert into tab values (:n, mult(:n, 2));
         end
       end
     n = n + 1;
   end!

   set term ;!
   ```

2. Start profiling

   ```sql
   select rdb$profiler.start_session('Profile Session 1') from rdb$database;
   set term !;

   execute block as
   begin
     execute procedure ins;
   ```
3. Data analysis

set transaction read committed;

select * from plg$prof_sessions;

select * from plg$prof_psql_stats_view;

select * from plg$prof_record_source_stats_view;

select preq.*
from plg$prof_requests preq
join plg$prof_sessions pses
  on pses.profile_id = preq.profile_id and
  pses.description = 'Profile Session 1';

select pstat.*
from plg$prof_psql_stats pstat
join plg$prof_sessions pses
  on pses.profile_id = pstat.profile_id and
  pses.description = 'Profile Session 1'
order by pstat.profile_id,
  pstat.request_id,
  pstat.line_num,
  pstat.column_num;

select pstat.*
from plg$prof_record_source_stats pstat
join plg$prof_sessions pses
  on pses.profile_id = pstat.profile_id and
11.3. RDB$TIME_ZONE_UTIL

A package of time zone utility functions and procedures.

11.3.1. Function DATABASE_VERSION

RDB$TIME_ZONE_UTIL.DATABASE_VERSION returns the version of the time zone database.

Return type: VARCHAR(10) CHARACTER SET ASCII.

Example

```sql
select rdb$time_zone_util.database_version()
from rdb$database;
```

Returns:

```
DATABASE_VERSION
==============
2023c
```

11.3.2. Procedure TRANSITIONS

RDB$TIME_ZONE_UTIL.TRANSITIONS returns the set of rules between the start and end timestamps for a named time zone.

Input parameters

- RDB$TIME_ZONE_NAME type CHAR(63)
- RDB$FROM_TIMESTAMP type TIMESTAMP WITH TIME ZONE
- RDB$TO_TIMESTAMP type TIMESTAMP WITH TIME ZONE

Output parameters:

- RDB$START_TIMESTAMP
type TIMESTAMP WITH TIME ZONE — The start timestamp of the transition

- RDB$END_TIMESTAMP
type TIMESTAMP WITH TIME ZONE — The end timestamp of the transition
RDB$ZONE_OFFSET
  type SMALLINT — The zone’s offset, in minutes

RDB$DST_OFFSET
  type SMALLINT — The zone’s DST offset, in minutes

RDB$EFFECTIVE_OFFSET
  type SMALLINT — Effective offset (ZONE_OFFSET + DST_OFFSET)

Example

```sql
select *
from rdb$time_zone_util.transitions(
  'America/Sao_Paulo',
  timestamp '2017-01-01',
  timestamp '2019-01-01');
```

Returns (RDB$ prefix left off for brevity):

<table>
<thead>
<tr>
<th>START_TIMESTAMP</th>
<th>END_TIMESTAMP</th>
<th>ZONE_OFFSET</th>
<th>DST_OFFSET</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-10-16 03:00:00.0000 GMT</td>
<td>2017-02-19 01:59:59.9999 GMT</td>
<td>-180</td>
<td>60</td>
</tr>
<tr>
<td>2017-02-19 02:00:00.0000 GMT</td>
<td>2017-10-15 02:59:59.9999 GMT</td>
<td>-180</td>
<td>0</td>
</tr>
<tr>
<td>2017-10-15 03:00:00.0000 GMT</td>
<td>2018-02-18 01:59:59.9999 GMT</td>
<td>-180</td>
<td>60</td>
</tr>
<tr>
<td>2018-02-18 02:00:00.0000 GMT</td>
<td>2018-10-21 02:59:59.9999 GMT</td>
<td>-180</td>
<td>0</td>
</tr>
<tr>
<td>2018-10-21 03:00:00.0000 GMT</td>
<td>2019-02-17 01:59:59.9999 GMT</td>
<td>-180</td>
<td>60</td>
</tr>
</tbody>
</table>
Chapter 12. Context Variables

Unless explicitly mentioned otherwise in an “Available in” section, context variables are available in at least DSQL and PSQL. Availability in ESQL is—bar some exceptions—not tracked by this Language Reference.

12.1. CURRENT_CONNECTION

Unique identifier of the current connection.

Type
BIGINT

Syntax

```
CURRENT_CONNECTION
```

Its value is derived from a counter on the database header page, which is incremented for each new connection. When a database is restored, this counter is reset to zero.

Examples

```
select current_connection from rdb$database
execute procedure P_Login(current_connection)
```

12.2. CURRENT_DATE

Current server date in the session time zone

Type
DATE

Syntax

```
CURRENT_DATE
```

Within a PSQL module (procedure, trigger or executable block), the value of CURRENT_DATE will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use 'TODAY'.

Examples

```
select current_date from rdb$database
```
12.3. CURRENT_ROLE

Current explicit role of the connection

Type
VARCHAR(63)

Syntax
CURRENT_ROLE

CURRENT_ROLE is a context variable containing the explicitly specified role of the currently connected user. If there is no explicitly specified role, CURRENT_ROLE is 'NONE'.

CURRENT_ROLE always represents a valid role or 'NONE'. If a user connects with a non-existing role, the engine silently resets it to 'NONE' without returning an error.

Roles that are active by default and not explicitly specified on connect or using SET ROLE are not returned by CURRENT_ROLE. Use RDB$ROLE_IN_USE to check for all active roles.

Example

if (current_role <> 'MANAGER')
    then exception only_managers_may_delete;
else
    delete from Customers where custno = :custno;

See also
RDB$ROLE_IN_USE

12.4. CURRENT_TIME

Current server time in the session time zone, with time zone information

Type
TIME WITH TIME ZONE

Data type changed in Firebird 4.0 from TIME WITHOUT TIME ZONE to TIME WITH TIME ZONE. Use LOCALTIME to obtain TIME WITHOUT TIME ZONE.

Syntax
CURRENT_TIME [ (<precision>) ]
The optional `precision` argument is not supported in ESQL.

**Table 243. CURRENT_TIME Parameter**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision. The default value is 0. Not supported in ESQL</td>
</tr>
</tbody>
</table>

The default is 0 decimals, i.e. seconds precision.

- CURRENT_TIME has a default precision of 0 decimals, where CURRENT_TIMESTAMP has a default precision of 3 decimals. As a result, CURRENT_TIMESTAMP is not the exact sum of CURRENT_DATE and CURRENT_TIME, unless you explicitly specify a precision (i.e. CURRENT_TIME(3) or CURRENT_TIMESTAMP(0)).

- Within a PSQL module (procedure, trigger or executable block), the value of CURRENT_TIME will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use 'NOW'.

**CURRENT_TIME and Firebird Time Zone Support**

Firebird 4.0 added support for time zones. As part of this support, an incompatibility with the CURRENT_TIME expression was introduced compared to previous version.

Since Firebird 4.0, CURRENT_TIME returns the TIME WITH TIME ZONE type. In order for your queries to be compatible with database code of Firebird 4.0 and higher, Firebird 3.0.4 and Firebird 2.5.9 introduced the LOCALTIME expression. In Firebird 3.0.4 and Firebird 2.5.9, LOCALTIME is a synonym for CURRENT_TIME.

In Firebird 5.0, LOCALTIME returns TIME [WITHOUT TIME ZONE], while CURRENT_TIME returns TIME WITH TIME ZONE.

**Examples**

```sql
select current_time from rdb$database
-- returns e.g. 14:20:19.0000

select current_time(2) from rdb$database
-- returns e.g. 14:20:23.1200
```

**See also**

CURRENT_TIMESTAMP, LOCALTIME, LOCALTIMESTAMP
12.5. CURRENT_TIMESTAMP

Current server date and time in the session time zone, with time zone information

Type
TIMESTAMP WITH TIME ZONE

Data type changed in Firebird 4.0 from TIMESTAMP WITHOUT TIME ZONE to TIMESTAMP WITH TIME ZONE. Use LOCALTIMESTAMP to obtain TIMESTAMP WITHOUT TIME ZONE.

Syntax

```
CURRENT_TIMESTAMP [ (<precision>) ]
```

<pre>
<precision> ::= 0 | 1 | 2 | 3
</pre>

The optional precision argument is not supported in ESQL.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision. The default value is 3. Not supported in ESQL</td>
</tr>
</tbody>
</table>

The default is 3 decimals, i.e. milliseconds precision.

- The default precision of CURRENT_TIME is 0 decimals, so CURRENT_TIMESTAMP is not the exact sum of CURRENT_DATE and CURRENT_TIME, unless you explicitly specify a precision (i.e. CURRENT_TIME(3) or CURRENT_TIMESTAMP(0)).
- Within a PSQL module (procedure, trigger or executable block), the value of CURRENT_TIMESTAMP will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use ‘NOW’.

CURRENT_TIMESTAMP and Firebird Time Zone Support

Firebird 4.0 added support for time zones. As part of this support, an incompatibility with the CURRENT_TIMESTAMP expression was introduced compared to previous versions.

Since Firebird 4.0, CURRENT_TIMESTAMP returns the TIMESTAMP WITH TIME ZONE type. In order for your queries to be compatible with database code of Firebird 4.0 and higher, Firebird 3.0.4 and Firebird 2.5.9 introduced the LOCALTIMESTAMP expression. In Firebird 3.0.4 and Firebird 2.5.9, LOCALTIMESTAMP is a synonym for CURRENT_TIMESTAMP.

In Firebird 5.0, LOCALTIMESTAMP returns TIMESTAMP [WITHOUT TIME ZONE], while CURRENT_TIMESTAMP returns TIMESTAMP WITH TIME ZONE.
Examples

```sql
select current_timestamp from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170

select current_timestamp(2) from rdb$database
-- returns e.g. 2008-08-13 14:20:23.1200
```

See also

CURRENT_TIME, LOCALTIME, LOCALTIMESTAMP

### 12.6. CURRENT_TRANSACTION

Unique identifier of the current transaction

**Type**

BIGINT

**Syntax**

```sql
CURRENT_TRANSACTION
```

The transaction identifier is derived from a counter on the database header page, which is incremented for each new transaction. When a database is restored, this counter is reset to zero.

**Examples**

```sql
select current_transaction from rdb$database

New.Txn_ID = current_transaction;
```

### 12.7. CURRENT_USER

Name of the user of the current connection

**Type**

VARCHAR(63)

**Syntax**

```sql
CURRENT_USER
```

CURRENT_USER is equivalent to USER.

**Example**

```sql
create trigger bi_customers for customers before insert as
begin
```
12.8. DELETING

Indicates if the trigger fired for a DELETE operation

Available in
PSQL — DML triggers only

Type
BOOLEAN

Syntax
DELETING

Intended for use in multi-action triggers.

Example

```sql
if (deleting) then
    begin
        insert into Removed_Cars (id, make, model, removed)
        values (old.id, old.make, old.model, current_timestamp);
    end
```

12.9. GDSCODE

Firebird error code of the error in a WHEN … DO block

Available in
PSQL

Type
INTEGER

Syntax
GDSCODE

In a “WHEN … DO” error handling block, the GDSCODE context variable contains the numeric value of the current Firebird error code. GDSCODE is non-zero in WHEN … DO blocks, if the current error has a Firebird error code. Outside error handlers, GDSCODE is always 0. Outside PSQL, it doesn’t exist at all.

After WHEN GDSCODE, you must use symbolic names like grant_obj_notfound etc. But
the GDSCODE context variable is an INTEGER. If you want to compare it against a specific error, the numeric value must be used, e.g. 335544551 for grant_obj_notfound.

**Example**

```sql
when gdsc ode grant_obj_notfound, gdsc ode grant_fld_notfound,
gdsc ode grant_nopriv, gdsc ode grant_nopriv_on_base
  do
  begin
  execute procedure log_grant_error(gdsc ode);
  exit;
  end
```

## 12.10. INSERTING

Indicates if the trigger fired for an INSERT operation

**Available in**

PSQL — triggers only

**Type**

BOOLEAN

**Syntax**

```
INSERTING
```

Intended for use in multi-action triggers.

**Example**

```sql
if (inserting or updating) then
begin
  if (new.serial_num is null) then
    new.serial_num = gen_id(gen_serials, 1);
end
```

## 12.11. LOCALTIME

Current server time in the session time zone, without time zone information

**Type**

TIME WITHOUT TIME ZONE

**Syntax**

```
LOCALTIME [ (<precision>) ]
```
The optional \textit{precision} argument is not supported in ESQL.

### Table 245. \textsc{localtime} Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision. The default value is 0. Not supported in ESQL</td>
</tr>
</tbody>
</table>

\textsc{localtime} returns the current server time in the session time zone. The default is 0 decimals, i.e. seconds precision.

- \textsc{localtime} was introduced in Firebird 3.0.4 and Firebird 2.5.9 as an alias of \textsc{current\_time}. In Firebird 5.0, \textsc{current\_time} returns a \textsc{time with time zone} instead of a \textsc{time [without time zone]}, while \textsc{localtime} returns \textsc{time [without time zone]}. It is recommended to use \textsc{localtime} when you do not need time zone information.

- \textsc{localtime} has a default precision of 0 decimals, where \textsc{localtimestamp} has a default precision of 3 decimals. As a result, \textsc{localtimestamp} is not the exact sum of \textsc{current\_date} and \textsc{localtime}, unless you explicitly specify a precision (i.e. \textsc{localtime}(3) or \textsc{localtimestamp}(0)).

- Within a PSQL module (procedure, trigger or executable block), the value of \textsc{localtime} will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use \textsc{now}.

#### Examples

```
select localtime from rdb$database
-- returns e.g. 14:20:19.0000

select localtime(2) from rdb$database
-- returns e.g. 14:20:23.1200
```

\textit{See also}

\textsc{current\_time}, \textsc{localtimestamp}

### 12.12. \textsc{localtimestamp}

Current server time and date in the session time zone, without time zone information

\textbf{Type}

\textsc{timestamp without time zone}
Syntax

```
LOCALTIMESTAMP [ (<precision>) ]
```

<precision> ::= 0 | 1 | 2 | 3

The optional `precision` argument is not supported in ESQL.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>precision</td>
<td>Precision. The default value is 3. Not supported in ESQL</td>
</tr>
</tbody>
</table>

LOCALTIMESTAMP returns the current server date and time in the session time zone. The default is 3 decimals, i.e. milliseconds precision.

- LOCALTIMESTAMP was introduced in Firebird 3.0.4 and Firebird 2.5.9 as a synonym of `CURRENT_TIMESTAMP`. In Firebird 5.0, `CURRENT_TIMESTAMP` returns a `TIMESTAMP WITH TIME ZONE` instead of a `TIMESTAMP [WITHOUT TIME ZONE]`, while `LOCALTIMESTAMP` returns `TIMESTAMP [WITHOUT TIME ZONE]`. It is recommended to use `LOCALTIMESTAMP` when you do not need time zone information.

- The default precision of `LOCALTIME` is 0 decimals, so `LOCALTIMESTAMP` is not the exact sum of `CURRENT_DATE` and `LOCALTIME`, unless you explicitly specify a precision (i.e. `LOCALTIME(3)` or `LOCALTIMESTAMP(0)`).

- Within a PSQL module (procedure, trigger or executable block), the value of `LOCALTIMESTAMP` will remain constant every time it is read. If multiple modules call or trigger each other, the value will remain constant throughout the duration of the outermost module. If you need a progressing value in PSQL (e.g. to measure time intervals), use "NOW".

Examples

```
select localtimestamp from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170

select localtimestamp(2) from rdb$database
-- returns e.g. 2008-08-13 14:20:23.1200
```

See also

`CURRENT_TIMESTAMP`, `LOCALTIME`

### 12.13. NEW

Record with the inserted or updated values of a row

Available in
PSQL — triggers only,
DSQL — RETURNING clause of UPDATE, UPDATE OR INSERT and MERGE

Type
Record type

Syntax

NEW.column_name

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>column_name</td>
<td>Column name to access</td>
</tr>
</tbody>
</table>

NEW contains the new version of a database record that has just been inserted or updated. NEW is read-only in AFTER triggers.

In multi-action triggers NEW is always available. However, if the trigger is fired by a DELETE, there will be no new version of the record. In that situation, reading from NEW will always return NULL; writing to it will cause a runtime exception.

12.14. 'NOW'

Current date and/or time in cast context

Type
CHAR(3), or depends on explicit CAST

'NOW' is not a variable, but a string literal or datetime mnemonic. It is, however, special in the sense that when you CAST() it to a datetime type, you will get the current date and/or time. If the datetime type has a time component, the precision is 3 decimals, i.e. milliseconds. 'NOW' is case-insensitive, and the engine ignores leading or trailing spaces when casting.

- 'NOW' always returns the actual date/time, even in PSQL modules, where CURRENT_DATE, CURRENT_TIME and CURRENT_TIMESTAMP return the same value throughout the duration of the outermost routine. This makes 'NOW' useful for measuring time intervals in triggers, procedures and executable blocks.
- Except in the situation mentioned above, reading CURRENT_DATE, CURRENT_TIME and CURRENT_TIMESTAMP is generally preferable to casting 'NOW'. Be aware though that CURRENT_TIME defaults to seconds precision; to get milliseconds precision, use CURRENT_TIME(3).
- Firebird 3.0 and earlier allowed the use of 'NOW' in datetime literals (a.k.a. "shorthand casts"), this is no longer allowed since Firebird 4.0.

Examples

select 'Now' from rdb$database
```
-- returns 'Now'
select cast('Now' as date) from rdb$database
-- returns e.g. 2008-08-13

select cast('now' as time) from rdb$database
-- returns e.g. 14:20:19.6170

select cast('NOW' as timestamp) from rdb$database
-- returns e.g. 2008-08-13 14:20:19.6170
```

### 12.15. OLD

Record with the initial values of a row before update or delete

**Available in**

PSQL — triggers only,
DSQL — RETURNING clause of UPDATE, UPDATE OR INSERT and MERGE

**Type**

Record type

**Syntax**

`OLD.column_name`

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>column_name</td>
<td>Column name to access</td>
</tr>
</tbody>
</table>

OLD contains the existing version of a database record just before a deletion or update. The OLD record is read-only.

In multi-action triggers OLD is always available. However, if the trigger is fired by an INSERT, there is obviously no pre-existing version of the record. In that situation, reading from OLD will always return NULL.

### 12.16. RESETTING

Indicates if the trigger fired during a session reset

**Available in**

PSQL — triggers only

**Type**

BOOLEAN
Syntax

RESETTING

Its value is TRUE if session reset is in progress and FALSE otherwise. Intended for use in ON DISCONNECT and ON CONNECT database triggers to detect an ALTER SESSION RESET.

### 12.17. ROW_COUNT

Number of affected rows of the last executed statement

**Available in**

PSQL

**Type**

INTEGER

**Syntax**

ROW_COUNT

The ROW_COUNT context variable contains the number of rows affected by the most recent DML statement (INSERT, UPDATE, DELETE, SELECT or FETCH) in the current PSQL module.

**Behaviour with SELECT and FETCH**

- After a singleton SELECT, ROW_COUNT is 1 if a data row was retrieved and 0 otherwise.
- In a FOR SELECT loop, ROW_COUNT is incremented with every iteration (starting at 0 before the first).
- After a FETCH from a cursor, ROW_COUNT is 1 if a data row was retrieved and 0 otherwise. Fetching more records from the same cursor does not increment ROW_COUNT beyond 1.

ROW_COUNT cannot be used to determine the number of rows affected by an EXECUTE STATEMENT or EXECUTE PROCEDURE command.

**Example**

```sql
update Figures set Number = 0 where id = :id;
if (row_count = 0) then
    insert into Figures (id, Number) values (:id, 0);
```

### 12.18. SQLCODE

SQLCODE of the Firebird error in a WHEN ... DO block

**Available in**

PSQL
**Deprecated in**

2.5.1

**Type**

INTEGER

**Syntax**

```sql
SQLCODE
```

In a “WHEN … DO” error handling block, the SQLCODE context variable contains the numeric value of the current SQL error code. SQLCODE is non-zero in WHEN … DO blocks, if the current error has a SQL error code. Outside error handlers, SQLCODE is always 0. Outside PSQL, it doesn’t exist at all.

SQLCODE is now deprecated in favour of the SQL-2003-compliant SQLSTATE status code. Support for SQLCODE and WHEN SQLCODE will be discontinued in a future version of Firebird.

**Example**

```sql
when any
do
begin
  if (sqlcode <> 0) then
    Msg = 'An SQL error occurred!';
  else
    Msg = 'Something bad happened!';
  exception ex_custom Msg;
end
```

**12.19. SQLSTATE**

SQLSTATE code of the Firebird error in a WHEN … DO block

**Available in**

PSQL

**Type**

CHAR(5)

**Syntax**

```sql
SQLSTATE
```

In a “WHEN … DO” error handler, the SQLSTATE context variable contains the 5-character, SQL-compliant status code of the current error. Outside error handlers, SQLSTATE is always '00000'. Outside PSQL, it is not available at all.
• SQLSTATE is destined to replace SQLCODE. The latter is now deprecated in Firebird and will disappear in a future version.

• Each SQLSTATE code is the concatenation of a 2-character class and a 3-character subclass. Classes 00 (successful completion), 01 (warning) and 02 (no data) represent completion conditions. Every status code outside these classes is an exception. Because classes 00, 01 and 02 don’t raise an error, they won’t ever show up in the SQLSTATE variable.

• For a complete listing of SQLSTATE codes, consult the SQLSTATE Codes and Message Texts section in Appendix B, Exception Codes and Messages.

Example

when any
do
begin
  Msg = case sqlstate
    when '22003' then 'Numeric value out of range.'
    when '22012' then 'Division by zero.'
    when '23000' then 'Integrity constraint violation.'
    else 'Something bad happened! SQLSTATE = ' || sqlstate
  end;
exception ex_custom Msg;
end

12.20. 'TODAY'

Current date in cast context

Type

CHAR(5), or depends on explicit CAST

'TODAY' is not a variable, but a string literal or date mnemonic. It is, however, special in the sense that when you CAST() it to a date/time type, you will get the current date. If the target datetime type has a time component, it will be set to zero. 'TODAY' is case-insensitive, and the engine ignores leading or trailing spaces when casting.

• 'TODAY' always returns the actual date, even in PSQL modules, where CURRENT_DATE, CURRENT_TIME and CURRENT_TIMESTAMP return the same value throughout the duration of the outermost routine. This makes 'TODAY' useful for measuring time intervals in triggers, procedures and executable blocks (at least if your procedures are running for days).

• Except in the situation mentioned above, reading CURRENT_DATE, is generally preferable to casting 'TODAY'.

• Firebird 3.0 and earlier allowed the use of 'TODAY' in datetime literals (a.k.a. "shorthand casts"), this is no longer allowed since Firebird 4.0.
When cast to a `TIMESTAMP WITH TIME ZONE`, the time reflected will be 00:00:00 in UTC rebased to the session time zone.

**Examples**

```sql
select 'Today' from rdb$database
-- returns 'Today'

select cast('Today' as date) from rdb$database
-- returns e.g. 2011-10-03

select cast('TODAY' as timestamp) from rdb$database
-- returns e.g. 2011-10-03 00:00:00.0000
```

## 12.21. 'TOMORROW'

Tomorrow's date in cast context

**Type**

CHAR(8), or depends on explicit `CAST`

'TOMORROW' is not a variable, but a string literal. It is, however, special in the sense that when you `CAST()` it to a date/time type, you will get the date of the next day. See also 'TODAY'.

**Examples**

```sql
select 'Tomorrow' from rdb$database
-- returns 'Tomorrow'

select cast('Tomorrow' as date) from rdb$database
-- returns e.g. 2011-10-04

select cast('TOMORROW' as timestamp) from rdb$database
-- returns e.g. 2011-10-04 00:00:00.0000
```

## 12.22. UPDATING

Indicates if the trigger fired for an `UPDATE` operation

**Available in**

PSQL — triggers only

**Type**

BOOLEAN
Syntax

UPDATING

Intended for use in multi-action triggers.

Example

if (inserting or updating) then
begin
  if (new.serial_num is null) then
    new.serial_num = gen_id(gen_serials, 1);
end

12.23. 'YESTERDAY'

Yesterday’s date in cast context

Type

CHAR(9), or depends on explicit CAST

'YESTERDAY' is not a variable, but a string literal. It is, however, special in the sense that when you CAST() it to a date/time type, you will get the date of the day before. See also 'TODAY'.

Examples

select 'Yesterday' from rdb$database
-- returns 'Yesterday'

select cast('Yesterday as date) from rdb$database
-- returns e.g. 2011-10-02

select cast('YESTERDAY' as timestamp) from rdb$database
-- returns e.g. 2011-10-02 00:00:00.0000

12.24. USER

Name of the user of the current connection

Type

VARCHAR(63)

Syntax

USER

USER is equivalent to (or, alias of) CURRENT_USER.
Example

create trigger bi_customers for customers before insert as
begin
    New.added_by  = USER;
    New.purchases = 0;
end
Chapter 13. Transaction Control

Almost all operations in Firebird occur in the context of a transaction. Units of work are isolated between a start point and end point. Changes to data remain reversible until the moment the client application instructs the server to commit them.

Unless explicitly mentioned otherwise in an “Available in” section, transaction control statements are available in DSQL. Availability in ESQL is—bar some exceptions—not tracked by this Language Reference. Transaction control statements are not available in PSQL.

13.1. Transaction Statements

Firebird has a small lexicon of SQL statements to start, manage, commit and reverse (roll back) the transactions that form the boundaries of most database tasks:

**SET TRANSACTION**
- configures and starts a transaction

**COMMIT**
- signals the end of a unit of work and writes changes permanently to the database

**ROLLBACK**
- undoes the changes performed in the transaction or to a savepoint

**SAVEPOINT**
- marks a position in the log of work done, in case a partial rollback is needed

**RELEASE SAVEPOINT**
- erases a savepoint

13.1.1. SET TRANSACTION

Configures and starts a transaction

*Available in*
DSQL, ESQL

*Syntax*

```sql
SET TRANSACTION
    [NAME tr_name]
    [<tr_option> ...]

<tr_option> ::= READ {ONLY | WRITE}
| [NO] WAIT
| [ISOLATION LEVEL] <isolation_level>
| NO AUTO UNDO
```
RESTART REQUESTS
AUTO COMMIT
IGNORE LIMBO
LOCK TIMEOUT seconds
RESERVING <tables>
USING <dbhandles>

<isolation_level> ::=  
   SNAPSHOT [AT NUMBER snapshot_number]  
   | SNAPSHOT TABLE [STABILITY]  
   | READ {UNCOMMITTED | COMMITTED} [<read-commited-opt>]

<brread-commited-opt> ::=  
   [NO] RECORD_VERSION | READ CONSISTENCY

<tables> ::= <table_spec> [, <table_spec> ...]
<table_spec> ::= tablename [, tablename ...]  
   | [FOR [SHARED | PROTECTED] [READ | WRITE]}

<dbhandles> ::= dbhandle [, dbhandle ...]

Table 249. SET TRANSACTION Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tr_name</td>
<td>Transaction name. Available only in ESQL</td>
</tr>
<tr>
<td>tr_option</td>
<td>Optional transaction option. Each option should be specified at most once, and some options are mutually exclusive (e.g. READ ONLY vs READ WRITE, WAIT vs NO WAIT)</td>
</tr>
<tr>
<td>seconds</td>
<td>The time in seconds for the statement to wait in case a conflict occurs. Has to be greater than or equal to 0.</td>
</tr>
<tr>
<td>snapshot_number</td>
<td>Snapshot number to use for this transaction</td>
</tr>
<tr>
<td>tables</td>
<td>The list of tables to reserve</td>
</tr>
<tr>
<td>dbhandles</td>
<td>The list of databases the database can access. Available only in ESQL</td>
</tr>
<tr>
<td>table_spec</td>
<td>Table reservation specification</td>
</tr>
<tr>
<td>tablename</td>
<td>The name of the table to reserve</td>
</tr>
<tr>
<td>dbhandle</td>
<td>The handle of the database the transaction can access. Available only in ESQL</td>
</tr>
</tbody>
</table>

Generally, only client applications start transactions. Exceptions are when the server starts an autonomous transaction, and transactions for certain background system threads/processes, such as sweeping.

A client application can start any number of concurrently running transactions. A single connection can have multiple concurrent active transactions (though not all drivers or access components support this). A limit does exist, for the total number of transactions in all client applications.
working with one particular database from the moment the database was restored from its gbak
backup or from the moment the database was created originally. The limit is $2^{48} - 281,474,976,710,656$.

All clauses in the SET TRANSACTION statement are optional. If the statement starting a transaction has
no clauses specified, the transaction will be started with default values for access mode, lock
resolution mode and isolation level, which are:

```
SET TRANSACTION
   READ WRITE
   WAIT
   ISOLATION LEVEL SNAPSHOT;
```

Database drivers or access components may use different defaults for transactions
started through their API. Check their documentation for details.

The server assigns integer numbers to transactions sequentially. Whenever a client starts any
transaction, either explicitly defined or by default, the server sends the transaction ID to the client.
This number can be retrieved in SQL using the context variable CURRENT_TRANSACTION.

Some database drivers—or their governing specifications—require that you
configure and start transaction through API methods. In that case, using SET
TRANSACTION is either not supported, or may result in unspecified behaviour. An
example of this is JDBC and the Firebird JDBC driver Jaybird.

Check the documentation of your driver for details.

The NAME and USING clauses are only valid in ESQL.

**Transaction Name**

The optional NAME attribute defines the name of a transaction. Use of this attribute is available only
in Embedded SQL (ESQL). In ESQL applications, named transactions make it possible to have
several transactions active simultaneously in one application. If named transactions are used, a
host-language variable with the same name must be declared and initialized for each named
transaction. This is a limitation that prevents dynamic specification of transaction names and thus
rules out transaction naming in DSQL.

**Transaction Parameters**

The main parameters of a transaction are:

- data access mode (READ WRITE, READ ONLY)
- lock resolution mode (WAIT, NO WAIT) with an optional LOCK TIMEOUT specification
- isolation level (READ COMMITTED, SNAPSHOT, SNAPSHOT TABLE STABILITY).

The READ UNCOMMITTED isolation level is a synonym for READ COMMITTED, and is
• a mechanism for reserving or releasing tables (the RESERVING clause)

**Access Mode**

The two database access modes for transactions are **READ WRITE** and **READ ONLY**.

• If the access mode is **READ WRITE**, operations in the context of this transaction can be both read operations and data update operations. This is the default mode.

• If the access mode is **READ ONLY**, only **SELECT** operations can be executed in the context of this transaction. Any attempt to change data in the context of such a transaction will result in database exceptions. However, this does not apply to global temporary tables (GTT), which are allowed to be changed in **READ ONLY** transactions, see *Global Temporary Tables (GTT)* in Chapter 5, **Data Definition (DDL) Statements** for details.

**Lock Resolution Mode**

When several client processes work with the same database, locks may occur when one process makes uncommitted changes in a table row, or deletes a row, and another process tries to update or delete the same row. Such locks are called *update conflicts*.

Locks may occur in other situations when multiple transaction isolation levels are used.

The two lock resolution modes are **WAIT** and **NO WAIT**.

**WAIT Mode**

In the **WAIT** mode (the default mode), if a conflict occurs between two parallel processes executing concurrent data updates in the same database, a **WAIT** transaction will wait till the other transaction has finished — by committing (**COMMIT**) or rolling back (**ROLLBACK**). The client application with the **WAIT** transaction will be put on hold until the conflict is resolved.

If a LOCK **TIMEOUT** is specified for the **WAIT** transaction, waiting will continue only for the number of seconds specified in this clause. If the lock is unresolved at the end of the specified interval, the error message “Lock time-out on wait transaction” is returned to the client.

Lock resolution behaviour can vary a little, depending on the transaction isolation level.

**NO WAIT Mode**

In the **NO WAIT** mode, a transaction will immediately throw a database exception if a conflict occurs.

LOCK TIMEOUT is a separate transaction option, but can only be used for **WAIT** transactions. Specifying LOCK **TIMEOUT** with a **NO WAIT** transaction will raise an error “invalid parameter in transaction parameter block -Option isc_tpb_lock_timeout is not valid if isc_tpb_nowait was used previously in TPB”
Isolation Level

Keeping the work of one database task separated from others is what isolation is about. Changes made by one statement become visible to all remaining statements executing within the same transaction, regardless of its isolation level. Changes that are in progress within other transactions remain invisible to the current transaction as long as they remain uncommitted. The isolation level and, sometimes, other attributes, determine how transactions will interact when another transaction wants to commit work.

The ISOLATION LEVEL attribute defines the isolation level for the transaction being started. It is the most significant transaction parameter for determining its behavior towards other concurrently running transactions.

The three isolation levels supported in Firebird are:

- **SNAPSHOT**
- **SNAPSHOT TABLE STABILITY**
- **READ COMMITTED** with three specifications (READ CONSISTENCY, NO RECORD_VERSION and RECORD_VERSION)

**SNAPSHOT Isolation Level**

SNAPSHOT isolation level — the default level — allows the transaction to see only those changes that were committed before it was started. Any committed changes made by concurrent transactions will not be seen in a SNAPSHOT transaction while it is active. The changes will become visible to a new transaction once the current transaction is either committed or rolled back, but not if it is only a roll back to a savepoint.

The SNAPSHOT isolation level is also known as “concurrency”.

### Autonomous Transactions

Changes made by autonomous transactions are not seen in the context of the SNAPSHOT transaction that launched it.

**Sharing Snapshot Transactions**

Using SNAPSHOT AT NUMBER snapshot_number, a SNAPSHOT transaction can be started sharing the snapshot of another transaction. With this feature it's possible to create parallel processes (using different attachments) reading consistent data from a database. For example, a backup process may create multiple threads reading data from the database in parallel, or a web service may dispatch distributed sub-services doing processing in parallel.

Alternatively, this feature can also be used via the API, using Transaction Parameter Buffer item isc_tpb_at_snapshot_number.

The snapshot_number from an active transaction can be obtained with RDB$GET_CONTEXT('SYSTEM', 'SNAPSHOT_NUMBER') in SQL or using the transaction information API call with fb_info_tra_snapshot_number information tag. The snapshot_number passed to the new transaction must be a snapshot of a currently active transaction.
To share a stable view between transactions, the other transaction also needs to have isolation level SNAPSHST. With READ COMMITTED, the snapshot number will move forward.

Example

```
SET TRANSACTION SNAPSHOT AT NUMBER 12345;
```

SNAPSHOT TABLE STABILITY Isolation Level

The SNAPSHOT TABLE STABILITY—or SNAPSHOT TABLE—isolation level is the most restrictive. As in SNAPSHOT, a transaction in SNAPSHOT TABLE STABILITY isolation sees only those changes that were committed before the current transaction was started. After a SNAPSHOT TABLE STABILITY is started, no other transactions can make any changes to any table in the database that has changes pending for this transaction. Other transactions can read other data, but any attempt at inserting, updating or deleting by a parallel process will cause conflict exceptions.

The RESERVING clause can be used to allow other transactions to change data in some tables.

If any other transaction has an uncommitted change pending in any (non-SHARED) table listed in the RESERVING clause, trying to start a SNAPSHOT TABLE STABILITY transaction will result in an indefinite wait (default or explicit WAIT), or an exception (NO WAIT or after expiration of the LOCK TIMEOUT).

The SNAPSHOT TABLE STABILITY isolation level is also known as “consistency”.

READ COMMITTED Isolation Level

The READ COMMITTED isolation level allows all data changes that other transactions have committed since it started to be seen immediately by the uncommitted current transaction. Uncommitted changes are not visible to a READ COMMITTED transaction.

To retrieve the updated list of rows in the table you are interested in—“refresh”—the SELECT statement needs to be executed again, whilst still in the uncommitted READ COMMITTED transaction.

Variants of READ COMMITTED

One of three modifying parameters can be specified for READ COMMITTED transactions, depending on the kind of conflict resolution desired: READ CONSISTENCY, RECORD_VERSION or NO RECORD_VERSION. When the ReadConsistency setting is set to 1 in firebird.conf (the default) or in databases.conf, these variants are effectively ignored and behave as READ CONSISTENCY. Otherwise, these variants are mutually exclusive.

- NO RECORD_VERSION (the default if ReadConsistency = 0) is a kind of two-phase locking mechanism: it will make the transaction unable to write to any row that has an update pending from another transaction.
  - with NO WAIT specified, it will throw a lock conflict error immediately
  - with WAIT specified, it will wait until the other transaction is either committed or rolled back. If the other transaction is rolled back, or if it is committed and its transaction ID is older
than the current transaction's ID, then the current transaction's change is allowed. A lock conflict error is returned if the other transaction was committed and its ID was newer than that of the current transaction.

- With RECORD_VERSION specified, the transaction reads the latest committed version of the row, regardless of other pending versions of the row. The lock resolution strategy (WAIT or NO WAIT) does not affect the behavior of the transaction at its start in any way.

- With READ CONSISTENCY specified (or ReadConsistency = 1), the execution of a statement obtains a snapshot of the database to ensure a consistent read at the statement-level of the transactions committed when execution started.

The other two variants can result in statement-level inconsistent reads as they may read some but not all changes of a concurrent transaction if that transaction commits during statement execution. For example, a SELECT COUNT(*) could read some, but not all inserted records of another transaction if the commit of that transaction occurs while the statement is reading records.

This statement-level snapshot is obtained for the execution of a top-level statement, nested statements (triggers, stored procedures and functions, dynamics statements, etc.) use the statement-level snapshot created for the top-level statement.

Obtaining a snapshot for READ CONSISTENCY is a very cheap action.

Setting ReadConsistency is set to 1 by default in firebird.conf.

---

**Handling of Update Conflicts with READ CONSISTENCY**

When a statement executes in a READ COMMITTED READ CONSISTENCY transaction, its database view is retained in a fashion similar to a SNAPSHOT transaction. This makes it pointless to wait for the concurrent transaction to commit, in the hope of being able to read the newly-committed record version. So, when a READ COMMITTED READ CONSISTENCY transaction reads data, it behaves similarly to a READ COMMITTED RECORD VERSION transaction: it walks the back versions chain looking for a record version visible to the current snapshot.

When an update conflict occurs, the behaviour of a READ COMMITTED READ CONSISTENCY transaction is different from READ COMMITTED RECORD VERSION. The following actions are performed:

1. Transaction isolation mode is temporarily switched to READ COMMITTED NO RECORD VERSION.

2. A write-lock is taken for the conflicting record.

3. Remaining records of the current UPDATE/DELETE cursor are processed, and they are write-locked too.

4. Once the cursor is fetched, all modifications performed since the top-level statement was started are undone, already taken write-locks for every updated/deleted/locked record are preserved, all inserted records are removed.
5. Transaction isolation mode is restored to `READ COMMITTED READ CONSISTENCY`, a new statement-level snapshot is created, and the top-level statement is restarted.

This algorithm ensures that already updated records remain locked after restart, they are visible to the new snapshot, and could be updated again with no further conflicts. Also, due to `READ CONSISTENCY` nature, the modified record set remains consistent.

- This restart algorithm is applied to `UPDATE`, `DELETE`, `SELECT WITH LOCK` and `MERGE` statements, with or without the `RETURNING` clause, executed directly by a client application or inside a PSQL object (stored procedure/function, trigger, `EXECUTE BLOCK`, etc).

- If an `UPDATE/DELETE` statement is positioned on an explicit cursor (using the `WHERE CURRENT OF` clause), then the step (3) above is skipped, i.e. remaining cursor records are not fetched and write-locked.

- If the top-level statement is selectable and update conflict happens after one or more records were returned to the client side, then an update conflict error is reported as usual and restart is not initiated.

- Restart does not happen for statements executed inside autonomous blocks (`IN AUTONOMOUS TRANSACTION DO …`).

- After 10 unsuccessful attempts the restart algorithm is aborted, all write locks are released, transaction isolation mode is restored to `READ COMMITTED READ CONSISTENCY`, and an update conflict error is raised.

- Any error not handled at step (3) above aborts the restart algorithm and statement execution continues normally.

- `UPDATE/DELETE` triggers fire multiple times for the same record if the statement execution was restarted and the record is updated/deleted again.

- Statement restart is usually fully transparent to client applications and no special actions should be taken by developers to handle it in any way. The only exception is the code with side effects that are outside the transactional control, for example:
  
  - usage of external tables, sequences or context variables
  - sending e-mails using UDF or UDR
  - usage of autonomous transactions or external queries

  and so on. Beware that such code could be executed more than once if update conflicts happen.

- There is no way to detect whether a restart happened, but it could be done manually using code with side effects as described above, for example using a context variable.

- Due to historical reasons, error `isc_update_conflict` is reported as the secondary error code, with the primary error code being `isc_deadlock`.

---

Chapter 13. Transaction Control
NO AUTO UNDO

The NO AUTO UNDO option affects the handling of record versions (garbage) produced by the transaction in the event of rollback. With NO AUTO UNDO flagged, the ROLLBACK statement marks the transaction as rolled back without deleting the record versions created in the transaction. They are left to be mopped up later by garbage collection.

NO AUTO UNDO might be useful when a lot of separate statements are executed that change data in conditions where the transaction is likely to be committed successfully most of the time.

The NO AUTO UNDO option is ignored for transactions where no changes are made.

RESTART REQUESTS

According to the Firebird sources, this will

```
Restart all requests in the current attachment to utilize the passed transaction.
```

— src/jrd/tra.cpp

The exact semantics and effects of this clause are not clear, and we recommend you do not use this clause.

AUTO COMMIT

Specifying AUTO COMMIT enables auto-commit mode for the transaction. In auto-commit mode, Firebird will internally execute the equivalent of COMMIT RETAIN after each statement execution.

This is not a generally useful auto-commit mode; the same transaction context is retained until the transaction is ended through a commit or rollback. In other words, when you use SNAPSHOT or SNAPSHOT TABLE STABILITY, this auto-commit will not change record visibility (effects of transactions that were committed after this transaction was started will not be visible).

For READ COMMITTED, the same warnings apply as for commit retaining: prolonged use of a single transaction in auto-commit mode can inhibit garbage collection and degrade performance.

IGNORE LIMBO

This flag is used to signal that records created by limbo transactions are to be ignored. Transactions are left “in limbo” if the second stage of a two-phase commit fails.

Historical Note

IGNORE LIMBO surfaces the TPB parameter isc_tpb_ignore_limbo, available in the API since InterBase times and is mainly used by gfix.

RESERVING

The RESERVING clause in the SET TRANSACTION statement reserves tables specified in the table list.
Reserving a table prevents other transactions from making changes in them or even, with the inclusion of certain parameters, from reading data from them while this transaction is running.

A RESERVING clause can also be used to specify a list of tables that can be changed by other transactions, even if the transaction is started with the SNAPSHOT TABLE STABILITY isolation level.

One RESERVING clause is used to specify as many reserved tables as required.

**Options for RESERVING Clause**

If one of the keywords SHARED or PROTECTED is omitted, SHARED is assumed. If the whole FOR clause is omitted, FOR SHARED READ is assumed. The names and compatibility of the four access options for reserving tables are not obvious.

*Table 250. Compatibility of Access Options for RESERVING*

<table>
<thead>
<tr>
<th></th>
<th>SHARED READ</th>
<th>SHARED WRITE</th>
<th>PROTECTED READ</th>
<th>PROTECTED WRITE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SHARED READ</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SHARED WRITE</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>PROTECTED READ</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>PROTECTED WRITE</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

The combinations of these RESERVING clause flags for concurrent access depend on the isolation levels of the concurrent transactions:

- **SNAPSHOT isolation**
  - Concurrent SNAPSHOT transactions with SHARED READ do not affect one other's access
  - A concurrent mix of SNAPSHOT and READ COMMITTED transactions with SHARED WRITE do not affect one another's access, but they block transactions with SNAPSHOT TABLE STABILITY isolation from either reading from or writing to the specified table(s)
  - Concurrent transactions with any isolation level and PROTECTED READ can only read data from the reserved tables. Any attempt to write to them will cause an exception
  - With PROTECTED WRITE, concurrent transactions with SNAPSHOT and READ COMMITTED isolation cannot write to the specified tables. Transactions with SNAPSHOT TABLE STABILITY isolation cannot read from or write to the reserved tables at all.

- **SNAPSHOT TABLE STABILITY isolation**
  - All concurrent transactions with SHARED READ, regardless of their isolation levels, can read from or write (if in READ WRITE mode) to the reserved tables
  - Concurrent transactions with SNAPSHOT and READ COMMITTED isolation levels and SHARED WRITE can read data from and write (if in READ WRITE mode) to the specified tables but concurrent access to those tables from transactions with SNAPSHOT TABLE STABILITY is blocked whilst these transactions are active
  - Concurrent transactions with any isolation level and PROTECTED READ can only read from the
reserved tables

- With PROTECTED WRITE, concurrent SNAPSHOT and READ COMMITTED transactions can read from but not write to the reserved tables. Access by transactions with the SNAPSHOT TABLE STABILITY isolation level is blocked.

- READ COMMITTED isolation

  - With SHARED READ, all concurrent transactions with any isolation level can both read from and write (if in READ WRITE mode) to the reserved tables

  - SHARED WRITE allows all transactions in SNAPSHOT and READ COMMITTED isolation to read from and write (if in READ WRITE mode) to the specified tables and blocks access from transactions with SNAPSHOT TABLE STABILITY isolation

  - With PROTECTED READ, concurrent transactions with any isolation level can only read from the reserved tables

  - With PROTECTED WRITE, concurrent transactions in SNAPSHOT and READ COMMITTED isolation can read from but not write to the specified tables. Access from transactions in SNAPSHOT TABLE STABILITY isolation is blocked.

---

In Embedded SQL, the USING clause can be used to conserve system resources by limiting the number of databases a transaction can access. USING is mutually exclusive with RESERVING. A USING clause in SET TRANSACTION syntax is not supported in DSQL.

See also

COMMIT, ROLLBACK

13.1.2. COMMIT

Commits a transaction

Available in

DSQL, ESQL

Syntax

```sql
COMMIT [TRANSACTION tr_name] [WORK] [RETAIN [SNAPSHOT] | RELEASE];
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tr_name</td>
<td>Transaction name. Available only in ESQL</td>
</tr>
</tbody>
</table>

Table 251. COMMIT Statement Parameter

The COMMIT statement commits all work carried out in the context of this transaction (inserts, updates, deletes, selects, execution of procedures). New record versions become available to other transactions and, unless the RETAIN clause is employed, all server resources allocated to its work are released.
If any conflicts or other errors occur in the database during the process of committing the transaction, the transaction is not committed, and the reasons are passed back to the user application for handling, and the opportunity to attempt another commit or to roll the transaction back.

The TRANSACTION and RELEASE clauses are only valid in ESQL.

**COMMIT Options**

- The optional TRANSACTION tr_name clause, available only in Embedded SQL, specifies the name of the transaction to be committed. With no TRANSACTION clause, COMMIT is applied to the default transaction.

  In ESQL applications, named transactions make it possible to have several transactions active simultaneously in one application. If named transactions are used, a host-language variable with the same name must be declared and initialized for each named transaction. This is a limitation that prevents dynamic specification of transaction names and thus, rules out transaction naming in DSQL.

- The keyword RELEASE is available only in Embedded SQL and enables disconnection from all databases after the transaction is committed. RELEASE is retained in Firebird only for compatibility with legacy versions of InterBase. It has been superseded in ESQL by the DISCONNECT statement.

- The RETAIN [SNAPSHOT] clause is used for the “soft” commit, variously referred to amongst host languages and their practitioners as COMMIT WITH RETAIN, “CommitRetaining”, “warm commit”, et al. The transaction is committed, but some server resources are retained and a new transaction is restarted transparently with the same Transaction ID. The state of row caches and cursors remains as it was before the soft commit.

  For soft-committed transactions whose isolation level is SNAPSHOT or SNAPSHOT TABLE STABILITY, the view of database state does not update to reflect changes by other transactions, and the user of the application instance continues to have the same view as when the original transaction started. Changes made during the life of the retained transaction are visible to that transaction, of course.

  **Recommendation**

  Use of the COMMIT statement in preference to ROLLBACK is recommended for ending transactions that only read data from the database, because COMMIT consumes fewer server resources and helps to optimize the performance of subsequent transactions.

*See also*

SET TRANSACTION, ROLLBACK
**13.1.3. ROLLBACK**

Rolls back a transaction or to a savepoint

*Available in*

DSQL, ESQL

**Syntax**

```
ROLLBACK [TRANSACTION tr_name] [WORK]
[RETAIN [SNAPSHOT] | RELEASE]
| ROLLBACK [WORK] TO [SAVEPOINT] sp_name
```

**Table 252. ROLLBACK Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>tr_name</td>
<td>Transaction name. Available only in ESQL</td>
</tr>
<tr>
<td>sp_name</td>
<td>Savepoint name. Available only in DSQL</td>
</tr>
</tbody>
</table>

The ROLLBACK statement rolls back all work carried out in the context of this transaction (inserts, updates, deletes, selects, execution of procedures). ROLLBACK never fails and, thus, never causes exceptions. Unless the RETAIN clause is employed, all server resources allocated to the work of the transaction are released.

The TRANSACTION and RELEASE clauses are only valid in ESQL. The ROLLBACK TO SAVEPOINT statement is not available in ESQL.

**ROLLBACK Options**

- The optional TRANSACTION tr_name clause, available only in Embedded SQL, specifies the name of the transaction to be committed. With no TRANSACTION clause, ROLLBACK is applied to the default transaction.

  In ESQL applications, named transactions make it possible to have several transactions active simultaneously in one application. If named transactions are used, a host-language variable with the same name must be declared and initialized for each named transaction. This is a limitation that prevents dynamic specification of transaction names and thus, rules out transaction naming in DSQL.

- The keyword RETAIN keyword specifies that, although all work of the transaction is to be rolled back, the transaction context is to be retained. Some server resources are retained, and the transaction is restarted transparently with the same Transaction ID. The state of row caches and cursors is kept as it was before the “soft” rollback.

  For transactions whose isolation level is SNAPSHOT or SNAPSHOT TABLE STABILITY, the view of database state is not updated by the soft rollback to reflect changes by other transactions. The user of the application instance continues to have the same view as when the transaction started originally. Changes that were made and soft-committed during the life of the retained
transaction are visible to that transaction, of course.

See also

SET TRANSACTION, COMMIT

ROLLBACK TO SAVEPOINT

The ROLLBACK TO SAVEPOINT statement specifies the name of a savepoint to which changes are to be rolled back. The effect is to roll back all changes made within the transaction, from the specified savepoint forward until the point when ROLLBACK TO SAVEPOINT is requested.

ROLLBACK TO SAVEPOINT performs the following operations:

- Any database mutations performed since the savepoint was created are undone. User variables set with RDB$SET_CONTEXT() remain unchanged.
- Any savepoints that were created after the one named are destroyed. Savepoints earlier than the one named are preserved, along with the named savepoint itself. Repeated rollbacks to the same savepoint are thus allowed.
- All implicit and explicit record locks that were acquired since the savepoint are released. Other transactions that have requested access to rows locked after the savepoint are not notified and will continue to wait until the transaction is committed or rolled back. Other transactions that have not already requested the rows can request and access the unlocked rows immediately.

See also

SAVEPOINT, RELEASE SAVEPOINT

13.1.4. SAVEPOINT

Creates a savepoint

Syntax

```
SAVEPOINT  sp_name
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sp_name</td>
<td>Savepoint name. Available only in DSQL</td>
</tr>
</tbody>
</table>

The SAVEPOINT statement creates an SQL-compliant savepoint that acts as a marker in the “stack” of data activities within a transaction. Subsequently, the tasks performed in the “stack” can be undone back to this savepoint, leaving the earlier work and older savepoints untouched. Savepoints are sometimes called “nested transactions”.

If a savepoint already exists with the same name as the name supplied for the new one, the existing savepoint is released, and a new one is created using the supplied name.

To roll changes back to the savepoint, the statement ROLLBACK TO SAVEPOINT is used.
Memory Considerations

The internal mechanism beneath savepoints can consume large amounts of memory, especially if the same rows receive multiple updates in one transaction. When a savepoint is no longer needed, but the transaction still has work to do, a \texttt{RELEASE SAVEPOINT} statement will erase it and thus free the resources.

Sample DSQL session with savepoints

```sql
CREATE TABLE TEST (ID INTEGER);
COMMIT;
INSERT INTO TEST VALUES (1);
COMMIT;
INSERT INTO TEST VALUES (2);
SAVEPOINT Y;
DELETE FROM TEST;
SELECT * FROM TEST; -- returns no rows
ROLLBACK TO Y;
SELECT * FROM TEST; -- returns two rows
ROLLBACK;
SELECT * FROM TEST; -- returns one row
```

See also

\texttt{ROLLBACK TO SAVEPOINT}, \texttt{RELEASE SAVEPOINT}

13.1.5. \texttt{RELEASE SAVEPOINT}

Releases a savepoint

Syntax

\texttt{RELEASE SAVEPOINT} \texttt{sp_name} [\texttt{ONLY}]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>sp_name</td>
<td>Savepoint name. Available only in DSQL</td>
</tr>
</tbody>
</table>

The statement \texttt{RELEASE SAVEPOINT} erases a named savepoint, freeing up all the resources it encompasses. By default, all the savepoints created after the named savepoint are released as well. The qualifier \texttt{ONLY} directs the engine to release only the named savepoint.

See also

\texttt{SAVEPOINT}

13.1.6. Internal Savepoints

By default, the engine uses an automatic transaction-level system savepoint to perform transaction rollback. When a \texttt{ROLLBACK} statement is issued, all changes performed in this transaction are backed
out via a transaction-level savepoint, and the transaction is then committed. This logic reduces the amount of garbage collection caused by rolled back transactions.

When the volume of changes performed under a transaction-level savepoint is getting large (~50000 records affected), the engine releases the transaction-level savepoint and uses the Transaction Inventory Page (TIP) as a mechanism to roll back the transaction if needed.

If you expect the volume of changes in your transaction to be large, you can specify the NO AUTO UNDO option in your SET TRANSACTION statement to block the creation of the transaction-level savepoint. Using the API, you can set this with the TPB flag isc_tpb_no_auto.undo.

### 13.1.7. Savepoints and PSQL

Transaction control statements are not allowed in PSQL, as that would break the atomicity of the statement that calls the procedure. However, Firebird does support the raising and handling of exceptions in PSQL, so that actions performed in stored procedures and triggers can be selectively undone without the entire procedure failing.

Internally, automatic savepoints are used to:

- undo all actions in the BEGIN…END block where an exception occurs
- undo all actions performed by the procedure or trigger or, in a selectable procedure, all actions performed since the last SUSPEND, when execution terminates prematurely because of an uncaught error or exception

Each PSQL exception handling block is also bounded by automatic system savepoints.

A BEGIN…END block does not itself create an automatic savepoint. A savepoint is created only in blocks that contain the WHEN statement for handling exceptions.
Chapter 14. Security

Databases must be secure and so must the data stored in them. Firebird provides three levels of data security: user authentication at the server level, SQL privileges within databases, and—optionally—database encryption. This chapter describes how to manage security at these three levels.

There is also a fourth level of data security: wire protocol encryption, which encrypts data in transit between client and server. Wire protocol encryption is out of scope for this Language Reference.

14.1. User Authentication

The security of the entire database depends on identifying a user and verifying its authority, a procedure known as authentication. User authentication can be performed in several ways, depending on the setting of the AuthServer parameter in the firebird.conf configuration file. This parameter contains the list of authentication plugins that can be used when connecting to the server. If the first plugin fails when authenticating, then the client can proceed with the next plugin, etc. When no plugin could authenticate the user, the user receives an error message.

The information about users authorised to access a specific Firebird server is stored in a special security database named security5.fdb. Each record in security5.fdb is a user account for one user. For each database, the security database can be overridden in the databases.conf file (parameter SecurityDatabase). Any database can be a security database, even for that database itself.

A username, with a maximum length of 63 characters, is an identifier, following the normal rules for identifiers (unquoted case-insensitive, double-quoted case-sensitive). For backwards compatibility, some statements (e.g. isql CONNECT) accept usernames enclosed in single quotes, which will behave as normal, unquoted identifiers.

The maximum password length depends on the user manager plugin (parameter UserManager, in firebird.conf or databases.conf). Passwords are case-sensitive. The default user manager is the first plugin in the UserManager list, but this can be overridden in the SQL user management statements. For the Srp plugin, the maximum password length is 255 characters, for an effective length of 20 bytes (see also Why is the effective password length of SRP 20 bytes?). For the Legacy_UserManager plugin only the first eight bytes of a password are significant; whilst it is valid to enter a password longer than eight bytes for Legacy_UserManager, any subsequent characters are ignored.

Why is the effective password length of SRP 20 bytes?

The SRP plugin does not actually have a 20 byte limit on password length, and longer passwords can be used (with an implementation limit of 255 characters). Hashes of different passwords longer than 20 bytes are also—usually—different. This effective limit comes from the limited hash length in SHA1 (used inside Firebird’s SRP implementation), 20 bytes or 160 bits, and the “pigeonhole principle”. Sooner or later, there will be a shorter (or longer) password that has the same hash (e.g. in a brute force attack). That is why often the effective
password length for the SHA1 algorithm is said to be 20 bytes.

The embedded version of the server does not use authentication; for embedded, the filesystem permissions to open the database file are used as authorization to access the database. However, the username, and—if necessary—the role, must be specified in the connection parameters, as they control access to database objects.

SYSDBA or the owner of the database have unrestricted access to all objects of the database. Users with the RDB$ADMIN role have similar unrestricted access if they specify that role when connecting or with SET ROLE.

14.1.1. Specially Privileged Users

In Firebird, the SYSDBA account is a “superuser” that exists beyond any security restrictions. It has complete access to all objects in all regular databases on the server, and full read/write access to the accounts in the security database security5.fdb. No user has remote access to the metadata of the security database.

For Srp, the SYSDBA account does not exist by default; it will need to be created using an embedded connection. For Legacy_Auth, the default SYSDBA password on Windows and macOS is “masterkey” — or “masterke”, to be exact, because of the 8-character length limit.

The default password “masterkey” is known across the universe. It should be changed as soon as the Firebird server installation is complete.

Other users can acquire elevated privileges in several ways, some of which depend on the operating system platform. These are discussed in the sections that follow and are summarised in Administrators and Fine-grained System Privileges.

POSIX Hosts

On POSIX systems, including macOS, the POSIX username will be used as the Firebird Embedded username if username is not explicitly specified.

The SYSDBA User on POSIX

On POSIX hosts, other than macOS, the SYSDBA user does not have a default password. If the full installation is done using the standard scripts, a one-off password will be created and stored in a text file in the same directory as security5.fdb, commonly /opt/firebird/. The name of the password file is SYSDBA.password.

In an installation performed by a distribution-specific installer, the location of the security database and the password file may be different from the standard one.

The root User

The root user can act directly as SYSDBA on Firebird Embedded. Firebird will treat root as though it were SYSDBA, and it provides access to all databases on the server.
Windows Hosts

On the Windows Server operating systems, operating system accounts can be used. Windows authentication (also known as “trusted authentication”) can be enabled by including the Win_Sspi plugin in the AuthServer list in firebird.conf. The plugin must also be present in the AuthClient setting at the client-side.

Windows operating system administrators are not automatically granted SYSDBA privileges when connecting to a database. To make that happen, the internally-created role RDB$ADMIN must be altered by SYSDBA or the database owner, to enable it. For details, refer to the later section entitled AUTO_ADMIN_MAPPING.

Prior to Firebird 3.0, with trusted authentication enabled, users who passed the default checks were automatically mapped to CURRENT_USER. In Firebird 3.0 and later, the mapping must be done explicitly using CREATE_MAPPING.

The Database Owner

The “owner” of a database is either the user who was CURRENT_USER at the time of creation (or restore) of the database or, if the USER parameter was supplied in the CREATE DATABASE statement, the specified user.

“Owner” is not a username. The user who is the owner of a database has full administrator privileges with respect to that database, including the right to drop it, to restore it from a backup and to enable or disable the AUTO_ADMIN_MAPPING capability.

Users with the USER_MANAGEMENT System Privilege

A user with the USER_MANAGEMENT system privilege in the security database can create, alter and drop users. To receive the USER_MANAGEMENT privilege, the security database must have a role with that privilege:

```sql
create role MANAGE_USERS
    set system privileges to USER_MANAGEMENT;
```

There are two options for the user to exercise these privileges:

1. Grant the role as a default role. The user will always be able to create, alter or drop users.

```sql
grant default MANAGE_USERS to user ALEX;
```

2. Grant the role as a normal role. The user will only be able to create, alter or drop users when the role is specified explicitly on login or using SET_ROLE.

```sql
grant MANAGE_USERS to user ALEX;
```

If the security database is a different database than the user connects to — which is usually the
case when using security5.fdb — then a role with the same name must also exist and be granted to the user in that database for the user to be able to activate the role. The role in the other database does not need any system privileges or other privileges.

The USER MANAGEMENT system privilege does not allow a user to grant or revoke the admin role. This requires the RDB$ADMIN role.

14.1.2. RDB$ADMIN Role

The internally-created role RDB$ADMIN is present in all databases. Assigning the RDB$ADMIN role to a regular user in a database grants that user the privileges of the SYSDBA, in that database only.

The elevated privileges take effect when the user is logged in to that regular database under the RDB$ADMIN role, and gives full control over all objects in that database.

Being granted the RDB$ADMIN role in the security database confers the authority to create, alter and drop user accounts.

In both cases, the user with the elevated privileges can assign RDB$ADMIN role to any other user. In other words, specifying WITH ADMIN OPTION is unnecessary because it is built into the role.

Granting the RDB$ADMIN Role in the Security Database

Since nobody — not even SYSDBA — can connect to the security database remotely, the GRANT and REVOKE statements are of no use for this task. Instead, the RDB$ADMIN role is granted and revoked using the SQL statements for user management:

```
CREATE USER new_user
    PASSWORD 'password'
    GRANT ADMIN ROLE;

ALTER USER existing_user
    GRANT ADMIN ROLE;

ALTER USER existing_user
    REVOKE ADMIN ROLE;
```

GRANT ADMIN ROLE and REVOKE ADMIN ROLE are not statements in the GRANT and REVOKE lexicon. They are three-word clauses to the statements CREATE USER and ALTER USER.

Table 255. Parameters for RDB$ADMIN Role GRANT and REVOKE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>new_user</td>
<td>Name for the new user</td>
</tr>
<tr>
<td>existing_user</td>
<td>Name of an existing user</td>
</tr>
<tr>
<td>password</td>
<td>User password</td>
</tr>
</tbody>
</table>
The grantor must be logged in as an administrator.

See also
CREATE USER, ALTER USER, GRANT, REVOKE

Doing the Same Task Using gsec

With Firebird 3.0, gsec was deprecated. It is recommended to use the SQL user management statements instead.

An alternative is to use gsec with the -admin parameter to store the RDB$ADMIN attribute on the user’s record:

```
gsec -add new_user -pw password -admin yes
```
```
gsec -mo existing_user -admin yes
```
```
gsec -mo existing_user -admin no
```

Depending on the administrative status of the current user, more parameters may be needed when invoking gsec, e.g. -user and -pass, -role, or -trusted.

Using the RDB$ADMIN Role in the Security Database

To manage user accounts through SQL, the user must have the RDB$ADMIN role in the security database. No user can connect to the security database remotely, so the solution is that the user connects to a regular database. From there, they can submit any SQL user management command.

Contrary to Firebird 3.0 or earlier, the user does not need to specify the RDB$ADMIN role on connect, nor do they need to have the RDB$ADMIN role in the database used to connect.

Using gsec with RDB$ADMIN Rights

To perform user management with gsec, the user must provide the extra switch -role rdb$admin.

Granting the RDB$ADMIN Role in a Regular Database

In a regular database, the RDB$ADMIN role is granted and revoked with the usual syntax for granting and revoking roles:

```
GRANT [DEFAULT] RDB$ADMIN TO username
```
```
REVOKE [DEFAULT] RDB$ADMIN FROM username
```

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>Name of the user</td>
</tr>
</tbody>
</table>

To grant and revoke the RDB$ADMIN role, the grantor must be logged in as an administrator.
See also

GRANT, REVOKE

Using the RDB$ADMIN Role in a Regular Database

To exercise their RDB$ADMIN privileges, the role must either have been granted as a default role, or the grantee has to include the role in the connection attributes when connecting to the database, or specify it later using SET ROLE.

AUTO ADMIN MAPPING

Windows Administrators are not automatically granted RDB$ADMIN privileges when connecting to a database (when Win_Sspi is enabled). The AUTO ADMIN MAPPING switch determines whether Administrators have automatic RDB$ADMIN rights, on a database-by-database basis. By default, when a database is created, it is disabled.

If AUTO ADMIN MAPPING is enabled in the database, it will take effect whenever a Windows Administrator connects:

a. using Win_Sspi authentication, and
b. without specifying any role

After a successful “auto admin” connection, the current role is set to RDB$ADMIN.

If an explicit role was specified on connect, the RDB$ADMIN role can be assumed later in the session using SET TRUSTED ROLE.

Auto Admin Mapping in Regular Databases

To enable and disable automatic mapping in a regular database:

```
ALTER ROLE RDB$ADMIN
    SET AUTO ADMIN MAPPING;  -- enable it

ALTER ROLE RDB$ADMIN
    DROP AUTO ADMIN MAPPING; -- disable it
```

Either statement must be issued by a user with sufficient rights, that is:

- The database owner
- An administrator
- A user with the ALTER ANY ROLE privilege

The statement

```
ALTER ROLE RDB$ADMIN
    SET AUTO ADMIN MAPPING;
```
is a simplified form of a CREATE MAPPING statement to create a mapping of the predefined group DOMAIN_ANY_RID_ADMINS to the role of RDB$ADMIN:

```
CREATE MAPPING WIN_ADMINS
    USING PLUGIN WIN_SSPI
    FROM Predefined_Group DOMAIN_ANY_RID_ADMINS
    TO ROLE RDB$ADMIN;
```

Accordingly, the statement

```
ALTER ROLE RDB$ADMIN
    DROP AUTO ADMIN MAPPING
```

is equivalent to the statement

```
DROP MAPPING WIN_ADMINS;
```

For details, see Mapping of Users to Objects

In a regular database, the status of AUTO ADMIN MAPPING is checked only at connect time. If an Administrator has the RDB$ADMIN role because auto-mapping was on when they logged in, they will keep that role for the duration of the session, even if they or someone else turns off the mapping in the meantime.

Likewise, switching on AUTO ADMIN MAPPING will not change the current role to RDB$ADMIN for Administrators who were already connected.

**Auto Admin Mapping in the Security Database**

The ALTER ROLE RDB$ADMIN statement cannot enable or disable AUTO ADMIN MAPPING in the security database. However, you can create a global mapping for the predefined group DOMAIN_ANY_RID_ADMINS to the role RDB$ADMIN in the following way:

```
CREATE GLOBAL MAPPING WIN_ADMINS
    USING PLUGIN WIN_SSPI
    FROM Predefined_Group DOMAIN_ANY_RID_ADMINS
    TO ROLE RDB$ADMIN;
```

Additionally, you can use gsec:

```
gsec -mapping set

gsec -mapping drop
```
Depending on the administrative status of the current user, more parameters may be needed when invoking `gsec`, e.g. `-user` and `-pass`, `-role`, or `-trusted`.

Only SYSDBA can enable `AUTO_ADMIN_MAPPING` if it is disabled, but any administrator can turn it off.

When turning off `AUTO_ADMIN_MAPPING` in `gsec`, the user turns off the mechanism itself which gave them access, and thus they would not be able to re-enable `AUTO_ADMIN_MAPPING`. Even in an interactive `gsec` session, the new flag setting takes effect immediately.

### 14.1.3. Administrators

An administrator is a user that has sufficient rights to read, write to, create, alter or delete any object in a database to which that user’s administrator status applies. The table summarises how “superuser” privileges are enabled in the various Firebird security contexts.

**Table 257. Administrator (“Superuser”) Characteristics**

<table>
<thead>
<tr>
<th>User</th>
<th>RDB$ADMIN Role</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSDBA</td>
<td>Auto</td>
<td>Exists automatically at server level. Has full privileges to all objects in all databases. Can create, alter and drop users, but has no direct remote access to the security database</td>
</tr>
<tr>
<td>root user on POSIX</td>
<td>Auto</td>
<td>Exactly like SYSDBA. Firebird Embedded only.</td>
</tr>
<tr>
<td>Superuser on POSIX</td>
<td>Auto</td>
<td>Exactly like SYSDBA. Firebird Embedded only.</td>
</tr>
</tbody>
</table>
| Windows Administrator if login succeeds | Set as `CURRENT_ROLE` if login succeeds | Exactly like SYSDBA if the following are all true:  
  • In `firebird.conf` file, `AuthServer` includes `Win_Sspi`, and `Win_Sspi` is present in the client-side plugins (`AuthClient`) configuration  
  • In databases where `AUTO_ADMIN_MAPPING` is enabled, or an equivalent mapping of the predefined group `DOMAIN_ANY_RID_ADMINS` for the role `RDB$ADMIN` exists  
  • If role is specified at login  
| Database owner    | Auto                    | Like SYSDBA, but only in the databases they own                                                                                                                                                           |
| Regular user      | Must be previously granted; must be supplied at login or have been granted as a default role | Like SYSDBA, but only in the databases where the role is granted                                                                                                                                         |
### 14.1.4. Fine-grained System Privileges

In addition to granting users full administrative privileges, system privileges make it possible to grant regular users a subset of administrative privileges that have historically been limited to SYSDBA and administrators only. For example:

- Run utilities such as `gbak`, `gfix`, `nbackup` and so on
- Shut down a database and bring it online
- Trace other users' attachments
- Access the monitoring tables
- Run management statements

The implementation defines a set of system privileges, analogous to object privileges, from which lists of privileged tasks can be assigned to roles.

It is also possible to grant normal privileges to a system privilege, making the system privilege act like a special role type.

The system privileges are assigned through `CREATE ROLE` and `ALTER ROLE`.

Be aware that each system privilege provides a very thin level of control. For some tasks it may be necessary to give the user more than one privilege to perform some task. For example, add `IGNORE_DB_TRIGGERS` to `USE_GSTAT Utility` because `gstat` needs to ignore database triggers.

### List of Valid System Privileges

The following table lists the names of the valid system privileges that can be granted to and revoked from roles.

<p>| USER_MANAGEMENT | Manage users (given in the security database) |
| READ_RAW_PAGES  | Read pages in raw format using Attachment::getInfo() |</p>
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CREATE_USER_TYPES</td>
<td>Add/change/delete non-system records in RDB$TYPES</td>
</tr>
<tr>
<td>USE_NBACKUPUTILITY</td>
<td>Use nbackup to create database copies</td>
</tr>
<tr>
<td>CHANGE_SHUTDOWN_MODE</td>
<td>Shut down database and bring online</td>
</tr>
<tr>
<td>TRACE_ANY_ATTACHMENT</td>
<td>Trace other users' attachments</td>
</tr>
<tr>
<td>MONITOR_ANY_ATTACHMENT</td>
<td>Monitor (tables MON$) other users' attachments</td>
</tr>
<tr>
<td>ACCESS_SHUTDOWN_DATABASE</td>
<td>Access database when it is shut down</td>
</tr>
<tr>
<td>CREATE_DATABASE</td>
<td>Create new databases (given in the security database)</td>
</tr>
<tr>
<td>DROP_DATABASE</td>
<td>Drop this database</td>
</tr>
<tr>
<td>USE_GBAKUTILITY</td>
<td>Use gbak utility</td>
</tr>
<tr>
<td>USE_GSTATUTILITY</td>
<td>Use gstat utility</td>
</tr>
<tr>
<td>USE_GFIXUTILITY</td>
<td>Use gfix utility</td>
</tr>
<tr>
<td>IGNORE_DB_TRIGGERS</td>
<td>Instruct engine not to run DB-level triggers</td>
</tr>
<tr>
<td>CHANGE_HEADER_SETTINGS</td>
<td>Modify parameters in DB header page</td>
</tr>
<tr>
<td>SELECT_ANY_OBJECT_IN_DATABASE</td>
<td>Use SELECT for any selectable object</td>
</tr>
<tr>
<td>ACCESS_ANY_OBJECT_IN_DATABASE</td>
<td>Access (in any possible way) any object</td>
</tr>
<tr>
<td>MODIFY_ANY_OBJECT_IN_DATABASE</td>
<td>Modify (up to drop) any object</td>
</tr>
<tr>
<td>CHANGE_MAPPING_RULES</td>
<td>Change authentication mappings</td>
</tr>
<tr>
<td>USE_GRANTED_BY_CLAUSE</td>
<td>Use GRANTED BY in GRANT and REVOKE statements</td>
</tr>
<tr>
<td>GRANT_REVOKE_ON_ANY_OBJECT</td>
<td>GRANT and REVOKE rights on any object in database</td>
</tr>
<tr>
<td>GRANT_REVOKE_ANYDDL_RIGHT</td>
<td>GRANT and REVOKE any DDL rights</td>
</tr>
<tr>
<td>CREATE_PRIVILEGED_ROLES</td>
<td>Use SET SYSTEM PRIVILEGES in roles</td>
</tr>
<tr>
<td>GET_DBCRYPTINFO</td>
<td>Get database encryption information</td>
</tr>
<tr>
<td>MODIFY_EXT_CONN_POOL</td>
<td>Use command ALTER EXTERNAL CONNECTIONS POOL</td>
</tr>
<tr>
<td>REPLICATE INTO DATABASE</td>
<td>Use replication API to load change sets into database</td>
</tr>
<tr>
<td>PROFILE_ANY_ATTACHMENT</td>
<td>Profile attachments of other users</td>
</tr>
</tbody>
</table>

### 14.2. SQL Statements for User Management

This section describes the SQL statements for creating, altering and dropping Firebird user
accounts. These statements can be executed by the following users:

- **SYSDBA**
- Any user with the `RDB$ADMIN` role in the security database
- When the `AUTO ADMIN MAPPING` flag is enabled in the security database (`security5.fdb` or the security database configured for the current database in the `databases.conf`), any Windows Administrator — assuming `Win_Sspi` was used to connect without specifying roles.
- Any user with the system privilege `USER_MANAGEMENT` in the security database

For a Windows Administrator, `AUTO ADMIN MAPPING` enabled only in a regular database is not sufficient to permit management of other users. For instructions to enable it in the security database, see Auto Admin Mapping in the Security Database.

Non-privileged users can use only the `ALTER USER` statement, and then only to modify some data of their own account.

### 14.2.1. CREATE USER

Creates a Firebird user account

*Available in*

DSQL

**Syntax**

```
CREATE USER username
   <user_option> [<user_option> ...]
TAGS (<user_var> [, , <user_var> ...])

<user_option> ::= 
   PASSWORD 'password'
| FIRSTNAME 'firstname'
| MIDDLENAME 'middlename'
| LASTNAME 'lastname'
| {GRANT | REVOKE} ADMIN ROLE
| {ACTIVE | INACTIVE}
| USING PLUGIN plugin_name

<user_var> ::= 
tag_name = 'tag_value'
| DROP tag_name
```

*Table 258. CREATE USER Statement Parameters*

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>username</td>
<td>Username. The maximum length is 63 characters, following the rules for Firebird identifiers.</td>
</tr>
</tbody>
</table>
### Parameter Description

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>password</td>
<td>User password. Valid or effective password length depends on the user manager plugin. Case-sensitive.</td>
</tr>
<tr>
<td>firstname</td>
<td>Optional: User's first name. Maximum length 32 characters</td>
</tr>
<tr>
<td>middlename</td>
<td>Optional: User's middle name. Maximum length 32 characters</td>
</tr>
<tr>
<td>plugin_name</td>
<td>Name of the user manager plugin.</td>
</tr>
<tr>
<td>tag_name</td>
<td>Name of a custom attribute. The maximum length is 63 characters, following the rules for Firebird regular identifiers.</td>
</tr>
<tr>
<td>tag_value</td>
<td>Value of the custom attribute. The maximum length is 255 characters.</td>
</tr>
</tbody>
</table>

If the user already exist in the Firebird security database for the specified user manager plugin, an error is raised. It is possible to create multiple users with the same name: one per user manager plugin.

The `username` argument must follow the rules for Firebird regular identifiers: see [Identifiers](#) in the [Structure](#) chapter. Usernames are case-sensitive when double-quoted (in other words, they follow the same rules as other delimited identifiers).

Usernames follow the general rules and syntax of [identifiers](#). Thus, a user named "Alex" is distinct from a user named "ALEX"

```sql
CREATE USER ALEX PASSWORD 'bz23ds';
- this user is the same as the first one
CREATE USER Alex PASSWORD 'bz23ds';
- this user is the same as the first one
CREATE USER "ALEX" PASSWORD 'bz23ds';
- and this is a different user
CREATE USER "Alex" PASSWORD 'bz23ds';
```

The `PASSWORD` clause specifies the user's password, and is required. The valid or effective password length depends on the user manager plugin, see also [User Authentication](#).

The optional `FIRSTNAME`, `MIDDLENAME` and `LASTNAME` clauses can be used to specify additional user properties, such as the person's first name, middle name and last name, respectively. These are `VARCHAR(32)` fields and can be used to store anything you prefer.

If the `GRANT ADMIN ROLE` clause is specified, the new user account is created with the privileges of the `RDB$ADMIN` role in the security database (`security5.fdb` or database-specific). It allows the new user to manage user accounts from any regular database they log into, but it does not grant the user any special privileges on objects in those databases.
The `REVOKE ADMIN ROLE` clause is syntactically valid in a `CREATE USER` statement, but has no effect. It is not possible to specify `GRANT ADMIN ROLE` and `REVOKE ADMIN ROLE` in one statement.

The `ACTIVE` clause specifies the user is active and can log in, this is the default.

The `INACTIVE` clause specifies the user is inactive and cannot log in. It is not possible to specify `ACTIVE` and `INACTIVE` in one statement. The `ACTIVE/INACTIVE` option is not supported by the `Legacy_UserManager` and will be ignored.

The `USING PLUGIN` clause explicitly specifies the user manager plugin to use for creating the user. Only plugins listed in the `UserManager` configuration for this database (`firebird.conf`, or overridden in `databases.conf`) are valid. The default user manager (first in the `UserManager` configuration) is applied when this clause is not specified.

> Users of the same name created using different user manager plugins are different objects. Therefore, the user created with one user manager plugin can only be altered or dropped by that same plugin.

> From the perspective of ownership, and privileges and roles granted in a database, different user objects with the same name are considered one and the same user.

The `TAGS` clause can be used to specify additional user attributes. Custom attributes are not supported (silently ignored) by the `Legacy_UserManager`. Custom attributes names follow the rules of Firebird identifiers, but are handled case-insensitive (for example, specifying both "A BC" and "a bc" will raise an error). The value of a custom attribute can be a string of maximum 255 characters. The `DROP tag_name` option is syntactically valid in `CREATE USER`, but behaves as if the property is not specified.

> Users can view and alter their own custom attributes. Do not use this for sensitive or security related information.

CREATE/ALTER/DROP USER are DDL statements, and only take effect at commit. Remember to `COMMIT` your work. In `isql`, the command `SET AUTO ON` will enable autocommit on DDL statements. In third-party tools and other user applications, this may not be the case.

**Who Can Create a User**

To create a user account, the current user must have

- *administrator privileges* in the security database
- the `USER_MANAGEMENT` system privilege in the security database. Users with the `USER_MANAGEMENT` system privilege can not grant or revoke the admin role.

**CREATE USER Examples**

1. Creating a user with the username `bigshot`:
2. Creating a user with the `Legacy_UserManager` user manager plugin

```sql
CREATE USER bigshot PASSWORD 'buckshot';
```

3. Creating the user `john` with custom attributes:

```sql
CREATE USER godzilla PASSWORD 'robot'
    USING PLUGIN Legacy_UserManager;
```

```sql
CREATE USER john PASSWORD 'fYe_3Ksw'
    FIRSTNAME 'John' LASTNAME 'Doe'
    TAGS (BIRTHYEAR='1970', CITY='New York');
```

4. Creating an inactive user:

```sql
CREATE USER john PASSWORD 'fYe_3Ksw'
    INACTIVE;
```

5. Creating the user `superuser` with user management privileges:

```sql
CREATE USER superuser PASSWORD 'kMn8Kjh'
    GRANT ADMIN ROLE;
```

See also

`ALTER USER`, `CREATE OR ALTER USER`, `DROP USER`

### 14.2.2. ALTER USER

Alters a Firebird user account

*Available in*

DSQL

*Syntax*

```sql
ALTER {USER username | CURRENT USER}
    [SET] [<user_option> [<user_option> ...]]
    [TAGS (<user_var> [, <user_var> ...])]

<user_option> ::= PASSWORD 'password'
    | FIRSTNAME 'firstname'
    | MIDDLENAME 'middleame'
    | LASTNAME 'lastname'
```
| {GRANT | REVOKE} ADMIN ROLE | {ACTIVE | INACTIVE} | USING PLUGIN plugin_name |

See CREATE USER for details on the statement parameters.

Any user can alter their own account, except that only an administrator may use GRANT/REVOKE ADMIN ROLE and ACTIVE/INACTIVE.

All clauses are optional, but at least one other than USING PLUGIN must be present:

- The PASSWORD parameter is for changing the password for the user
- FIRSTNAME, MIDDLENAME and LASTNAME update these optional user properties, such as the person’s first name, middle name and last name respectively
- GRANT ADMIN ROLE grants the user the privileges of the RDB$ADMIN role in the security database (security5.fdb), enabling them to manage the accounts of other users. It does not grant the user any special privileges in regular databases.
- REVOKE ADMIN ROLE removes the user’s administrator in the security database which, once the transaction is committed, will deny that user the ability to alter any user account except their own
- ACTIVE will enable a disabled account (not supported for Legacy_UserManager)
- INACTIVE will disable an account (not supported for Legacy_UserManager). This is convenient to temporarily disable an account without deleting it.
- USING PLUGIN specifies the user manager plugin to use
- TAGS can be used to add, update or remove (DROP) additional custom attributes (not supported for Legacy_UserManager). Attributes not listed will not be changed.

See CREATE USER for more details on the clauses.

If you need to change your own account, then instead of specifying the name of the current user, you can use the CURRENT USER clause.

The ALTER CURRENT USER statement follows the normal rules for selecting the user manager plugin. If the current user was created with a non-default user manager plugin, they will need to explicitly specify the user manager plugins with USING PLUGIN plugin_name, or they will receive an error that the user is not found. Or, if a user with the same name exists for the default user manager, they will alter that user instead.

Remember to commit your work if you are working in an application that does not auto-commit DDL.
Who Can Alter a User?

To modify the account of another user, the current user must have

- **administrator privileges** in the security database
- the USER_MANAGEMENT system privilege in the security database

Users with the USER_MANAGEMENT system privilege cannot grant or revoke the admin role.

Anyone can modify their own account, except for the GRANT/REVOKE ADMIN ROLE and ACTIVE/INACTIVE options, which require administrative privileges to change.

**ALTER USER Examples**

1. Changing the password for the user bobby and granting them user management privileges:

   ```
   ALTER USER bobby PASSWORD '67-Uit_68'
   GRANT ADMIN ROLE;
   ```

2. Editing the optional properties (the first and last names) of the user dan:

   ```
   ALTER USER dan
   FIRSTNAME 'No_Jack'
   LASTNAME 'Kennedy';
   ```

3. Revoking user management privileges from user dumbbell:

   ```
   ALTER USER dumbbell
   DROP ADMIN ROLE;
   ```

See also

CREATE USER, DROP USER

**14.2.3. CREATE OR ALTER USER**

Creates a Firebird user account if it doesn’t exist, or alters a Firebird user account

Available in

DSQL

Syntax

```sql
CREATE OR ALTER USER username
  [SET] [<user_option> [<user_option> ...]]
  [TAGS (<user_var> [, <user_var> ...])]

<user_option> ::= PASSWORD 'password'
```
See CREATE USER and ALTER USER for details on the statement parameters.

If the user does not exist, it will be created as if executing a CREATE USER statement. If the user already exists, it will be modified as if executing an ALTER USER statement. The CREATE OR ALTER USER statement must contain at least one of the optional clauses other than USING PLUGIN. If the user does not exist yet, the PASSWORD clause is required.

Remember to commit your work if you are working in an application that does not auto-commit DDL.

CREATE OR ALTER USER Examples

Creating or altering a user

    CREATE OR ALTER USER john PASSWORD 'fYe_3Ksw'
    FIRSTNAME 'John'
    LASTNAME 'Doe'
    INACTIVE;

See also

CREATE USER, ALTER USER, DROP USER

14.2.4. DROP USER

Drops a Firebird user account

Available in
DSQL

Syntax

    DROP USER username
        [USING PLUGIN plugin_name]

Table 259. DROP USER Statement Parameter
### Who Can Drop a User?

To drop a user, the current user must have

- **administrator privileges** in the security database
- the `USER_MANAGEMENT` system privilege in the security database

#### DROP USER Example

1. Deleting the user `bobby`:

   ```sql
   DROP USER bobby;
   ```

2. Removing a user created with the `Legacy_UserManager` plugin:

   ```sql
   DROP USER Godzilla
   USING PLUGIN Legacy_UserManager;
   ```

### 14.3. SQL Privileges

The second level of Firebird's security model is SQL privileges. Whilst a successful login — the first level — authorises a user's access to the server and to all databases under that server, it does not imply that the user has access to any objects in any databases. When an object is created, only the user that created it (its owner) and administrators have access to it. The user needs **privileges** on each object they need to access. As a general rule, privileges must be **granted** explicitly to a user by the object owner or an **administrator** of the database.
A privilege comprises a DML access type (SELECT, INSERT, UPDATE, DELETE, EXECUTE and REFERENCES), the name of a database object (table, view, procedure, role) and the name of the grantee (user, procedure, trigger, role). Various means are available to grant multiple types of access on an object to multiple users in a single GRANT statement. Privileges may be revoked from a user with REVOKE statements.

An additional type of privileges, DDL privileges, provide rights to create, alter or drop specific types of metadata objects. System privileges provide a subset of administrator permissions to a role (and indirectly, to a user).

Privileges are stored in the database to which they apply and are not applicable to any other database, except the DATABASE DDL privileges, which are stored in the security database.

14.3.1. The Object Owner

The user who created a database object becomes its owner. Only the owner of an object and users with administrator privileges in the database, including the database owner, can alter or drop the database object.

Administrators, the database owner or the object owner can grant privileges to and revoke them from other users, including privileges to grant privileges to other users. The process of granting and revoking SQL privileges is implemented with two statements, GRANT and REVOKE.

14.4. ROLE

A role is a database object that packages a set of privileges. Roles implement the concept of access control at a group level. Multiple privileges are granted to the role and then that role can be granted to or revoked from one or many users, or even other roles.

A role that has been granted as a “default” role will be activated automatically. Otherwise, a user must supply that role in their login credentials — or with SET ROLE — to exercise the associated privileges. Any other privileges granted to the user directly are not affected by their login with the role.

Logging in with multiple explicit roles simultaneously is not supported, but a user can have multiple default roles active at the same time.

In this section the tasks of creating and dropping roles are discussed.

14.4.1. CREATE ROLE

Creates a role

Available in
DSQL, ESQL

Syntax

CREATE ROLE rolemname
[SET SYSTEM PRIVILEGES TO <sys_privileges>]

<sys_privileges> ::=  
(sys_privilege) [, (sys_privilege) ...]  

(sys_privilege) ::=  
USER_MANAGEMENT | READ_RAW_PAGES  
| CREATE_USER_TYPES | USE_NBACKUP.Utility  
| CHANGE_SHUTDOWN_MODE | TRACE_ANY_ATTACHMENT  
| MONITOR_ANY_ATTACHMENT | ACCESS_SHUTDOWN_DATABASE  
| CREATE_DATABASE | DROP_DATABASE  
| USE_GBAKUTILITY | USE_GSTAT_UTILITY  
| USE_GFIX_UTILITY | IGNORE_DB_TRIGGERS  
| CHANGE_HEADER_SETTINGS  
| SELECT_ANY_OBJECT_IN_DATABASE  
| ACCESS_ANY_OBJECT_IN_DATABASE  
| MODIFY_ANY_OBJECT_IN_DATABASE  
| CHANGE_MAPPING_RULES | USE_GRANTED_BY_CLAUSE  
| GRANT_REVOKE_ON_ANY_OBJECT  
| GRANT_REVOKE_ANY_DDL_RIGHT  
| CREATE_PRIVILEGED_ROLES | GET_DBCRYPT_INFO  
| MODIFY_EXT_CONN_POOL | REPLICATE_INTO_DATABASE  
| PROFILE_ANY_ATTACHMENT

Table 260. CREATE ROLE Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rolename</td>
<td>Role name. The maximum length is 63 characters</td>
</tr>
<tr>
<td>sys_privilege</td>
<td>System privilege to grant</td>
</tr>
</tbody>
</table>

The statement CREATE ROLE creates a new role object, to which one or more privileges can be granted subsequently. The name of a role must be unique among the names of roles in the current database.

It is advisable to make the name of a role unique among usernames as well. The system will not prevent the creation of a role whose name clashes with an existing username, but if it happens, the user will be unable to connect to the database.

Who Can Create a Role

The CREATE ROLE statement can be executed by:

- **Administrators**
- Users with the CREATE ROLE privilege
  - Setting system privileges also requires the system privilege CREATE_PRIVILEGED_ROLES

The user executing the CREATE ROLE statement becomes the owner of the role.
CREATE ROLE Examples

Creating a role named SELLERS

```
CREATE ROLE SELLERS;
```

Creating a role SELECT_ALL with the system privilege to select from any selectable object

```
CREATE ROLE SELECT_ALL
SET SYSTEM PRIVILEGES TO SELECT_ANY_OBJECT_IN_DATABASE;
```

See also

ALTER ROLE, DROP ROLE, GRANT, REVOKE, Fine-grained System Privileges

14.4.2. ALTER ROLE

Alters a role

Available in
DSQL

Syntax

```
ALTER ROLE rolename
{ SET SYSTEM PRIVILEGES TO <sys_privileges>
| DROP SYSTEM PRIVILEGES
| {SET | DROP} AUTO ADMIN MAPPING }

<sys_privileges> ::= !! See CREATE ROLE !!
```

Table 261. ALTER ROLE Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>roldname</td>
<td>Role name; specifying anything other than RDB$ADMIN will fail</td>
</tr>
<tr>
<td>sys_privilege</td>
<td>System privilege to grant</td>
</tr>
</tbody>
</table>

ALTER ROLE can be used to grant or revoke system privileges from a role, or enable and disable the capability for Windows Administrators to assume administrator privileges automatically when logging in.

This last capability can affect only one role: the system-generated role RDB$ADMIN.

For details on auto admin mapping, see AUTO ADMIN MAPPING.

It is not possible to selectively grant or revoke system privileges. Only the privileges listed in the SET SYSTEM PRIVILEGES clause will be available to the role after commit, and DROP SYSTEM PRIVILEGES will remove all system privileges from this role.
**Who Can Alter a Role**

The ALTER ROLE statement can be executed by:

- **Administrators**
- Users with the ALTER ANY ROLE privilege, with the following caveats
  - Setting or dropping system privileges also requires the system privilege `CREATE_PRIVILEGED_ROLES`
  - Setting or dropping auto admin mapping also requires the system privilege `CHANGE_MAPPING_RULES`

**ALTER ROLE Examples**

*Drop all system privileges from a role named SELECT_ALL*

```
ALTER ROLE SELLERS
DROP SYSTEM PRIVILEGES;
```

*Grant a role SELECT_ALL the system privilege to select from any selectable object*

```
ALTER ROLE SELECT_ALL
SET SYSTEM PRIVILEGES TO SELECT_ANY_OBJECT_IN_DATABASE;
```

See also

CREATE ROLE, GRANT, REVOKE, Fine-grained System Privileges

**14.4.3. DROP ROLE**

Drops a role

*Available in*

DSQL, ESQL

*Syntax*

```
DROP ROLE rolename
```

The statement DROP ROLE deletes an existing role. It takes a single argument, the name of the role. Once the role is deleted, the entire set of privileges is revoked from all users and objects that were granted the role.

**Who Can Drop a Role**

The DROP ROLE statement can be executed by:

- **Administrators**
- The owner of the role
• Users with the DROP ANY ROLE privilege

**DROP ROLE Examples**

*Deleting the role SELLERS*

```
DROP ROLE SELLERS;
```

*See also*

CREATE ROLE, GRANT, REVOKE

### 14.5. Statements for Granting Privileges

A GRANT statement is used for granting privileges—including roles—to users and other database objects.

#### 14.5.1. GRANT

Grants privileges and assigns roles

*Available in*

DSQL, ESQL

*Syntax (granting privileges)*

```
GRANT <privileges>
TO <grantee_list>
[WITH GRANT OPTION]
[{{GRANTED BY | AS} [USER] grantor}]

<privileges> ::=<table_privileges> | <execute_privilege>
| <usage_privilege> | <ddl_privileges>

<table_privileges> ::= {ALL [PRIVILEGES] | <table_privilege_list> }
ON [TABLE] {table_name | view_name}

<table_privilege_list> ::=<table_privilege> [, <tableprivilege> ...]

<table_privilege> ::= SELECT | DELETE | INSERT
| UPDATE [(col [, col ...])]
| REFERENCES [(col [, col ...])]

<execute_privilege> ::= EXECUTE ON
{ PROCEDURE proc_name | FUNCTION func_name
```
\begin{verbatim}

| PACKAGE package_name }

<usage_privilege> ::= USAGE ON
{ EXCEPTION exception_name
| {GENERATOR | SEQUENCE} sequence_name }

<ddl_privileges> ::= {ALL [PRIVILEGES] | <ddl_privilege_list>} <object_type>

<ddl_privilege_list> ::= <ddl_privilege> [, <ddl_privilege> ...]

<ddl_privilege> ::= CREATE | ALTER ANY | DROP ANY

<object_type> ::= CREATE | ALTER ANY | DROP ANY

| CHARACTERS | COLLATION | DOMAIN | EXCEPTION
| FILTER | FUNCTION | GENERATOR | PACKAGE
| PROCEDURE | ROLE | SEQUENCE | TABLE | VIEW

<db_ddl_privileges> ::= {ALL [PRIVILEGES] | <db_ddl_privilege_list>} {DATABASE | SCHEMA}

<db_ddl_privilege_list> ::= <db_ddl_privilege> [, <db_ddl_privilege> ...]

<db_ddl_privilege> ::= CREATE | ALTER | DROP

<grantee_list> ::= <grantee> [, <grantee> ...]

<grantee> ::= PROCEDURE proc_name | FUNCTION func_name
| PACKAGE package_name | TRIGGER trig_name
| VIEW view_name | ROLE role_name
| [USER] username | GROUP Unix_group
| SYSTEM PRIVILEGE <sys_privilege>

<sys_privilege> ::= !! See CREATE ROLE !!

Syntax (granting roles)

GRANT <role_granted_list>
TO <role_grantee_list>
[WITH ADMIN OPTION]
[GRANTED BY | AS] [USER] grantor

<role_granted_list> ::= <role_granted> [, <role_granted> ...]

<role_granted> ::= [DEFAULT] role_name
\end{verbatim}
The `GRANT` statement grants one or more privileges on database objects to users, roles, or other database objects.

A regular, authenticated user has no privileges on any database object until they are explicitly granted to that individual user, to a role granted to the user as a default role, or to all users bundled as the user `PUBLIC`. When an object is created, only its creator (the owner) and `administrators` have privileges to it, and can grant privileges to other users, roles, or objects.

Different sets of privileges apply to different types of metadata objects. The different types of privileges will be described separately later in this section.

SCHEMA is currently a synonym for `DATABASE`; this may change in a future version, so
we recommend to always use DATABASE

The TO Clause

The TO clause specifies the users, roles, and other database objects that are to be granted the privileges enumerated in *privileges*. The clause is mandatory.

The optional USER keyword in the TO clause allow you to specify exactly who or what is granted the privilege. If a USER (or ROLE) keyword is not specified, the server first checks for a role with this name and, if there is no such role, the privileges are granted to the user with that name without further checking.

It is recommended to always explicitly specify USER and ROLE to avoid ambiguity. Future versions of Firebird may make USER mandatory.

- When a GRANT statement is executed, the security database is not checked for the existence of the grantee user. This is not a bug: SQL permissions are concerned with controlling data access for authenticated users, both native and trusted, and trusted operating system users are not stored in the security database.

- When granting a privilege to a database object other than user or role, such as a procedure, trigger or view, you must specify the object type.

- Although the USER keyword is optional, it is advisable to use it, to avoid ambiguity with roles.

- Privileges granted to a system privilege will be applied when the user is logged in with a role that has that system privilege.

Packaging Privileges in a ROLE Object

A role is a "container" object that can be used to package a collection of privileges. Use of the role is then granted to each user or role that requires those privileges. A role can also be granted to a list of users or roles.

The role must exist before privileges can be granted to it. See `CREATE ROLE` for the syntax and rules. The role is maintained by granting privileges to it and, when required, revoking privileges from it. When a role is dropped — see `DROP ROLE` — all users lose the privileges acquired through the role. Any privileges that were granted additionally to an affected user by way of a different grant statement are retained.

Unless the role is granted as a default role, a user that is granted a role must explicitly specify that role, either with their login credentials or activating it using `SET ROLE`, to exercise the associated privileges. Any other privileges granted to the user or received through default roles are not affected by explicitly specifying a role.

More than one role can be granted to the same user. Although only one role can be explicitly specified, multiple roles can be active for a user, either as default roles, or as roles granted to the current role.
A role can be granted to a user or to another role.

**Cumulative Roles**

The ability to grant roles to other roles and default roles results in so-called cumulative roles. Multiple roles can be active for a user, and the user receives the cumulative privileges of all those roles.

When a role is explicitly specified on connect or using `SET ROLE`, the user will assume all privileges granted to that role, including those privileges granted to the secondary roles (including roles granted on that secondary role, etc). Or in other words, when the primary role is explicitly specified, the secondary roles are also activated. The function `RDB$ROLE_IN_USE` can be used to check if a role is currently active.

See also **Default Roles** for the effects of `DEFAULT` with cumulative roles, and **The WITH ADMIN OPTION Clause** for effects on granting.

**Default Roles**

A role can be granted as a default role by prefixing the role with `DEFAULT` in the `GRANT` statement. Granting roles as a default role to users simplifies management of privileges, as this makes it possible to group privileges on a role and granting that group of privileges to a user without requiring the user to explicitly specify the role. Users can receive multiple default roles, granting them all privileges of those default roles.

The effects of a default role depend on whether the role is granted to a user or to another role:

- When a role is granted to a user as a default role, the role will be activated automatically, and its privileges will be applied to the user without the need to explicitly specify the role.

  Roles that are active by default are not returned from `CURRENT_ROLE`, but the function `RDB$ROLE_IN_USE` can be used to check if a role is currently active.

- When a role is granted to another role as a default role, the rights of that role will only be automatically applied to the user if the primary role is granted as a default role to the user, otherwise the primary role needs to be specified explicitly (in other words, it behaves the same as when the secondary role was granted without the `DEFAULT` clause).

For a linked list of granted roles, all roles need to be granted as a default role for them to be applied automatically. That is, for `GRANT DEFAULT ROLEA TO ROLE ROLEB, GRANT ROLEB TO ROLE ROLEC, GRANT DEFAULT ROLEC TO USER USER1` only `ROLEC` is active by default for `USER1`. To assume the privileges of `ROLEA` and `ROLEB`, `ROLEC` needs to be explicitly specified, or `ROLEB` needs to be granted `DEFAULT` to `ROLEC`.

**The User PUBLIC**

Firebird has a predefined user named `PUBLIC`, that represents all users. Privileges for operations on a particular object that are granted to the user `PUBLIC` can be exercised by any authenticated user.

> If privileges are granted to the user `PUBLIC`, they should be revoked from the user
The WITH GRANT OPTION Clause

The optional WITH GRANT OPTION clause allows the users specified in the user list to grant the privileges specified in the privilege list to other users.

It is possible to assign this option to the user PUBLIC. Do not do this!

The GRANTED BY Clause

By default, when privileges are granted in a database, the current user is recorded as the grantor. The GRANTED BY clause enables the current user to grant those privileges as another user.

When using the REVOKE statement, it will fail if the current user is not the user that was named in the GRANTED BY clause.

The GRANTED BY (and AS) clause can be used only by the database owner and other administrators. The object owner cannot use GRANTED BY unless they also have administrator privileges.

Alternative Syntax Using AS username

The non-standard AS clause is supported as a synonym of the GRANTED BY clause to simplify migration from other database systems.

Privileges on Tables and Views

For tables and views, unlike other metadata objects, it is possible to grant several privileges at once.

List of Privileges on Tables

SELECT
Permits the user or object to SELECT data from the table or view

INSERT
Permits the user or object to INSERT rows into the table or view

DELETE
Permits the user or object to DELETE rows from the table or view

UPDATE
Permits the user or object to UPDATE rows in the table or view, optionally restricted to specific columns

REFERENCES
Permits the user or object to reference the table via a foreign key, optionally restricted to the specified columns. If the primary or unique key referenced by the foreign key of the other table is composite then all columns of the key must be specified.
ALL [PRIVILEGES]
Combines SELECT, INSERT, UPDATE, DELETE and REFERENCES privileges in a single package

Examples of GRANT <privilege> on Tables

1. SELECT and INSERT privileges to the user ALEX:

   GRANT SELECT, INSERT ON TABLE SALES
   TO USER ALEX;

2. The SELECT privilege to the MANAGER, ENGINEER roles and to the user IVAN:

   GRANT SELECT ON TABLE CUSTOMER
   TO ROLE MANAGER, ROLE ENGINEER, USER IVAN;

3. All privileges to the ADMINISTRATOR role, together with the authority to grant the same privileges to others:

   GRANT ALL ON TABLE CUSTOMER
   TO ROLE ADMINISTRATOR
   WITH GRANT OPTION;

4. The SELECT and REFERENCES privileges on the NAME column to all users and objects:

   GRANT SELECT, REFERENCES (NAME) ON TABLE COUNTRY
   TO PUBLIC;

5. The SELECT privilege being granted to the user IVAN by the user ALEX:

   GRANT SELECT ON TABLE EMPLOYEE
   TO USER IVAN
   GRANTED BY ALEX;

6. Granting the UPDATE privilege on the FIRST_NAME, LAST_NAME columns:

   GRANT UPDATE (FIRST_NAME, LAST_NAME) ON TABLE EMPLOYEE
   TO USER IVAN;

7. Granting the INSERT privilege to the stored procedure ADD_EMP_PROJ:

   GRANT INSERT ON EMPLOYEE_PROJECT
   TO PROCEDURE ADD_EMP_PROJ;
**The EXECUTE Privilege**

The EXECUTE privilege applies to stored procedures, stored functions (including UDFs), and packages. It allows the grantee to execute the specified object, and, if applicable, to retrieve its output.

In the case of selectable stored procedures, it acts somewhat like a SELECT privilege, insofar as this style of stored procedure is executed in response to a SELECT statement.

For packages, the EXECUTE privilege can only be granted for the package as a whole, not for individual subroutines.

**Examples of Granting the EXECUTE Privilege**

1. Granting the EXECUTE privilege on a stored procedure to a role:

   ```sql
   GRANT EXECUTE ON PROCEDURE ADD_EMP_PROJ TO ROLE MANAGER;
   ```

2. Granting the EXECUTE privilege on a stored function to a role:

   ```sql
   GRANT EXECUTE ON FUNCTION GET_BEGIN_DATE TO ROLE MANAGER;
   ```

3. Granting the EXECUTE privilege on a package to user PUBLIC:

   ```sql
   GRANT EXECUTE ON PACKAGE APP_VAR TO USER PUBLIC;
   ```

4. Granting the EXECUTE privilege on a function to a package:

   ```sql
   GRANT EXECUTE ON FUNCTION GET_BEGIN_DATE TO PACKAGE APP_VAR;
   ```

**The USAGE Privilege**

To be able to use metadata objects other than tables, views, stored procedures or functions, triggers and packages, it is necessary to grant the user (or database object like trigger, procedure or function) the USAGE privilege on these objects.

By default, Firebird executes PSQL modules with the privileges of the caller, so it is necessary that either the user or otherwise the routine itself has been granted the USAGE privilege. This can be changed with the SQL SECURITY clause of the DDL statements of those objects.

The USAGE privilege is currently only available for exceptions and sequences (in `gen_id(gen_name, n)` or `next value for gen_name`). Support for the USAGE privilege...
for other metadata objects may be added in future releases.

For sequences (generators), the `USAGE` privilege only grants the right to increment the sequence using the `GEN_ID` function or `NEXT VALUE FOR`. The `SET GENERATOR` statement is a synonym for `ALTER SEQUENCE ... RESTART WITH ...`, and is considered a DDL statement. By default, only the owner of the sequence and administrators have the rights to such operations. The right to set the initial value of any sequence can be granted with `GRANT ALTER ANY SEQUENCE`, which is not recommend for general users.

**Examples of Granting the `USAGE` Privilege**

1. Granting the `USAGE` privilege on a sequence to a role:

   ```sql
   GRANT USAGE ON SEQUENCE GEN_AGE TO ROLE MANAGER;
   ```

2. Granting the `USAGE` privilege on a sequence to a trigger:

   ```sql
   GRANT USAGE ON SEQUENCE GEN_AGE TO TRIGGER TR_AGE_BI;
   ```

3. Granting the `USAGE` privilege on an exception to a package:

   ```sql
   GRANT USAGE ON EXCEPTION TO PACKAGE PKG_BILL;
   ```

**DDL Privileges**

By default, only administrators can create new metadata objects. Altering or dropping these objects is restricted to the owner of the object (its creator) and administrators. DDL privileges can be used to grant privileges for these operations to other users.

**Available DDL Privileges**

**CREATE**

Allows creation of an object of the specified type

**ALTER ANY**

Allows modification of any object of the specified type

**DROP ANY**

Allows deletion of any object of the specified type

**ALL [PRIVILEGES]**

Combines the `CREATE`, `ALTER ANY` and `DROP ANY` privileges for the specified type
There are no separate DDL privileges for triggers and indexes. The necessary privileges are inherited from the table or view. Creating, altering or dropping a trigger or index requires the `ALTER ANY TABLE` or `ALTER ANY VIEW` privilege.

**Examples of Granting DDL Privileges**

1. Allow user JOE to create tables

   ```sql
   GRANT CREATE TABLE
       TO USER Joe;
   ```

2. Allow user JOE to alter any procedure

   ```sql
   GRANT ALTER ANY PROCEDURE
       TO USER Joe;
   ```

**Database DDL Privileges**

The syntax for granting privileges to create, alter or drop a database deviates from the normal syntax of granting DDL privileges for other object types.

**Available Database DDL Privileges**

- **CREATE**
  
  Allows creation of a database

- **ALTER**

  Allows modification of the current database

- **DROP**

  Allows deletion of the current database

- **ALL [PRIVILEGES]**

  Combines the ALTER and DROP privileges. `ALL` does not include the CREATE privilege.

The `ALTER DATABASE` and `DROP DATABASE` privileges apply only to the current database, whereas DDL privileges `ALTER ANY` and `DROP ANY` on other object types apply to all objects of the specified type in the current database. The privilege to alter or drop the current database can only be granted by administrators.

The `CREATE DATABASE` privilege is a special kind of privilege as it is saved in the security database. A list of users with the `CREATE DATABASE` privilege is available from the virtual table `SEC$DB_CREATORS`. Only administrators in the security database can grant the privilege to create a new database.

**SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE**
Examples of Granting Database DDL Privileges

1. Granting SUPERUSER the privilege to create databases:

   ```sql
   GRANT CREATE DATABASE
   TO USER Superuser;
   ```

2. Granting JOE the privilege to execute ALTER DATABASE for the current database:

   ```sql
   GRANT ALTER DATABASE
   TO USER Joe;
   ```

3. Granting FEDOR the privilege to drop the current database:

   ```sql
   GRANT DROP DATABASE
   TO USER Fedor;
   ```

Assigning Roles

Assigning a role is similar to granting a privilege. One or more roles can be assigned to one or more users, including the user PUBLIC, using one GRANT statement.

The WITH ADMIN OPTION Clause

The optional WITH ADMIN OPTION clause allows the users specified in the user list to grant the role(s) specified to other users or roles.

It is possible to assign this option to PUBLIC. Do not do this!

For cumulative roles, a user can only exercise the WITH ADMIN OPTION of a secondary role if all intermediate roles are also granted WITH ADMIN OPTION. That is, GRANT ROLEA TO ROLE ROLEB WITH ADMIN OPTION, GRANT ROLEB TO ROLE ROLEC, GRANT ROLEC TO USER USER1 WITH ADMIN OPTION only allows USER1 to grant ROLEC to other users or roles, while using GRANT ROLEB TO ROLE ROLEC WITH ADMIN OPTION allows USER1 to grant ROLEA, ROLEB and ROLEC to other users.

Examples of Role Assignment

1. Assigning the DIRECTOR and MANAGER roles to the user IVAN:

   ```sql
   GRANT DIRECTOR, MANAGER
   TO USER IVAN;
   ```

2. Assigning the MANAGER role to the user ALEX with the authority to assign this role to other users:

   ```sql
   GRANT MANAGER
   ```
3. Assigning the DIRECTOR role to user ALEX as a default role:

```
GRANT DEFAULT DIRECTOR
TO USER ALEX;
```

4. Assigning the MANAGER role to role DIRECTOR:

```
GRANT MANAGER
TO ROLE DIRECTOR;
```

See also

**REVOKE**

### 14.6. Statements for Revoking Privileges

A REVOKE statement is used for revoking privileges—including roles—from users and other database objects.

#### 14.6.1. REVOKE

Revokes privileges or role assignments

*Available in*

DSQL, ESQL

**Syntax (revoking privileges)**

```
REVOKE [GRANT OPTION FOR] <privileges>
FROM <grantee_list>
[{{GRANTED BY | AS} [USER] grantor}]
```

<privileges> ::=  
!! See **GRANT syntax** !!

**Syntax (revoking roles)**

```
REVOKE [ADMIN OPTION FOR] <role_granted_list>
FROM <role_grantee_list>
[{{GRANTED BY | AS} [USER] grantor}]
```

<role_granted_list> ::=  
!! See **GRANT syntax** !!

<role_grantee_list> ::=  
Syntax (revoking all)

REVOKE ALL ON ALL FROM <grantee_list>

<grantee_list> ::= ! See GRANT syntax !!

Table 263. REVOKE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>grantor</td>
<td>The grantor user on whose behalf the privilege(s) are being revoked</td>
</tr>
</tbody>
</table>

The REVOKE statement revokes privileges that were granted using the GRANT statement from users, roles, and other database objects. See GRANT for detailed descriptions of the various types of privileges.

Only the user who granted the privilege can revoke it.

The DEFAULT Clause

When the DEFAULT clause is specified, the role itself is not revoked, only its DEFAULT property is removed without revoking the role itself.

The FROM Clause

The FROM clause specifies a list of users, roles and other database objects that will have the enumerated privileges revoked. The optional USER keyword in the FROM clause allow you to specify exactly which type is to have the privilege revoked. If a USER (or ROLE) keyword is not specified, the server first checks for a role with this name and, if there is no such role, the privileges are revoked from the user with that name without further checking.

- Although the USER keyword is optional, it is advisable to use them to avoid ambiguity with roles.
- The REVOKE statement does not check for the existence of the user from which the privileges are being revoked.
- When revoking a privilege from a database object other than USER or ROLE, you must specify its object type.

Revoking Privileges from user PUBLIC

Privileges that were granted to the special user named PUBLIC must be revoked from the user PUBLIC. User PUBLIC provides a way to grant privileges to all users at once, but it is not “a group of users”.
Revoking the GRANT OPTION

The optional GRANT OPTION FOR clause revokes the user’s privilege to grant the specified privileges to other users, roles, or database objects (as previously granted with the WITH GRANT OPTION). It does not revoke the specified privilege itself.

Removing the Privilege to One or More Roles

One usage of the REVOKE statement is to remove roles that were assigned to a user, or a group of users, by a GRANT statement. In the case of multiple roles and/or multiple grantees, the REVOKE verb is followed by the list of roles that will be removed from the list of users specified after the FROM clause.

The optional ADMIN OPTION FOR clause provides the means to revoke the grantee’s “administrator” privilege, the ability to assign the same role to other users, without revoking the grantee's privilege to the role.

Multiple roles and grantees can be processed in a single statement.

Revoking Privileges That Were GRANTED BY

A privilege that has been granted using the GRANTED BY clause is internally attributed explicitly to the grantor designated by that original GRANT statement. Only that user can revoke the granted privilege. Using the GRANTED BY clause you can revoke privileges as if you are the specified user. To revoke a privilege with GRANTED BY, the current user must be logged in either with full administrative privileges, or as the user designated as grantor by that GRANTED BY clause.

Not even the owner of a role can use GRANTED BY unless they have administrative privileges.

The non-standard AS clause is supported as a synonym of the GRANTED BY clause to simplify migration from other database systems.

Revoking ALL ON ALL

The REVOKE ALL ON ALL statement allows a user to revoke all privileges (including roles) on all object from one or more users, roles or other database objects. It is a quick way to “clear” privileges when access to the database must be blocked for a particular user or role.

When the current user is logged in with full administrator privileges in the database, the REVOKE ALL ON ALL will remove all privileges, no matter who granted them. Otherwise, only the privileges granted by the current user are removed.

The GRANTED BY clause is not supported with ALL ON ALL.

Examples using REVOKE

1. Revoking the privileges for selecting and inserting into the table (or view) SALES
2. Revoking the privilege for selecting from the CUSTOMER table from the MANAGER and ENGINEER roles and from the user IVAN:

   REVOKE SELECT ON TABLE CUSTOMER
   FROM ROLE MANAGER, ROLE ENGINEER, USER IVAN;

3. Revoking the privilege for selecting from the SALES table from the user ALEX:

   REVOKE SELECT, INSERT ON TABLE SALES
   FROM USER ALEX;

4. Revoking the privilege for selecting from the COUNTRY table and the privilege to reference the NAME column of the COUNTRY table from any user, via the special user PUBLIC:

   REVOKE SELECT, REFERENCES (NAME) ON TABLE COUNTRY
   FROM PUBLIC;

5. Revoking the privilege for selecting form the EMPLOYEE table from the user IVAN, that was granted by the user ALEX:

   REVOKE SELECT ON TABLE EMPLOYEE
   FROM USER IVAN GRANTED BY ALEX;

6. Revoking the privilege for updating the FIRST_NAME and LAST_NAME columns of the EMPLOYEE table from the user IVAN:

   REVOKE UPDATE (FIRST_NAME, LAST_NAME) ON TABLE EMPLOYEE
   FROM USER IVAN;

7. Revoking the privilege for inserting records into the EMPLOYEE_PROJECT table from the ADD_EMP_PROJ procedure:

   REVOKE INSERT ON EMPLOYEE_PROJECT
   FROM PROCEDURE ADD_EMP_PROJ;

8. Revoking the privilege for executing the procedure ADD_EMP_PROJ from the MANAGER role:
9. Revoking the privilege to grant the EXECUTE privilege for the function GET_BEGIN_DATE to other users from the role MANAGER:

```sql
REVOKE GRANT OPTION FOR EXECUTE
ON FUNCTION GET_BEGIN_DATE
FROM ROLE MANAGER;
```

10. Revoking the EXECUTE privilege on the package DATE_UTILS from user ALEX:

```sql
REVOKE EXECUTE ON PACKAGE DATE_UTILS
FROM USER ALEX;
```

11. Revoking the USAGE privilege on the sequence GEN_AGE from the role MANAGER:

```sql
REVOKE USAGE ON SEQUENCE GEN_AGE
FROM ROLE MANAGER;
```

12. Revoking the USAGE privilege on the sequence GEN_AGE from the trigger TR_AGE_BI:

```sql
REVOKE USAGE ON SEQUENCE GEN_AGE
FROM TRIGGER TR_AGE_BI;
```

13. Revoking the USAGE privilege on the exception E_ACCESS_DENIED from the package PKG_BILL:

```sql
REVOKE USAGE ON EXCEPTION E_ACCESS_DENIED
FROM PACKAGE PKG_BILL;
```

14. Revoking the privilege to create tables from user JOE:

```sql
REVOKE CREATE TABLE
FROM USER Joe;
```

15. Revoking the privilege to alter any procedure from user JOE:

```sql
REVOKE ALTER ANY PROCEDURE
FROM USER Joe;
```

16. Revoking the privilege to create databases from user SUPERUSER:
REVOKE CREATE DATABASE FROM USER Superuser;

17. Revoking the DIRECTOR and MANAGER roles from the user IVAN:

REVOKE DIRECTOR, MANAGER FROM USER IVAN;

18. Revoke from the user ALEX the privilege to grant the MANAGER role to other users:

REVOKE ADMIN OPTION FOR MANAGER FROM USER ALEX;

19. Revoking all privileges (including roles) on all objects from the user IVAN:

REVOKE ALL ON ALL FROM USER IVAN;

After this statement is executed by an administrator, the user IVAN will have no privileges whatsoever, except those granted through PUBLIC.

20. Revoking the DEFAULT property of the DIRECTOR role from user ALEX, while the role itself remains granted:

REVOKE DEFAULT DIRECTOR FROM USER ALEX;

See also

GRANT

14.7. Mapping of Users to Objects

Now Firebird support multiple security databases, new problems arise that could not occur with a single, global security database. Clusters of databases using the same security database are effectively separated. Mappings provide the means to achieve the same effect when multiple databases are using their own security databases. Some cases require control for limited interaction between such clusters. For example:

• when EXECUTE STATEMENT ON EXTERNAL DATA SOURCE requires data exchange between clusters
• when server-wide SYSDBA access to databases is needed from other clusters, using services.
• On Windows, due to support for Trusted User authentication: to map Windows users to a Firebird user and/or role. An example is the need for a ROLE granted to a Windows group to be assigned automatically to members of that group.

The single solution for all such cases is mapping the login information assigned to a user when it
connects to a Firebird server to internal security objects in a database—CURRENT_USER and CURRENT_ROLE.

14.7.1. The Mapping Rule

The mapping rule consists of four pieces of information:

1. mapping scope — whether the mapping is local to the current database or whether its effect is to be global, affecting all databases in the cluster, including security databases
2. mapping name — an SQL identifier, since mappings are objects in a database, like any other
3. the object FROM which the mapping maps. It consists of four items:
   - The authentication source
     - plugin name or
     - the product of a mapping in another database or
     - use of server-wide authentication or
     - any method
   - The name of the database where authentication succeeded
   - The name of the object from which mapping is performed
   - The type of that name — username, role, or OS group — depending upon the plugin that added that name during authentication.

   Any item is accepted but only type is required.

4. the object TO which the mapping maps. It consists of two items:
   - The name of the object TO which mapping is performed
   - The type, for which only USER or ROLE is valid

14.7.2. CREATE MAPPING

Creates a mapping of a security object

Available in

DSQL

Syntax

```
CREATE [GLOBAL] MAPPING name
USING
   { PLUGIN plugin_name [IN database]
   | ANY PLUGIN [IN database | SERVERWIDE]
   | MAPPING [IN database] | '*' [IN database] }
FROM {ANY type | type from_name}
TO {USER | ROLE} [to_name]
```
Table 264. CREATE MAPPING Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Mapping name The maximum length is 63 characters. Must be unique among all mapping names in the context (local or GLOBAL).</td>
</tr>
<tr>
<td>plugin_name</td>
<td>Authentication plugin name</td>
</tr>
<tr>
<td>database</td>
<td>Name of the database that authenticated against</td>
</tr>
<tr>
<td>type</td>
<td>The type of object to be mapped. Possible types are plugin-specific.</td>
</tr>
<tr>
<td>from_name</td>
<td>The name of the object to be mapped</td>
</tr>
<tr>
<td>to_name</td>
<td>The name of the user or role to map to</td>
</tr>
</tbody>
</table>

The `CREATE MAPPING` statement creates a mapping of security objects (e.g. users, groups, roles) of one or more authentication plugins to internal security objects — CURRENT_USER and CURRENT_ROLE.

If the `GLOBAL` clause is present, then the mapping will be applied not only for the current database, but for all databases in the same cluster, including security databases.

- There can be global and local mappings with the same name. They are distinct objects.
- Global mapping works best if a Firebird 3.0 or higher version database is used as the security database. If you plan to use another database for this purpose — using your own provider, for example — then you should create a table in it named RDB$MAP, with the same structure as RDB$MAP in a Firebird 3.0 or higher database and with SYSDBA-only write access.

The `USING` clause describes the mapping source. It has a complex set of options:

- an explicit plugin name (`PLUGIN plugin_name`) means it applies only for that plugin
- it can use any available plugin (`ANY PLUGIN`); although not if the source is the product of a previous mapping
- it can be made to work only with server-wide plugins (`SERVERWIDE`)
- it can be made to work only with previous mapping results (`MAPPING`)
- you can omit to use of a specific method by using the asterisk (`*`) argument
- it can specify the name of the database that defined the mapping for the FROM object (`IN database`)

This argument is not valid for mapping server-wide authentication.

The `FROM` clause describes the object to map. The `FROM` clause has a mandatory argument, the `type` of the object named. It has the following options:

- When mapping names from plugins, `type` is defined by the plugin
- When mapping the product of a previous mapping, `type` can be only USER or ROLE
• If an explicit *from_name* is provided, it will be taken into account by this mapping
• Use the *ANY* keyword to work with any name of the given type.

The `TO` clause specifies the user or role that is the result of the mapping. The `to_name` is optional. If it is not specified, then the original name of the mapped object will be used.

For roles, the role defined by a mapping rule is only applied when the user does not explicitly specify a role on connect. The mapped role can be assumed later in the session using `SET TRUSTED ROLE`, even when the mapped role is not explicitly granted to the user.

**Who Can Create a Mapping**

The `CREATE MAPPING` statement can be executed by:

• Administrators
• The database owner — if the mapping is local
• Users with the `CHANGE_MAPPING_RULES` system privilege — if the mapping is local

**CREATE MAPPING examples**

1. Enable use of Windows trusted authentication in all databases that use the current security database:

   ```sql
   CREATE GLOBAL MAPPING TRUSTED_AUTH
   USING PLUGIN WIN_SSPI
   FROM ANY USER
   TO USER;
   ```

2. Enable RDB$ADMIN access for windows admins in the current database:

   ```sql
   CREATE MAPPING WIN_ADMINS
   USING PLUGIN WIN_SSPI
   FROM Predefined_Group
   DOMAIN_ANY_RID_ADMINS
   TO ROLE RDB$ADMIN;
   ```

   The group `DOMAIN_ANY_RID_ADMINS` does not exist in Windows, but such a name would be added by the `Win_Sspi` plugin to provide exact backwards compatibility.

3. Enable a particular user from another database to access the current database with another name:

   ```sql
   CREATE MAPPING FROM_RT
   USING PLUGIN SRP IN "rt"
   ```
FROM USER U1 TO USER U2;

Database names or aliases will need to be enclosed in double quotes on operating systems that have case-sensitive file names.

4. Enable the server's SYSDBA (from the main security database) to access the current database. (Assume that the database is using a non-default security database):

```sql
CREATE MAPPING DEF_SYSDBA
    USING PLUGIN SRP IN "security.db"
    FROM USER SYSDBA
    TO USER;
```

5. Ensure users who logged in using the legacy authentication plugin do not have too many privileges:

```sql
CREATE MAPPING LEGACY_2_GUEST
    USING PLUGIN legacy_auth
    FROM ANY USER
    TO USER GUEST;
```

See also
ALTER MAPPING, CREATE OR ALTER MAPPING, DROP MAPPING

14.7.3. ALTER MAPPING

Alters a mapping of a security object

Available in
DSQL

Syntax

```
ALTER [GLOBAL] MAPPING name
    USING
    { PLUGIN plugin_name [IN database]
    | ANY PLUGIN [IN database | SERVERWIDE]
    | MAPPING [IN database] | '*' [IN database] } FROM {ANY type | type from_name}
    TO {USER | ROLE} [to_name]
```

For details on the options, see CREATE MAPPING.

The ALTER MAPPING statement allows you to modify any of the existing mapping options, but a local mapping cannot be changed to GLOBAL or vice versa.
Who Can Alter a Mapping

The ALTER MAPPING statement can be executed by:

- Administrators
- The database owner — if the mapping is local
- Users with the CHANGE_MAPPING_RULES system privilege — if the mapping is local

ALTER MAPPING examples

Alter mapping

```sql
ALTER MAPPING FROM_RT USING PLUGIN SRP IN "rt" FROM USER U1 TO USER U3;
```

See also

CREATE MAPPING, CREATE OR ALTER MAPPING, DROP MAPPING

14.7.4. CREATE OR ALTER MAPPING

Creates a mapping of a security object if it doesn’t exist, or alters a mapping

Available in

DSQL

Syntax

```sql
CREATE OR ALTER [GLOBAL] MAPPING name USING
    { PLUGIN plugin_name [IN database]
    | ANY PLUGIN [IN database | SERVERWIDE]
    | MAPPING [IN database] | '*' [IN database] }
FROM {ANY type | type from_name}
TO {USER | ROLE} [to_name]
```

For details on the options, see CREATE MAPPING.

The CREATE OR ALTER MAPPING statement creates a new or modifies an existing mapping.

Global and local mappings of the same name are different objects.

CREATE OR ALTER MAPPING examples
Creating or altering a mapping

CREATE OR ALTER MAPPING FROM_RT
USING PLUGIN SRP IN "rt"
FROM USER U1 TO USER U4;

See also
CREATE MAPPING, ALTER MAPPING, DROP MAPPING

14.7.5. DROP MAPPING

Drops a mapping of a security object

Available in
DSQL

Syntax

DROP [GLOBAL] MAPPING name

Table 265. DROP MAPPING Statement Parameter

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>name</td>
<td>Mapping name</td>
</tr>
</tbody>
</table>

The DROP MAPPING statement removes an existing mapping. If GLOBAL is specified, then a global mapping will be removed.

Global and local mappings of the same name are different objects.

Who Can Drop a Mapping

The DROP MAPPING statement can be executed by:

- Administrators
- The database owner — if the mapping is local
- Users with the CHANGE_MAPPING_RULES system privilege — if the mapping is local

DROP MAPPING examples

Alter mapping

DROP MAPPING FROM_RT;

See also
CREATE MAPPING
14.8. Database Encryption

Firebird provides a plugin mechanism to encrypt the data stored in the database. This mechanism does not encrypt the entire database, but only data pages, index pages, and blob pages.

To make database encryption possible, you need to obtain or write a database encryption plugin.

Out of the box, Firebird does not include a database encryption plugin.

The encryption plugin example in `examples/dbcrypt` does not perform real encryption, it is only intended as an example how such a plugin can be written.

On Linux, an example plugin named `libDbCrypt_example.so` can be found in `plugins/`.

The main problem with database encryption is how to store the secret key. Firebird provides support for transferring the key from the client, but this does not mean that storing the key on the client is the best way; it is one of several alternatives. However, keeping encryption keys on the same disk as the database is an insecure option.

For efficient separation of encryption and key access, the database encryption plugin data is divided into two parts, the encryption itself and the holder of the secret key. This can be an efficient approach when you want to use a good encryption algorithm, but you have your own custom method of storing the keys.

Once you have decided on the plugin and key-holder, you can perform the encryption.

14.8.1. Encrypting a Database

Encrypts the database using the specified encryption plugin

**Syntax**

```
ALTER {DATABASE | SCHEMA}
    ENCRYPT WITH plugin_name [KEY key_name]
```

**Table 266. ALTER DATABASE ENCRYPT Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>plugin_name</td>
<td>The name of the encryption plugin</td>
</tr>
<tr>
<td>key_name</td>
<td>The name of the encryption key</td>
</tr>
</tbody>
</table>

Encryption starts immediately after this statement completes, and will be performed in the background. Normal operations of the database are not disturbed during encryption.

The optional `KEY` clause specifies the name of the key for the encryption plugin. The plugin decides what to do with this key name.

The encryption process can be monitored using the `MON$CRYPT_PAGE` field in the
MON$DATABASE virtual table, or viewed in the database header page using gstat -e. gstat -h will also provide limited information about the encryption status.

For example, the following query will display the progress of the encryption process as a percentage.

```
select MON$CRYPT_PAGE * 100 / MON$PAGES
from MON$DATABASE;
```

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

See also
Decrypting a Database, ALTER DATABASE

14.8.2. Decrypting a Database

Decrypts the database using the configured plugin and key

**Syntax**

```
ALTER {DATABASE | SCHEMA} DECRYPT
```

Decryption starts immediately after this statement completes, and will be performed in the background. Normal operations of the database are not disturbed during decryption.

SCHEMA is currently a synonym for DATABASE; this may change in a future version, so we recommend to always use DATABASE

See also
Encrypting a Database, ALTER DATABASE

14.9. SQL Security

The SQL SECURITY clause of various DDL statements enables executable objects (triggers, stored procedures, stored functions) to be defined to run in a specific context of privileges.

The SQL Security feature has two contexts: INVOKER and DEFINER. The INVOKER context corresponds to the privileges available to the current user or the calling object, while DEFINER corresponds to those available to the owner of the object.

The SQL SECURITY property is an optional part of an object’s definition that can be applied to the object with DDL statements. The property cannot be dropped, but it can be changed from INVOKER to DEFINER and vice versa.

This is not the same thing as SQL privileges, which are applied to users and database objects to give them various types of access to other database objects. When an executable object in Firebird needs
access to a table, view or another executable object, the target object is not accessible if the invoker does not have the necessary privileges on that object. That is, by default all executable objects have the SQL SECURITY INVOKER property, and any caller lacking the necessary privileges will be rejected. The default SQL Security behaviour of a database can be overridden using `ALTER DATABASE`.

If a routine has the SQL SECURITY DEFINER property applied, the invoking user or routine will be able to execute it if the required privileges have been granted to its owner, without the need for the caller to be granted those privileges as well.

In summary:

- If INVOKER is set, the access rights for executing the call to an executable object are determined by checking the current user's active set of privileges
- If DEFINER is set, the access rights of the object owner will be applied instead, regardless of the current user's active set of privileges.
Chapter 15. Management Statements

Management statements are a class of SQL statements for administering aspects of the client/server environment, usually for the current session. Typically, such statements start with the verb `SET`.

The `isql` tool also has a collection of `SET` commands. Those commands are not part of Firebird's SQL lexicon. For information on `isql`'s `SET` commands, see `Isql Set Commands` in `Firebird Interactive SQL Utility`.

Management statements can run anywhere DSQL can run, but typically, the developer will want to run a management statement in a database trigger. A subset of management statements can be used directly in PSQL modules without the need to wrap them in an `EXECUTE STATEMENT` block. For more details of the current set, see `Management Statements in PSQL` in the PSQL chapter.

Most of the management statements affect the current connection (attachment, or “session”) only, and do not require any authorization over and above the login privileges of the current user without elevated privileges.

Some management statements operate beyond the scope of the current session. Examples are the `ALTER DATABASE {BEGIN | END} BACKUP` statements to control the “copy-safe” mode, or the `ALTER EXTERNAL CONNECTIONS POOL` statements to manage connection pooling. A set of `system privileges`, analogous with SQL privileges granted for database objects, is provided to enable the required authority to run a specific management statement in this category.

Some statements of this class use the verb `ALTER`, although management statements should not be confused with DDL `ALTER` statements that modify database objects like tables, views, procedures, roles, et al.

Although some `ALTER DATABASE` clauses (e.g. `BEGIN BACKUP`) can be considered as management statements, they are documented in the `DDL` chapter.

Unless explicitly mentioned otherwise in an “Available in” section, management statements are available in DSQL and PSQL. Availability in ESQL is not tracked by this Language Reference.

15.1. Data Type Behaviour

15.1.1. SET BIND (Data Type Coercion Rules)

Configures data type coercion rules for the current session

Syntax

```
SET BIND OF <type_from> TO <type_to>
```

```
<type_from> ::=  
   <scalar_datatype>  
   | <blob_datatype>  
   | TIME ZONE
```
This statement makes it possible to substitute one data type with another when performing client-server interactions. In other words, `type_from` returned by the engine is represented as `type_to` in the client API.

Only fields returned by the database engine in regular messages are substituted according to these rules. Variables returned as an array slice are not affected by the `SET BIND` statement.

When a partial type definition is used (e.g. `CHAR` instead of `CHAR(n)`) in `from_type`, the coercion is performed for all `CHAR` columns. The special partial type `TIME ZONE` stands for `TIME WITH TIME ZONE` and `TIMESTAMP WITH TIME ZONE`. When a partial type definition is used in `to_type`, the engine defines missing details about that type automatically based on source column.

Changing the binding of any `NUMERIC` or `DECIMAL` data type does not affect the underlying integer type. In contrast, changing the binding of an integer data type also affects appropriate `NUMERIC` and `DECIMAL` types. For example, `SET BIND OF INT128 TO DOUBLE PRECISION` will also map `NUMERIC` and `DECIMAL` with precision 19 or higher, as these types use INT128 as their underlying type.

The special type `LEGACY` is used when a data type, missing in previous Firebird version, should be represented in a way, understandable by old client software (possibly with data loss). The coercion rules applied in this case are shown in the table below.

<table>
<thead>
<tr>
<th>Native data type</th>
<th>Legacy data type</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOOLEAN</td>
<td>CHAR(5)</td>
</tr>
<tr>
<td>DECFLOAT</td>
<td>DOUBLE PRECISION</td>
</tr>
<tr>
<td>INT128</td>
<td>BIGINT</td>
</tr>
<tr>
<td>TIME WITH TIME ZONE</td>
<td>TIME WITHOUT TIME ZONE</td>
</tr>
<tr>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>TIMESTAMP WITHOUT TIME ZONE</td>
</tr>
</tbody>
</table>

Using `EXTENDED` for `type_to` causes the engine to coerce to an extended form of the `type_from` data type.
type. Currently, this works only for TIME/TIMESTAMP WITH TIME ZONE, they are coerced to EXTENDED TIME/TIMESTAMP WITH TIME ZONE. The EXTENDED type contains both the time zone name, and the corresponding GMT offset, so it remains usable if the client application cannot process named time zones properly (e.g. due to the missing ICU library).

Setting a binding to NATIVE resets the existing coercion rule for this data type and returns it in its native format.

The initial bind rules of a connection be configured through the DPB by providing a semicolon separated list of <type_from> TO <type_to> options as the string value of isc_dpb_set_bind.

Execution of ALTER SESSION RESET will revert to the binding rules configured through the DPB, or otherwise the system default.

It is also possible to configure a default set of data type coercion rules for all clients through the DataTypeCompatibility configuration option, either as a global configuration in firebird.conf or per database in databases.conf.

DataTypeCompatibility currently has two possible values: 3.0 and 2.5. The 3.0 option maps data types introduced after Firebird 3.0—in particular DECIMAL/NUMERIC with precision 19 or higher, INT128, DECFLOAT, and TIME/TIMESTAMP WITH TIME ZONE—to data types supported in Firebird 3.0. The 2.5 option also converts the BOOLEAN data type.

See the Native to LEGACY coercion rules for details. This setting allows legacy client applications to work with Firebird 5.0 without recompiling or otherwise adjusting them to understand the new data types.

**SET BIND Examples**

```sql
-- native
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;

CAST
---------------------
123.45

-- double
SET BIND OF DECFLOAT TO DOUBLE PRECISION;
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;

CAST
---------------------
123.45000000000000

-- still double
SET BIND OF DECFLOAT(34) TO CHAR;
SELECT CAST('123.45' AS DECFLOAT(16)) FROM RDB$DATABASE;
```
CAST
=======================
123.45000000000

-- text
SELECT CAST('123.45' AS DECFLOAT(34)) FROM RDB$DATABASE;

CAST
=======================
123.45

In the case of missing ICU on the client side:

SELECT CURRENT_TIMESTAMP FROM RDB$DATABASE;

CURRENT_TIMESTAMP
==========================================
2020-02-21 16:26:48.0230 GMT*

SET BIND OF TIME ZONE TO EXTENDED;
SELECT CURRENT_TIMESTAMP FROM RDB$DATABASE;

CURRENT_TIMESTAMP
==========================================
2020-02-21 19:26:55.6820 +03:00

### 15.1.2. SET DECFLOAT

Configures DECFLOAT rounding and error behaviour for the current session

**Syntax**

```sql
SET DECFLOAT
   { ROUND <round_mode>
   | TRAPS TO [<trap_opt> [, <trap_opt> ...]] }
```

`<round_mode>` ::= 
- CEILING | UP | HALF_UP | HALF_EVEN |
- HALF_DOWN | DOWN | FLOOR | REROUND

`<trap_opt>` ::= 
- DIVISION_BY_ZERO | INEXACT | INVALID_OPERATION |
- OVERFLOW | UNDERFLOW

**SET DECFLOAT ROUND**

SET DECFLOAT ROUND changes the rounding behaviour of operations on DECFLOAT. The default rounding mode is HALF_UP. The initial configuration of a connection can also be specified using the
DPB tag isc_dpb_decfloat_round with the desired \textit{round_mode} as string value.

The valid rounding modes are:

- \textbf{CEILING} \quad \text{towards $+\infty$}
- \textbf{UP} \quad \text{away from 0}
- \textbf{HALF_UP} \quad \text{to nearest, if equidistant, then up (default)}
- \textbf{HALF_EVEN} \quad \text{to nearest, if equidistant, ensure last digit in the result will be even}
- \textbf{HALF_DOWN} \quad \text{to nearest, if equidistant, then down}
- \textbf{DOWN} \quad \text{towards 0}
- \textbf{FLOOR} \quad \text{towards $-\infty$}
- \textbf{REROUND} \quad \text{up if digit to be rounded is 0 or 5, down in other cases}

The current value for the connection can be found using \texttt{RDB$\text{GET\_CONTEXT($\text{\texttt{\textsc{SYSTEM}}}$, 'DECFLOAT\_ROUND')}\).}

Execution of \texttt{ALTER SESSION RESET} will revert to the value configured through the DPB, or otherwise the system default.

\textbf{SET DECFLOAT TRAPS}

\texttt{SET DECFLOAT TRAPS} changes the error behaviour of operations on \texttt{DECFLOAT}. The default traps are DIVISION\_BY\_ZERO, INVALID\_OPERATION, OVERFLOW; this default matches the behaviour specified in the SQL standard for \texttt{DECFLOAT}. This statement controls whether certain exceptional conditions result in an error ("trap") or alternative handling (for example, an underflow returns 0 when not set, or an overflow returns an infinity). The initial configuration of a connection can also be specified using the DPB tag \texttt{isc_dpb_decfloat_traps} with the desired comma-separated \textit{trap_opt} values as a string value.

Valid trap options (exceptional conditions) are:

- \textbf{Division\_by\_zero} \quad \text{(set by default)}
- \textbf{Inexact} \quad \text{—}
- \textbf{Invalid\_operation} \quad \text{(set by default)}
- \textbf{Overflow} \quad \text{(set by default)}
- \textbf{Underflow} \quad \text{—}

The current value for the connection can be found using \texttt{RDB$\text{GET\_CONTEXT($\text{\texttt{\textsc{SYSTEM}}}$, 'DECFLOAT\_TRAPS')}\).}

Execution of \texttt{ALTER SESSION RESET} will revert to the value configured through the DPB, or otherwise the system default.
15.2. Connections Pool Management

Management statements to manage the external connections pool.

This connection pool is part of the Firebird server and used for connections to other databases or servers from the Firebird server itself.

15.2.1. ALTER EXTERNAL CONNECTIONS POOL

Manages the external connections pool

Syntax

\[
\text{ALTER EXTERNAL CONNECTIONS POOL} \\
\{ \text{CLEAR ALL} \\
| \text{CLEAR OLDEST} \\
| \text{SET LIFETIME lifetime } \langle\text{time-unit}\rangle \\
| \text{SET SIZE size } \}
\]

\(<\text{time-unit}> ::= \text{SECOND} \mid \text{MINUTE} \mid \text{HOUR}\)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>lifetime</td>
<td>Maximum lifetime of a connection in the pool. Minimum values is 1 SECOND, maximum is 24 HOUR.</td>
</tr>
<tr>
<td>size</td>
<td>Maximum size of the connection pool. Range 0 - 1000. Setting to 0 disables the external connections pool.</td>
</tr>
</tbody>
</table>

When prepared it is described like a DDL statement, but its effect is immediate — it is executed immediately and to completion, without waiting for transaction commit.

This statement can be issued from any connection, and changes are applied to the in-memory instance of the pool in the current Firebird process. If the process is Firebird Classic, execution only affects the current process (current connection), and does not affect other Classic processes.

Changes made with ALTER EXTERNAL CONNECTIONS POOL are not persistent: after a restart, Firebird will use the pool settings configured in firebird.conf by ExtConnPoolSize and ExtConnPoolLifeTime.

Clauses of ALTER EXTERNAL CONNECTIONS POOL

CLEAR ALL

Closes all idle connections and disassociates currently active connections; they are immediately closed when unused.

CLEAR OLDEST

Closes expired connections
SET LIFETIME

Configures the maximum lifetime of an idle connection in the pool. The default value (in seconds) is set using the parameter ExtConnPoolLifetime in firebird.conf.

SET SIZE

Configures the maximum number of idle connections in the pool. The default value is set using the parameter ExtConnPoolSize in firebird.conf.

How the Connection Pool Works

Every successful connection is associated with a pool, which maintains two lists—one for idle connections and one for active connections. When a connection in the “active” list has no active requests and no active transactions, it is assumed to be “unused”. A reset of the unused connection is attempted using an ALTER SESSION RESET statement and,

• if the reset succeeds (no errors occur) the connection is moved into the “idle” list;
• if the reset fails, the connection is closed;
• if the pool has reached its maximum size, the oldest idle connection is closed.
• When the lifetime of an idle connection expires, it is deleted from the pool and closed.

New Connections

When the engine is asked to create a new external connection, the pool first looks for a candidate in the “idle” list. The search, which is case-sensitive, involves four parameters:

1. connection string
2. username
3. password
4. role

If a suitable connection is found, it is tested to check that it is still alive.

• If it fails the check, it is deleted, and the search is repeated, without reporting any error to the client
• Otherwise, the live connection is moved from the “idle” list to the “active” list and returned to the caller
• If there are multiple suitable connections, the most recently used one is chosen
• If there is no suitable connection, a new one is created and added to the “active” list.

Who Can Alter the External Connections Pool

The ALTER EXTERNAL CONNECTIONS POOL statement can be executed by:

• Administrators
• Users with the MODIFY_EXT_CONN_POOL privilege
15.3. Changing the Current Role

15.3.1. SET ROLE

Sets the active role of the current session

Available in
DSQL

Syntax

```
SET ROLE {role_name | NONE}
```

Table 269. SET ROLE Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>role_name</td>
<td>The name of the role to apply</td>
</tr>
</tbody>
</table>

The SET ROLE statement allows a user to assume a different role; it sets the CURRENT_ROLE context variable to `role_name`, if that role has been granted to the CURRENT_USER. For this session, the user receives the privileges granted by that role. Any rights granted to the previous role are removed from the session. Use NONE instead of `role_name` to clear the CURRENT_ROLE.

When the specified role does not exist or has not been explicitly granted to the user, the error “Role `role_name` is invalid or unavailable” is raised.

SET ROLE Examples

1. Change the current role to MANAGER

```sql
SET ROLE manager;
select current_role from rdb$database;

ROLE
--------------------
MANAGER
```

2. Clear the current role

```sql
SET ROLE NONE;
select current_role from rdb$database;

ROLE
--------------------
```
See also
SET TRUSTED ROLE, GRANT

15.3.2. SET TRUSTED ROLE

Sets the active role of the current session to the trusted role

Available in
DSQL

Syntax

```
SET TRUSTED ROLE
```

The `SET TRUSTED ROLE` statement makes it possible to assume the role assigned to the user through a mapping rule (see Mapping of Users to Objects). The role assigned through a mapping rule is assumed automatically on connect, if the user hasn't specified an explicit role. The `SET TRUSTED ROLE` statement makes it possible to assume the mapped (or “trusted”) role at a later time, or to assume it again after the current role was changed using `SET ROLE`.

A trusted role is not a specific type of role, but can be any role that was created using `CREATE ROLE`, or a predefined system role such as `RDB$ADMIN`. An attachment (session) has a trusted role when the security objects mapping subsystem finds a match between the authentication result passed from the plugin and a local or global mapping to a role for the current database. The role may be one that is not granted explicitly to that user.

When a session has no trusted role, executing `SET TRUSTED ROLE` will raise error “*Your attachment has no trusted role*”.

While the `CURRENT_ROLE` can be changed using `SET ROLE`, it is not always possible to revert to a trusted role using the same command, because `SET ROLE` checks if the role has been granted to the user. With `SET TRUSTED ROLE`, the trusted role can be assumed again even when `SET ROLE` fails.

**SET TRUSTED ROLE Examples**

1. Assuming a mapping rule that assigns the role `ROLE1` to a user `ALEX`:

   ```
   CONNECT 'employee' USER ALEX PASSWORD 'password';
   SELECT CURRENT_ROLE FROM RDB$DATABASE;
   
   ROLE
   -------------------------------
   ROLE1
   
   SET ROLE ROLE2;
   ```
SELECT CURRENT_ROLE FROM RDB$DATABASE;

ROLE
===============================
ROLE2

SET TRUSTED ROLE;
SELECT CURRENT_ROLE FROM RDB$DATABASE;

ROLE
===============================
ROLE1

See also

SET ROLE, Mapping of Users to Objects

15.4. Session Timeouts

Statements for management of timeouts of the current connection.

15.4.1. SET SESSION IDLE TIMEOUT

Sets the session idle timeout

Syntax

SET SESSION IDLE TIMEOUT <time-unit> [ <time-unit> ]

<time-unit> ::= MINUTE | HOUR | SECOND

Table 270. SET SESSION IDLE TIMEOUT Statement Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>The timeout duration expressed in time-unit. A value of 0 defers to connection idle timeout configured for the database.</td>
</tr>
<tr>
<td>time-unit</td>
<td>Time unit of the timeout. Defaults to MINUTE.</td>
</tr>
</tbody>
</table>

The SET SESSION IDLE TIMEOUT sets an idle timeout at connection level and takes effect immediately. The statement can run outside transaction control (without an active transaction).

Setting a value larger than configured for the database is allowed, but is effectively ignored, see also Determining the Timeout that is In Effect.

The current timeout set for the session can be retrieved through RDB$GET_CONTEXT, namespace SYSTEM and variable SESSION_IDLE_TIMEOUT. Information is also available from MON$ATTACHMENTS:

MON$IDLE_TIMEOUT
Connection-level idle timeout in seconds; 0 if timeout is not set.
**MON$IDLE_TIMER**

Idle timer expiration time; contains NULL if an idle timeout was not set, or if a timer is not running.

Both `RDB$GET_CONTEXT('SYSTEM', 'SESSION_IDLE_TIMEOUT')` and `MON$ATTACHMENTS.MON$IDLE_TIMEOUT` report the idle timeout configured for the connection; they do not report the effective idle timeout.

The session idle timeout is reset when **ALTER SESSION RESET** is executed.

### Idle Session Timeouts

An idle session timeout allows a use connection to close automatically after a specified period of inactivity. A database administrator can use it to enforce closure of old connections that have become inactive, to reduce unnecessary consumption of resources. It can also be used by application and tools developers as an alternative to writing their own modules for controlling connection lifetime.

By default, the idle timeout is not enabled. No minimum or maximum limit is imposed, but a reasonably large period — such as a few hours — is recommended.

**How the Idle Session Timeout Works**

- When the user API call leaves the engine (returns to the calling connection) a special idle timer associated with the current connection is started
- When another user API call from that connection enters the engine, the idle timer is stopped and reset to zero
- If the maximum idle time is exceeded, the engine immediately closes the connection in the same way as with asynchronous connection cancellation:
  - all active statements and cursors are closed
  - all active transactions are rolled back
  - The network connection remains open at this point, allowing the client application to get the exact error code on the next API call. The network connection will be closed on the server side, after an error is reported or in due course as a result of a network timeout from a client-side disconnection.

Whenever a connection is cancelled, the next user API call returns the error `isc_att_shutdown` with a secondary error specifying the exact reason. Now, we have

```plaintext
isc_att_shut_idle
   Idle timeout expired
```

in addition to

```plaintext
isc_att_shut_killed
   Killed by database administrator
```
Database is shut down
Engine is shut down

**Setting the Idle Session Timeout**

- The idle timer will not start if the timeout period is set to zero.

An idle session timeout can be set:

- At database level, the database administrator can set the configuration parameter `ConnectionIdleTimeout`, an integer value **in minutes**. The default value of zero means no timeout is set. It is configurable per-database, so it may be set globally in `firebird.conf` and overridden for individual databases in `databases.conf` as required.

  The scope of this method is all user connections, except system connections (garbage collector, cache writer, etc.).

- At connection level, the idle session timeout is supported by both the `SET SESSION IDLE TIMEOUT` statement and the API (`setIdlTimeout`). The scope of this method is specific to the supplied connection (attachment). Its value in the API is **in seconds**. In the SQL syntax it can be hours, minutes or seconds. Scope for this method is the connection to which it is applied.

  For more information about the API calls, consult the Firebird 4.0 Release Notes.

**Determining the Timeout that is In Effect**

The effective idle timeout value is determined whenever a user API call leaves the engine, checking first at connection level and then at database level. A connection-level timeout can override the value of a database-level setting, as long as the period of time for the connection-level setting is no longer than any non-zero timeout that is applicable at database level.

- Take note of the difference between the time units at each level. At database level, in the configuration files, the unit for `SessionTimeout` is minutes. In SQL, the default unit is minutes but can also be expressed in hours or seconds explicitly. At the API level, the unit is seconds.

  Absolute precision is not guaranteed in any case, especially when the system load is high, but timeouts are guaranteed not to expire earlier than the moment specified.

**15.4.2. SET STATEMENT TIMEOUT**

Sets the statement timeout for a connection
Syntax

```
SET STATEMENT TIMEOUT value [<time-unit>]
```

`<time-unit>` ::= SECOND | MILLISECOND | MINUTE | HOUR

**Table 271. SET STATEMENT TIMEOUT Statement Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>The timeout duration expressed in <code>time-unit</code>. A value of 0 defers to statement timeout configured for the database.</td>
</tr>
<tr>
<td>time-unit</td>
<td>Time unit of the timeout. Defaults to SECOND.</td>
</tr>
</tbody>
</table>

The SET STATEMENT TIMEOUT sets a statement timeout at connection level and takes effect immediately. The statement can run outside transaction control (without an active transaction).

Setting a `value` larger than configured for the database is allowed, but is effectively ignored, see also *Determining the Statement Timeout that is In Effect*.

The current statement timeout set for the session can be retrieved through `RDB$GET_CONTEXT`, namespace `SYSTEM` and variable `STATEMENT_TIMEOUT`. Information is also available from `MON$ATTACHMENTS`:

- **MON$STATEMENT_TIMEOUT**
  - Connection-level statement timeout in milliseconds; 0 if timeout is not set.

In `MON$STATEMENTS`:

- **MON$STATEMENT_TIMEOUT**
  - Statement-level statement timeout in milliseconds; 0 if timeout is not set.

- **MON$STATEMENT_TIMER**
  - Timeout timer expiration time; contains NULL if an idle timeout was not set, or if a timer is not running.

Both `RDB$GET_CONTEXT('SYSTEM', 'STATEMENT_TIMEOUT')` and `MON$ATTACHMENTS.MON$STATEMENT_TIMEOUT` report the statement timeout configured for the connection, and `MON$STATEMENTS.MON$STATEMENT_TIMEOUT` for the statement; they do not report the effective statement timeout.

The statement timeout is reset when `ALTER SESSION RESET` is executed.

**Statement Timeouts**

The statement timeout feature allows execution of a statement to be stopped automatically when it has been running longer than a given timeout period. It gives the database administrator an instrument for limiting excessive resource consumption from heavy queries.

Statement timeouts can also be useful to application developers when creating and debugging...
complex queries without advance knowledge of execution time. Testers and others could find them handy for detecting long-running queries and establishing finite run times for test suites.

**How the Statement Timeout Works**

When the statement starts execution, or a cursor is opened, the engine starts a special timer. It is stopped when the statement completes execution, or the last record has been fetched by the cursor.

- A fetch does not reset this timer.

When the timeout point is reached:

- if statement execution is active, it stops at closest possible moment
- if statement is not active currently (between fetches, for example), it is marked as cancelled, and the next fetch will break execution and return an error

**Statement types excluded from timeouts**

Statement timeouts are not applicable to some types of statement and will be ignored:

- All DDL statements
- All internal queries issued by the engine itself

**Setting a Statement Timeout**

- The timer will not start if the timeout period is set to zero.

A statement timeout can be set:

- at database level, by the database administrator, by setting the configuration parameter `StatementTimeout` in `firebird.conf` or `databases.conf`. `StatementTimeout` is an integer representing the number of seconds after which statement execution will be cancelled automatically by the engine. Zero means no timeout is set. A non-zero setting will affect all statements in all connections.

- at connection level, using `SET STATEMENT TIMEOUT` or the API for setting a statement timeout (`setStatementTimeout`). A connection-level setting (via SQL or the API) affects all statements for the given connection; units for the timeout period at this level can be specified to any granularity from hours to milliseconds.

- at statement level, using the API, in milliseconds

**Determining the Statement Timeout that is In Effect**

The statement timeout value that is in effect is determined whenever a statement starts executing, or a cursor is opened. In searching out the timeout in effect, the engine goes up through the levels, from statement through to database and/or global levels until it finds a non-zero value. If the value in effect turns out to be zero then no statement timer is running and no timeout applies.

A statement-level or connection-level timeout can override the value of a database-level setting, as
long as the period of time for the lower-level setting is no longer than any non-zero timeout that is applicable at database level.

Take note of the difference between the time units at each level. At database level, in the conf file, the unit for `StatementTimeout` is seconds. In SQL, the default unit is seconds but can be expressed in hours, minutes or milliseconds explicitly. At the API level, the unit is milliseconds.

Absolute precision is not guaranteed in any case, especially when the system load is high, but timeouts are guaranteed not to expire earlier than the moment specified.

Whenever a statement times out and is cancelled, the next user API call returns the error `isc_cancelled` with a secondary error specifying the exact reason, viz.,

- `isc_cfg_stmt_timeout` - Config level timeout expired
- `isc_att_stmt_timeout` - Attachment level timeout expired
- `isc_req_stmt_timeout` - Statement level timeout expired

### Notes about Statement Timeouts

1. A client application could wait longer than the time set by the timeout value if the engine needs to undo a large number of actions as a result of the statement cancellation

2. When the engine runs an `EXECUTE` `STATEMENT` statement, it passes the remainder of the currently active timeout to the new statement. If the external (remote) engine does not support statement timeouts, the local engine silently ignores any corresponding error.

3. When the engine acquires a lock from the lock manager, it tries to lower the value of the lock timeout using the remainder of the currently active statement timeout, if possible. Due to lock manager internals, any statement timeout remainder will be rounded up to whole seconds.

### 15.5. Time Zone Management

Statements for management of time zone features of the current connections.

#### 15.5.1. SET TIME ZONE

Sets the session time zone
Syntax

```sql
SET TIME ZONE { time_zone_string | LOCAL }
```

Changes the session time zone to the specified time zone. Specifying `LOCAL` will revert to initial session time zone of the session (either the default or as specified through connection property `isc_dpb_session_time_zone`).

Executing `ALTER SESSION RESET` has the same effect on the session time zone as `SET TIME ZONE LOCAL`, but will also reset other session properties.

**SET TIME ZONE Examples**

```sql
set time zone '-02:00';
set time zone 'America/Sao_Paulo';
set time zone local;
```

### 15.6. Optimizer Configuration

#### 15.6.1. SET OPTIMIZE

Configures whether the optimizer should optimize for fetching first or all rows.

**Syntax**

```sql
SET OPTIMIZE <optimize-mode>
```

```sql
<optimize-mode> ::= 
  FOR {FIRST | ALL} ROWS 
  | TO DEFAULT
```

This feature allows the optimizer to consider another (hopefully better) plan if only a subset or rows is fetched initially by the user application (with the remaining rows being fetched on demand), thus improving the response time.

It can also be specified at the statement level using the `OPTIMIZE FOR` clause.

The default behaviour can be specified globally using the `OptimizeForFirstRows` setting in `firebird.conf` or `databases.conf`.

### 15.7. Reset Session State

#### 15.7.1. ALTER SESSION RESET

Resets the session state of the current connection to its initial values
Syntax

```
ALTER SESSION RESET
```

Resetting the session can be useful for reusing the connection by a client application (for example, by a client-side connection pool). When this statement is executed, all user context variables are cleared, contents of global temporary tables are cleared, and all session-level settings are reset to their initial values.

It is possible to execute `ALTER SESSION RESET` without a transaction.

Execution of `ALTER SESSION RESET` performs the following steps:

- Error `isc_ses_reset_err` (335545206) is raised if any transaction is active in the current session other than the current transaction (the one executing `ALTER SESSION RESET`) and two-phase transactions in the prepared state.
- System variable `RESETTING` is set to `TRUE`.
- `ON DISCONNECT` database triggers are fired, if present and if database triggers are not disabled for the current connection.
- The current transaction (the one executing `ALTER SESSION RESET`), if present, is rolled back. A warning is reported if this transaction modified data before resetting the session.
- Session configuration is reset to their initial values. This includes, but is not limited to:
  - `DECFLOAT` parameters (TRAP and ROUND) are reset to the initial values defined using the DPB at connect time, or otherwise the system default.
  - Session and statement timeouts are reset to zero.
  - The current role is restored to the initial value defined using DPB at connect time, and — if the role changed — the security classes cache is cleared.
  - The session time zone is reset to the initial value defined using the DPB at connect time, or otherwise the system default.
  - The bind configuration is reset to the initial value defined using the DPB at connect time, or otherwise the database or system default.
  - In general, configuration values should revert to the values configured using the DPB at connect time, or otherwise the database or system default.
- Context variables defined for the `USER_SESSION` namespace are removed (`USER_TRANSACTION` was cleared earlier by the transaction roll back).
- Global temporary tables defined as `ON COMMIT PRESERVE ROWS` are truncated (their contents is cleared).
- `ON CONNECT` database triggers are fired, if present and if database triggers are not disabled for the current connection.
- A new transaction is implicitly started with the same parameters as the transaction that was rolled back (if there was a transaction)
- System variable `RESETTING` is set to `FALSE`. 

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Chapter 15. Management Statements

639
• The context variables CURRENT_USER and CURRENT_CONNECTION will not be changed.
• As isql starts multiple transactions for a single connection, ALTER SESSION RESET cannot be executed in isql.

**Error Handling**

Any error raised by ON DISCONNECT triggers aborts the session reset and leaves the session state unchanged. Such errors are reported using primary error code `isc_session_reset_err` (335545206) and error text "Cannot reset user session".

Any error raised after ON DISCONNECT triggers (including the ones raised by ON CONNECT triggers) aborts both the session reset and the connection itself. Such errors are reported using primary error code `isc_ses_reset_failed` (335545272) and error text "Reset of user session failed. Connection is shut down.". Subsequent operations on the connection (except detach) will fail with error `isc_att_shutdown` (335544856).

### 15.8. Debugging

#### 15.8.1. SET DEBUG OPTION

Sets debug options

**Syntax**

```
SET DEBUG OPTION option-name = value
```

**Table 272. Supported options**

<table>
<thead>
<tr>
<th>Option name</th>
<th>Value Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DSQL_KEEP_BLR</td>
<td>BOOLEAN</td>
<td>Stores statement BLR for retrieval with <code>isc_info_sql_exec_path_blr_bytes</code> and <code>isc_info_sql_exec_path_blr_text</code>.</td>
</tr>
</tbody>
</table>

SET DEBUG OPTION configures debug information for the current connection.

Debug options are closely tied to engine internals and their usage is discouraged if you do not understand how these internals are subject to change between versions.
Appendix A: Supplementary Information

In this Appendix are topics that developers may wish to refer to, to enhance understanding of features or changes.

The RDB$VALID_BLR Field

The field RDB$VALID_BLR in system tables RDB$PROCEDURES, RDB$FUNCTIONS and RDB$TRIGGERS signal possible invalidation of a PSQL module after alteration of a domain or table column on which the module depends. RDB$VALID_BLR is set to 0 for any procedure or trigger whose code is made invalid by such a change.

The field RDB$VALID_BODY_FLAG in RDB$PACKAGES serves a similar purpose for packages.

How Invalidation Works

In PSQL modules, dependencies arise on the definitions of table columns accessed and also on any parameter or variable that has been defined in the module using the TYPE OF clause.

After the engine has altered any domain, including the implicit domains created internally behind column definitions and output parameters, the engine internally recompiles all of its dependencies.

Any module that fails to recompile because of an incompatibility arising from a domain change is marked as invalid (“invalidated” by setting the RDB$VALID_BLR in its system record (in RDB$PROCEDURES, RDB$FUNCTIONS or RDB$TRIGGERS, as appropriate) to zero.

Revalidation (setting RDB$VALID_BLR to 1) occurs when

1. the domain is altered again and the new definition is compatible with the previously invalidated module definition, or
2. the previously invalidated module is altered to match the new domain definition

The following query will find the modules that depend on a specific domain and report the state of their RDB$VALID_BLR fields:

```
SELECT * FROM ( 
    SELECT 
        'Procedure', 
        rdb$procedure_name, 
        rdb$valid_blr 
    FROM rdb$procedures 
    UNION ALL 
    SELECT 
        'Function', 
        rdb$function_name, 
        rdb$valid_blr 
    FROM rdb$functions 
    UNION ALL 
) 
```
The following query will find the modules that depend on a specific table column and report the state of their RDB$VALID_BLR fields:

```
SELECT * FROM (  
  SELECT  
    'Procedure',  
    rdb$procedure_name,  
    rdb$valid_blr  
  FROM rdb$procedures  
  UNION ALL  
  SELECT  
    'Function',  
    rdb$function_name,  
    rdb$valid_blr  
  FROM rdb$functions  
  UNION ALL  
  SELECT  
    'Trigger',  
    rdb$trigger_name,  
    rdb$valid_blr  
  FROM rdb$triggers  
) (type, name, valid)  
WHERE EXISTS  
  (SELECT * FROM rdb$dependencies  
   WHERE rdb$dependent_name = name  
   AND rdb$depended_on_name = 'MYTABLE'  
   AND rdb$field_name = 'MYCOLUMN')  
/* Replace MYDOMAIN with the actual domain name.  
Use all-caps if the domain was created  
case-insensitively. Otherwise, use the exact  
capitalisation. */
```

All PSQL invalidations caused by domain/column changes are reflected in the RDB$VALID_BLR field. However, other kinds of changes, such as the number of input or output parameters, called routines and so on, do not affect the validation field even though they potentially invalidate the module. A typical such scenario might be one of the following:
1. A procedure (B) is defined, that calls another procedure (A) and reads output parameters from it. In this case, a dependency is registered in RDB$DEPENDENCIES. Subsequently, the called procedure (A) is altered to change or remove one or more of those output parameters. The ALTER PROCEDURE A statement will fail with an error when commit is attempted.

2. A procedure (B) calls procedure A, supplying values for its input parameters. No dependency is registered in RDB$DEPENDENCIES. Subsequent modification of the input parameters in procedure A will be allowed. Failure will occur at runtime, when B calls A with the mismatched input parameter set.

Other Notes

• For PSQL modules inherited from earlier Firebird versions (including a number of system triggers, even if the database was created under Firebird 2.1 or higher), RDB$VALID_BLR is NULL. This does not imply that their BLR is invalid.

• The isql commands SHOW PROCEDURES and SHOW TRIGGERS display an asterisk in the RDB$VALID_BLR column for any module for which the value is zero (i.e. invalid). However, SHOW PROCEDURE <procname> and SHOW TRIGGER <trigname>, which display individual PSQL modules, do not signal invalid BLR at all.

A Note on Equality

This note about equality and inequality operators applies everywhere in Firebird’s SQL language.

The “=” operator, which is explicitly used in many conditions, only matches values to values. According to the SQL standard, NULL is not a value and hence two NULLs are neither equal nor unequal to one another. If you need NULLs to match each other in a condition, use the IS NOT DISTINCT FROM operator. This operator returns true if the operands have the same value or if they are both NULL.

```
select *
from A join B
on A.id is not distinct from B.code
```

Likewise, in cases where you want to test against NULL for a condition of inequality, use IS DISTINCT FROM, not “<>”. If you want NULL to be considered different from any value and two NULLs to be considered equal:

```
select *
from A join B
on A.id is distinct from B.code
```
Appendix B: Exception Codes and Messages

This appendix includes:

• **SQLSTATE Error Codes and Descriptions**
• **GDSCODE Error Codes, SQLCODEs and Descriptions**

**Custom Exceptions**

Firebird DDL provides a simple syntax for creating custom exceptions for use in PSQL modules, with message text of up to 1,021 characters. For more information, see **CREATE EXCEPTION** in Data Definition (DDL) Statements and, for usage, the statement **EXCEPTION** in Procedural SQL (PSQL) Statements.

The Firebird SQLCODE error codes do not correlate with the standards-compliant SQLSTATE codes. SQLCODE has been used for many years and should be considered as deprecated now. Support for SQLCODE is likely to be dropped in a future version.

**SQLSTATE Error Codes and Descriptions**

This table provides the error codes and message texts for the SQLSTATE context variables.

The structure of an SQLSTATE error code is five characters comprising the SQL error class (2 characters) and the SQL subclass (3 characters).

Although Firebird tries to use SQLSTATE codes defined in ISO/IEC 9075 (the SQL standard), some are non-standard or derive from older standards like X/Open SQL for historic reasons.

**Table 273. SQLSTATE Codes and Message Texts**

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>SQLCLASS 00</td>
<td>Success</td>
</tr>
<tr>
<td>00000</td>
<td>Success</td>
</tr>
<tr>
<td>SQLCLASS 01</td>
<td>General warning</td>
</tr>
<tr>
<td>01000</td>
<td>General warning</td>
</tr>
<tr>
<td>01001</td>
<td>Cursor operation conflict</td>
</tr>
<tr>
<td>01002</td>
<td>Disconnect error</td>
</tr>
<tr>
<td>01003</td>
<td>NULL value eliminated in set function</td>
</tr>
<tr>
<td>01004</td>
<td>String data, right-truncated</td>
</tr>
<tr>
<td>01005</td>
<td>Insufficient item descriptor areas</td>
</tr>
<tr>
<td>01006</td>
<td>Privilege not revoked</td>
</tr>
<tr>
<td>01007</td>
<td>Privilege not granted</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>Mapped Message</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------</td>
</tr>
<tr>
<td>01008</td>
<td>Implicit zero-bit padding</td>
</tr>
<tr>
<td>01100</td>
<td>Statement reset to unprepared</td>
</tr>
<tr>
<td>01101</td>
<td>Ongoing transaction has been committed</td>
</tr>
<tr>
<td>01102</td>
<td>Ongoing transaction has been rolled back</td>
</tr>
<tr>
<td>SQLCLASS 02 (No Data)</td>
<td></td>
</tr>
<tr>
<td>02000</td>
<td>No data found or no rows affected</td>
</tr>
<tr>
<td>SQLCLASS 07 (Dynamic SQL error)</td>
<td></td>
</tr>
<tr>
<td>07000</td>
<td>Dynamic SQL error</td>
</tr>
<tr>
<td>07001</td>
<td>Wrong number of input parameters</td>
</tr>
<tr>
<td>07002</td>
<td>Wrong number of output parameters</td>
</tr>
<tr>
<td>07003</td>
<td>Cursor specification cannot be executed</td>
</tr>
<tr>
<td>07004</td>
<td>USING clause required for dynamic parameters</td>
</tr>
<tr>
<td>07005</td>
<td>Prepared statement not a cursor-specification</td>
</tr>
<tr>
<td>07006</td>
<td>Restricted data type attribute violation</td>
</tr>
<tr>
<td>07007</td>
<td>USING clause required for result fields</td>
</tr>
<tr>
<td>07008</td>
<td>Invalid descriptor count</td>
</tr>
<tr>
<td>07009</td>
<td>Invalid descriptor index</td>
</tr>
<tr>
<td>SQLCLASS 08 (Connection Exception)</td>
<td></td>
</tr>
<tr>
<td>08001</td>
<td>Client unable to establish connection</td>
</tr>
<tr>
<td>08002</td>
<td>Connection name in use</td>
</tr>
<tr>
<td>08003</td>
<td>Connection does not exist</td>
</tr>
<tr>
<td>08004</td>
<td>Server rejected the connection</td>
</tr>
<tr>
<td>08006</td>
<td>Connection failure</td>
</tr>
<tr>
<td>08007</td>
<td>Transaction resolution unknown</td>
</tr>
<tr>
<td>SQLCLASS 0A (Feature Not Supported)</td>
<td></td>
</tr>
<tr>
<td>0A000</td>
<td>Feature Not Supported</td>
</tr>
<tr>
<td>SQLCLASS 0B (Invalid Transaction Initiation)</td>
<td></td>
</tr>
<tr>
<td>0B000</td>
<td>Invalid transaction initiation</td>
</tr>
<tr>
<td>SQLCLASS 0L (Invalid Grantor)</td>
<td></td>
</tr>
<tr>
<td>0L000</td>
<td>Invalid grantor</td>
</tr>
<tr>
<td>SQLCLASS 0P (Invalid Role Specification)</td>
<td></td>
</tr>
<tr>
<td>0P000</td>
<td>Invalid role specification</td>
</tr>
<tr>
<td>SQLCLASS 0U (Attempt to Assign to Non-Updatable Column)</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>0U000</td>
<td>Attempt to assign to non-updatable column</td>
</tr>
</tbody>
</table>

**SQLCLASS 0V (Attempt to Assign to Ordering Column)**

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>0V000</td>
<td>Attempt to assign to Ordering column</td>
</tr>
</tbody>
</table>

**SQLCLASS 20 (Case Not Found For Case Statement)**

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
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<tbody>
<tr>
<td>20000</td>
<td>Case not found for case statement</td>
</tr>
</tbody>
</table>

**SQLCLASS 21 (Cardinality Violation)**

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>21000</td>
<td>Cardinality violation</td>
</tr>
<tr>
<td>21S01</td>
<td>Insert value list does not match column list</td>
</tr>
<tr>
<td>21S02</td>
<td>Degree of derived table does not match column list</td>
</tr>
</tbody>
</table>

**SQLCLASS 22 (Data Exception)**

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
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<tbody>
<tr>
<td>22000</td>
<td>Data exception</td>
</tr>
<tr>
<td>22001</td>
<td>String data, right truncation</td>
</tr>
<tr>
<td>22002</td>
<td>Null value, no indicator parameter</td>
</tr>
<tr>
<td>22003</td>
<td>Numeric value out of range</td>
</tr>
<tr>
<td>22004</td>
<td>Null value not allowed</td>
</tr>
<tr>
<td>22005</td>
<td>Error in assignment</td>
</tr>
<tr>
<td>22006</td>
<td>Null value in field reference</td>
</tr>
<tr>
<td>22007</td>
<td>Invalid datetime format</td>
</tr>
<tr>
<td>22008</td>
<td>Datetime field overflow</td>
</tr>
<tr>
<td>22009</td>
<td>Invalid time zone displacement value</td>
</tr>
<tr>
<td>2200A</td>
<td>Null value in reference target</td>
</tr>
<tr>
<td>2200B</td>
<td>Escape character conflict</td>
</tr>
<tr>
<td>2200C</td>
<td>Invalid use of escape character</td>
</tr>
<tr>
<td>2200D</td>
<td>Invalid escape octet</td>
</tr>
<tr>
<td>2200E</td>
<td>Null value in array target</td>
</tr>
<tr>
<td>2200F</td>
<td>Zero-length character string</td>
</tr>
<tr>
<td>2200G</td>
<td>Most specific type mismatch</td>
</tr>
<tr>
<td>22010</td>
<td>Invalid indicator parameter value</td>
</tr>
<tr>
<td>22011</td>
<td>Substring error</td>
</tr>
<tr>
<td>22012</td>
<td>Division by zero</td>
</tr>
<tr>
<td>22014</td>
<td>Invalid update value</td>
</tr>
<tr>
<td>22015</td>
<td>Interval field overflow</td>
</tr>
<tr>
<td>22018</td>
<td>Invalid character value for cast</td>
</tr>
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<td>SQLSTATE</td>
<td>Mapped Message</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------</td>
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<tr>
<td>22019</td>
<td>Invalid escape character</td>
</tr>
<tr>
<td>2201B</td>
<td>Invalid regular expression</td>
</tr>
<tr>
<td>2201C</td>
<td>Null row not permitted in table</td>
</tr>
<tr>
<td>22012</td>
<td>Division by zero</td>
</tr>
<tr>
<td>22020</td>
<td>Invalid limit value</td>
</tr>
<tr>
<td>22021</td>
<td>Character not in repertoire</td>
</tr>
<tr>
<td>22022</td>
<td>Indicator overflow</td>
</tr>
<tr>
<td>22023</td>
<td>Invalid parameter value</td>
</tr>
<tr>
<td>22024</td>
<td>Character string not properly terminated</td>
</tr>
<tr>
<td>22025</td>
<td>Invalid escape sequence</td>
</tr>
<tr>
<td>22026</td>
<td>String data, length mismatch</td>
</tr>
<tr>
<td>22027</td>
<td>Trim error</td>
</tr>
<tr>
<td>22028</td>
<td>Row already exists</td>
</tr>
<tr>
<td>2202D</td>
<td>Null instance used in mutator function</td>
</tr>
<tr>
<td>2202E</td>
<td>Array element error</td>
</tr>
<tr>
<td>2202F</td>
<td>Array data, right truncation</td>
</tr>
<tr>
<td></td>
<td>SQLCLASS 23 (Integrity Constraint Violation)</td>
</tr>
<tr>
<td>23000</td>
<td>Integrity constraint violation</td>
</tr>
<tr>
<td></td>
<td>SQLCLASS 24 (Invalid Cursor State)</td>
</tr>
<tr>
<td>24000</td>
<td>Invalid cursor state</td>
</tr>
<tr>
<td>24504</td>
<td>The cursor identified in the UPDATE, DELETE, SET, or GET statement is not positioned on a row</td>
</tr>
<tr>
<td></td>
<td>SQLCLASS 25 (Invalid Transaction State)</td>
</tr>
<tr>
<td>25000</td>
<td>Invalid transaction state</td>
</tr>
<tr>
<td>25S01</td>
<td>Transaction state</td>
</tr>
<tr>
<td>25S02</td>
<td>Transaction is still active</td>
</tr>
<tr>
<td>25S03</td>
<td>Transaction is rolled back</td>
</tr>
<tr>
<td></td>
<td>SQLCLASS 26 (Invalid SQL Statement Name)</td>
</tr>
<tr>
<td>26000</td>
<td>Invalid SQL statement name</td>
</tr>
<tr>
<td></td>
<td>SQLCLASS 27 (Triggered Data Change Violation)</td>
</tr>
<tr>
<td>27000</td>
<td>Triggered data change violation</td>
</tr>
<tr>
<td></td>
<td>SQLCLASS 28 (Invalid Authorization Specification)</td>
</tr>
<tr>
<td>28000</td>
<td>Invalid authorization specification</td>
</tr>
<tr>
<td></td>
<td>SQLCLASS 2B (Dependent Privilege Descriptors Still Exist)</td>
</tr>
</tbody>
</table>
### Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>2B000</td>
<td>Dependent privilege descriptors still exist</td>
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<td>SQLCLASS 2C (Invalid Character Set Name)</td>
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<td>Invalid character set name</td>
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<tr>
<td>SQLCLASS 2D (Invalid Transaction Termination)</td>
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</tr>
<tr>
<td>2D000</td>
<td>Invalid transaction termination</td>
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<tr>
<td>SQLCLASS 2E (Invalid Connection Name)</td>
<td></td>
</tr>
<tr>
<td>2E000</td>
<td>Invalid connection name</td>
</tr>
<tr>
<td>SQLCLASS 2F (SQL Routine Exception)</td>
<td></td>
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<tr>
<td>2F000</td>
<td>SQL routine exception</td>
</tr>
<tr>
<td>2F002</td>
<td>Modifying SQL-data not permitted</td>
</tr>
<tr>
<td>2F003</td>
<td>Prohibited SQL-statement attempted</td>
</tr>
<tr>
<td>2F004</td>
<td>Reading SQL-data not permitted</td>
</tr>
<tr>
<td>2F005</td>
<td>Function executed no return statement</td>
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<td>SQLCLASS 33 (Invalid SQL Descriptor Name)</td>
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<td>33000</td>
<td>Invalid SQL descriptor name</td>
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<td>SQLCLASS 34 (Invalid Cursor Name)</td>
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<td>Invalid cursor name</td>
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<td>SQLCLASS 35 (Invalid Condition Number)</td>
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<td>Invalid condition number</td>
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<td>SQLCLASS 36 (Cursor Sensitivity Exception)</td>
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<td>36001</td>
<td>Request rejected</td>
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<td>36002</td>
<td>Request failed</td>
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<td>SQLCLASS 37 (Invalid Identifier)</td>
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<td>37000</td>
<td>Invalid identifier</td>
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<tr>
<td>37001</td>
<td>Identifier too long</td>
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<td>SQLCLASS 38 (External Routine Exception)</td>
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<td>38000</td>
<td>External routine exception</td>
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<tr>
<td>SQLCLASS 39 (External Routine Invocation Exception)</td>
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</tr>
<tr>
<td>39000</td>
<td>External routine invocation exception</td>
</tr>
<tr>
<td>SQLCLASS 3B (Invalid Save Point)</td>
<td></td>
</tr>
<tr>
<td>3B000</td>
<td>Invalid save point</td>
</tr>
<tr>
<td>SQLCLASS 3C (Ambiguous Cursor Name)</td>
<td></td>
</tr>
<tr>
<td>3C000</td>
<td>Ambiguous cursor name</td>
</tr>
<tr>
<td>SQLSTATE</td>
<td>Mapped Message</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>SQLCLASS 3D (Invalid Catalog Name)</td>
<td></td>
</tr>
<tr>
<td>3D000</td>
<td>Invalid catalog name</td>
</tr>
<tr>
<td>3D001</td>
<td>Catalog name not found</td>
</tr>
<tr>
<td>SQLCLASS 3F (Invalid Schema Name)</td>
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</tr>
<tr>
<td>3F000</td>
<td>Invalid schema name</td>
</tr>
<tr>
<td>SQLCLASS 40 (Transaction Rollback)</td>
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</tr>
<tr>
<td>40000</td>
<td>Ongoing transaction has been rolled back</td>
</tr>
<tr>
<td>40001</td>
<td>Serialization failure</td>
</tr>
<tr>
<td>40002</td>
<td>Transaction integrity constraint violation</td>
</tr>
<tr>
<td>40003</td>
<td>Statement completion unknown</td>
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<tr>
<td>SQLCLASS 42 (Syntax Error or Access Violation)</td>
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<td>42000</td>
<td>Syntax error or access violation</td>
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<td>42702</td>
<td>Ambiguous column reference</td>
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<tr>
<td>42725</td>
<td>Ambiguous function reference</td>
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<tr>
<td>42818</td>
<td>The operands of an operator or function are not compatible</td>
</tr>
<tr>
<td>42S01</td>
<td>Base table or view already exists</td>
</tr>
<tr>
<td>42S02</td>
<td>Base table or view not found</td>
</tr>
<tr>
<td>42S11</td>
<td>Index already exists</td>
</tr>
<tr>
<td>42S12</td>
<td>Index not found</td>
</tr>
<tr>
<td>42S21</td>
<td>Column already exists</td>
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<tr>
<td>42S22</td>
<td>Column not found</td>
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<tr>
<td>SQLCLASS 44 (With Check Option Violation)</td>
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<td>44000</td>
<td>WITH CHECK OPTION Violation</td>
</tr>
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<td>SQLCLASS 45 (Unhandled User-defined Exception)</td>
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<td>45000</td>
<td>Unhandled user-defined exception</td>
</tr>
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<td>SQLCLASS 54 (Program Limit Exceeded)</td>
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</tr>
<tr>
<td>54000</td>
<td>Program limit exceeded</td>
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<td>54001</td>
<td>Statement too complex</td>
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<tr>
<td>54011</td>
<td>Too many columns</td>
</tr>
<tr>
<td>54023</td>
<td>Too many arguments</td>
</tr>
<tr>
<td>SQLCLASS HY (CLI-specific Condition)</td>
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</tr>
<tr>
<td>HY000</td>
<td>CLI-specific condition</td>
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<tr>
<td>HY001</td>
<td>Memory allocation error</td>
</tr>
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<td>SQLSTATE</td>
<td>Mapped Message</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------</td>
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<tr>
<td>HY003</td>
<td>Invalid data type in application descriptor</td>
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<tr>
<td>HY004</td>
<td>Invalid data type</td>
</tr>
<tr>
<td>HY007</td>
<td>Associated statement is not prepared</td>
</tr>
<tr>
<td>HY008</td>
<td>Operation canceled</td>
</tr>
<tr>
<td>HY009</td>
<td>Invalid use of null pointer</td>
</tr>
<tr>
<td>HY010</td>
<td>Function sequence error</td>
</tr>
<tr>
<td>HY011</td>
<td>Attribute cannot be set now</td>
</tr>
<tr>
<td>HY012</td>
<td>Invalid transaction operation code</td>
</tr>
<tr>
<td>HY013</td>
<td>Memory management error</td>
</tr>
<tr>
<td>HY014</td>
<td>Limit on the number of handles exceeded</td>
</tr>
<tr>
<td>HY015</td>
<td>No cursor name available</td>
</tr>
<tr>
<td>HY016</td>
<td>Cannot modify an implementation row descriptor</td>
</tr>
<tr>
<td>HY017</td>
<td>Invalid use of an automatically allocated descriptor handle</td>
</tr>
<tr>
<td>HY018</td>
<td>Server declined the cancellation request</td>
</tr>
<tr>
<td>HY019</td>
<td>Non-string data cannot be sent in pieces</td>
</tr>
<tr>
<td>HY020</td>
<td>Attempt to concatenate a null value</td>
</tr>
<tr>
<td>HY021</td>
<td>Inconsistent descriptor information</td>
</tr>
<tr>
<td>HY024</td>
<td>Invalid attribute value</td>
</tr>
<tr>
<td>HY055</td>
<td>Non-string data cannot be used with string routine</td>
</tr>
<tr>
<td>HY090</td>
<td>Invalid string length or buffer length</td>
</tr>
<tr>
<td>HY091</td>
<td>Invalid descriptor field identifier</td>
</tr>
<tr>
<td>HY092</td>
<td>Invalid attribute identifier</td>
</tr>
<tr>
<td>HY095</td>
<td>Invalid Function ID specified</td>
</tr>
<tr>
<td>HY096</td>
<td>Invalid information type</td>
</tr>
<tr>
<td>HY097</td>
<td>Column type out of range</td>
</tr>
<tr>
<td>HY098</td>
<td>Scope out of range</td>
</tr>
<tr>
<td>HY099</td>
<td>Nullable type out of range</td>
</tr>
<tr>
<td>HY100</td>
<td>Uniqueness option type out of range</td>
</tr>
<tr>
<td>HY101</td>
<td>Accuracy option type out of range</td>
</tr>
<tr>
<td>HY103</td>
<td>Invalid retrieval code</td>
</tr>
<tr>
<td>HY104</td>
<td>Invalid Length/Precision value</td>
</tr>
<tr>
<td>HY105</td>
<td>Invalid parameter type</td>
</tr>
<tr>
<td>HY106</td>
<td>Invalid fetch orientation</td>
</tr>
</tbody>
</table>
### SQLSTATE

<table>
<thead>
<tr>
<th>SQLSTATE</th>
<th>Mapped Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>HY107</td>
<td>Row value out of range</td>
</tr>
<tr>
<td>HY109</td>
<td>Invalid cursor position</td>
</tr>
<tr>
<td>HY110</td>
<td>Invalid driver completion</td>
</tr>
<tr>
<td>HY111</td>
<td>Invalid bookmark value</td>
</tr>
<tr>
<td>HYC00</td>
<td>Optional feature not implemented</td>
</tr>
<tr>
<td>HYT00</td>
<td>Timeout expired</td>
</tr>
<tr>
<td>HYT01</td>
<td>Connection timeout expired</td>
</tr>
</tbody>
</table>

### SQLCLASS XX (Internal Error)

<table>
<thead>
<tr>
<th>SQLCLASS</th>
<th>Error Code</th>
<th>Message Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>XX000</td>
<td>Internal error</td>
<td>Internal error</td>
</tr>
<tr>
<td>XX001</td>
<td>Data corrupted</td>
<td>Data corrupted</td>
</tr>
<tr>
<td>XX002</td>
<td>Index corrupted</td>
<td>Index corrupted</td>
</tr>
</tbody>
</table>

### SQLCODE and GDSCODE Error Codes and Descriptions

The table provides the SQLCODE groupings, the numeric and symbolic values for the GDSCODE errors and the message texts.

SQLCODE has been used for many years and should be considered as deprecated now. Support for SQLCODE is likely to be dropped in a future version.

**Table 274. SQLCODE and GDSCODE Error Codes and Message Texts**

<table>
<thead>
<tr>
<th>SQLCODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>501</td>
<td>335544802</td>
<td>dialect_reset_warning</td>
<td>Database dialect being changed from 3 to 1</td>
</tr>
<tr>
<td>304</td>
<td>335545266</td>
<td>truncate_warn</td>
<td>String truncated warning due to the following reason</td>
</tr>
<tr>
<td>304</td>
<td>335545267</td>
<td>truncate_monitor</td>
<td>Monitoring data does not fit into the field</td>
</tr>
<tr>
<td>304</td>
<td>335545268</td>
<td>truncate_context</td>
<td>Engine data does not fit into return value of system function</td>
</tr>
<tr>
<td>301</td>
<td>335544808</td>
<td>dtype_renamed</td>
<td>DATE data type is now called TIMESTAMP</td>
</tr>
<tr>
<td>301</td>
<td>336003076</td>
<td>dsql_dialect_warning_expr</td>
<td>Use of @1 expression that returns different results in dialect 1 and dialect 3</td>
</tr>
<tr>
<td>301</td>
<td>336003080</td>
<td>dsql_warning_number_ambiguous</td>
<td>WARNING: Numeric literal @1 is interpreted as a floating-point</td>
</tr>
<tr>
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<td>value in SQL dialect 1, but as an exact numeric value in SQL dialect 3.</td>
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<td>WARNING: NUMERIC and DECIMAL fields with precision 10 or greater are stored</td>
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<td>no match for first value expression</td>
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<td>Only @1 or user with privilege USE_GRANTED_BY_CLAUSE can use GRANTED BY clause</td>
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<td>dyn_incompat_alter_database</td>
<td>Incompatible ALTER DATABASE clauses: '@1' and '@2'</td>
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Appendix B: Exception Codes and Messages
<table>
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<tr>
<th>SQL-CODE</th>
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<tr>
<td>-84</td>
<td>335544554</td>
<td>nonsql_security_rel</td>
<td>object has non-SQL security class defined</td>
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<td>nonsql_security fld</td>
<td>column has non-SQL security class defined</td>
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<td>procedure @1 does not return any values</td>
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<td>usernameTooLong</td>
<td>The username entered is too long. Maximum length is 31 bytes.</td>
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<td>passwordTooLong</td>
<td>The password specified is too long. Maximum length is 8 bytes.</td>
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<td>usernameRequired</td>
<td>A username is required for this operation.</td>
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<td>passwordRequired</td>
<td>A password is required for this operation</td>
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<td>The network protocol specified is invalid</td>
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<td>A duplicate user name was found in the security database</td>
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<td>An error occurred while attempting to add the user.</td>
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<td>errorModifyingSecRecord</td>
<td>An error occurred while attempting to modify the user record.</td>
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<td>errorDeletingSecRecord</td>
<td>An error occurred while attempting to delete the user record.</td>
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<td>context not defined (BLR error)</td>
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<td>Unexpected end of command</td>
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<td>Token unknown</td>
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<td>dsq1_token_unk_err</td>
<td>Token unknown - line @1, column @2</td>
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<td>Client/Server Express not supported in this release</td>
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<td>a string constant is delimited by double quotes</td>
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<td>DATE must be changed to TIMESTAMP</td>
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<td>Client SQL dialect @1 does not support reference to @2 datatype</td>
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<td>You created an indirect dependency on uncommitted metadata. You must roll back the current transaction.</td>
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<td>Cannot use an aggregate or window function in a WHERE clause, use HAVING (for aggregate only) instead</td>
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<td>Invalid expression in the @1 (not contained in either an aggregate function or the GROUP BY clause)</td>
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<td>Nested aggregate and window functions are not allowed</td>
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<td>BLR stream length @1 exceeds implementation limit @2</td>
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<td>Incorrect parameters provided to internal function @1</td>
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<td>Cannot copy statement @1</td>
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<td>No isc_info_svc_stdin in user request, but service thread requested stdin data</td>
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<td>All services except for getting server log require switches</td>
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<td>Size of stdin data is more than was requested from client</td>
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<td>Crypt plugin @1 failed to load</td>
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<td>Length of crypt plugin name should not exceed @1 bytes</td>
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<td>NULL data with non-zero SPB length</td>
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<td>If &lt;window frame bound 1&gt; specifies @1, then &lt;window frame bound 2&gt; shall not specify @2</td>
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<td>dsq1_window_range_inv_key_type</td>
<td>RANGE based window with &lt;offset&gt; PRECEDING/FOLLOWING must have a single ORDER BY key of numerical, date, time or timestamp types</td>
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<td>Key holder plugin @1 failed to load</td>
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<td>Precision 10 to 18 changed from DOUBLE PRECISION in SQL dialect 1 to 64-bit scaled integer in SQL dialect 3</td>
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<td>Label @1 @2 in the current scope</td>
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<td>Datatypes @1 are not comparable in expression @2</td>
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<td>dsq1_max_sort_items</td>
<td>cannot sort on more than 255 items</td>
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<td>dsq1_max_group_items</td>
<td>cannot group on more than 255 items</td>
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<td>Cannot include the same field (@1.@2) twice in the ORDER BY clause with conflicting sorting options</td>
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<td>column list from derived table @1 has more columns than the number of items in its SELECT statement</td>
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<td>dsq1 derived_field.dup_name</td>
<td>column @1 was specified multiple times for derived table @2</td>
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<td>Internal dsq1 error: alias type expected by pass1 Expand select node</td>
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<td>Internal dsq1 error: alias type expected by pass1 field</td>
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<td>Internal dsq1 error: column position out of range in pass1 union auto_cast</td>
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<td>Recursive CTE member (@1) can refer itself only in FROM clause</td>
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<td>CTE @1 has cyclic dependencies</td>
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<td>Recursive member of CTE can’t be member of an outer join</td>
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<td>dsq1 cte_mult_references</td>
<td>Recursive member of CTE can’t reference itself more than once</td>
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<td>dsq1 cte_not_a_union</td>
<td>Recursive CTE (@1) must be an UNION</td>
</tr>
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<td>Message Text</td>
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<td>dsqle_nonrecurs_after_recurse</td>
<td>CTE '@1' defined non-recursive member after recursive</td>
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<td>Recursive member of CTE '@1' has @2 clause</td>
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<td>Recursive members of CTE (@1) must be linked with another members via UNION ALL</td>
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<td>Non-recursive member is missing in CTE '@1'</td>
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<td>dsqle_nested_with</td>
<td>WITH clause can't be nested</td>
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<td>column @1 appears more than once in USING clause</td>
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<td>CTE &quot;@1&quot; is not used in query</td>
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<td>column @1 appears more than once in ALTER VIEW</td>
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<td>Cannot have more than 255 items in DISTINCT / UNION DISTINCT list</td>
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<td>Recursive member of CTE cannot use aggregate or window function</td>
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<td>WITH LOCK can be used only with a single physical table</td>
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<td>FIRST/SKIP cannot be used with OFFSET/FETCH or ROWS</td>
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<td>WITH LOCK cannot be used with aggregates</td>
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<td>dsqle_wlock_conflict</td>
<td>WITH LOCK cannot be used with @1</td>
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<td>column not array or invalid dimensions (expected @1, encountered @2)</td>
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<td>could not find column for GRANT</td>
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<td>At line @1, column @2</td>
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<td>At unknown line and column</td>
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<td>Log file header of @1 too small</td>
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<td>Invalid version of log file @1</td>
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<td>Log file @1 not latest in the chain but open flag still set</td>
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<td>Log file @1 not closed properly; database recovery may be required</td>
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<td>Unexpected end of log file @1 at offset @2</td>
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<td>Incomplete log record at offset @1 in log file @2</td>
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<td>Log block too small at offset @1 in log file @2</td>
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<td>Insufficient memory to allocate page buffer cache</td>
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<td>Log size too small</td>
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<td>Log partition size too small</td>
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<td>Cannot roll over to the next log file @1</td>
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<td>no_wal</td>
<td>database does not use Write-ahead Log</td>
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<td>WAL subsystem encountered error</td>
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<td>wal_subsys_corrupt</td>
<td>WAL subsystem corrupted</td>
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<td>wal_bugcheck</td>
<td>Database @1: WAL subsystem bug for pid @2 @3</td>
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<td>Could not expand the WAL segment for database @1</td>
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<td>Unable to roll over please see Firebird log.</td>
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<td>WAL I/O error. Please see Firebird log.</td>
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<td>WAL writer - Journal server communication error. Please see Firebird log.</td>
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<td>WAL buffers cannot be increased. Please see Firebird log.</td>
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<td>wal_err_setup</td>
<td>WAL setup error. Please see Firebird log.</td>
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<td>Cannot start WAL writer for the database @1</td>
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<td>Write-ahead Log without shared cache configuration not allowed</td>
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<td>start_cm_for_wal</td>
<td>WAL defined; Cache Manager must be started first</td>
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<td>wal_ovflow_log_required</td>
<td>Overflow log specification required for round-robin log</td>
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<td>Write-ahead Log with shadowing configuration not allowed</td>
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<td>Partitions not supported in series of log file specification</td>
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<td>Total length of a partitioned log must be specified</td>
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<td>table or procedure @1 is not referenced in plan</td>
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<td>Procedures cannot specify access type other than NATURAL in the plan</td>
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<td>the table @1 is referenced twice; use aliases to differentiate</td>
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<td>table or procedure @1 is referenced twice in view; use an alias to distinguish</td>
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<td>view @1 has more than one base table; use aliases to distinguish</td>
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<td>Column used in a PRIMARY constraint must be NOT NULL.</td>
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<td>Domain used in the PRIMARY KEY constraint of table @1 must be NOT NULL.</td>
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<td>Empty cursor name is not allowed</td>
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<td>Effective user is @1</td>
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<td>user does not have GRANT privileges for operation</td>
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<td>user does not have GRANT privileges on base table/view for operation</td>
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<td>the current position is on a crack</td>
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<td>Inappropriate self-reference of column</td>
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<td>Array/BLOB/DATE data types not allowed in arithmetic</td>
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<td>&quot;REFERENCES table&quot; without &quot;(column)&quot; requires PRIMARY KEY on referenced table</td>
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<td>Can’t have relation with only computed fields or constraints</td>
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<td>Cannot SELECT RDB$DB_KEY from a stored procedure.</td>
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<td>Data type @1 is not supported for EXTERNAL TABLES. Relation '@2', field '@3'</td>
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<td>To be used with RDB$RECORD_VERSION, @1 must be a table or a view of single table</td>
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<td>dyn_cannot_del_syscoll</td>
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### Appendix B: Exception Codes and Messages

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<td>Invalid DDL statement for procedure @1</td>
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<td>Table @1 does not exist</td>
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<td>dsq1_view_not_found</td>
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<td>Array and BLOB data types not allowed in computed field</td>
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<td>lock on table @1 conflicts with existing lock</td>
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<td>record_lock</td>
<td>requested record lock conflicts with existing lock</td>
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<td>drop_wal</td>
<td>cannot drop log file when journaling is enabled</td>
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<td>range_in_use</td>
<td>refresh range number @1 already in use</td>
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<td>Cannot delete PRIMARY KEY being used in FOREIGN KEY definition.</td>
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<td>integ_index_del</td>
<td>Cannot delete index used by an Integrity Constraint</td>
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<td>integ_index_mod</td>
<td>Cannot modify index used by an Integrity Constraint</td>
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<td>SQL-CODE</td>
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<td>last column in a table cannot be deleted</td>
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<tr>
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<td>key_field_err</td>
<td>too few key columns found for index @1 (incorrect column name?)</td>
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<tr>
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<td>keytoobig</td>
<td>key size exceeds implementation restriction for index &quot;@1&quot;</td>
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<td>@1 extension error</td>
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<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>invalid BLOB type for operation</td>
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<td>attempt to index BLOB column in index @1</td>
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<td>array_idx_err</td>
<td>attempt to index array column in index @1</td>
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<td>badpagtyp</td>
<td>page @1 is of wrong type (expected @2, found @3)</td>
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<td>page_type_err</td>
<td>wrong page type</td>
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<td>no_segments_err</td>
<td>segments not allowed in expression index @1</td>
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<td>rec_size_err</td>
<td>new record size of @1 bytes is too big</td>
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<td>max_idx</td>
<td>maximum indexes per table (@1) exceeded</td>
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<td>req_max_clones_exceeded</td>
<td>Too many concurrent executions of the same request</td>
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<td>no_field_access</td>
<td>cannot access column @1 in view @2</td>
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<td>-802</td>
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<td>arith_except</td>
<td>arithmetic exception, numeric overflow, or string truncation</td>
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<td>-802</td>
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<td>concat_overflow</td>
<td>Concatenation overflow. Resulting string cannot exceed 32765 bytes in length.</td>
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<td>string_truncation</td>
<td>string right truncation</td>
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<td>-802</td>
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<td>blob_truncation</td>
<td>blob truncation when converting to a string: length limit exceeded</td>
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<td>numeric_out_of_range</td>
<td>numeric value is out of range</td>
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<td>dsq1_invalid_sqlda_version</td>
<td>SQLDA version expected between @1 and @2, found @3</td>
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<td>at SQLVAR index @1</td>
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<td>dsq1_no_sq1ind</td>
<td>empty pointer to NULL indicator variable</td>
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<tr>
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<td>dsq1_no_sq1data</td>
<td>empty pointer to data</td>
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<td>No SQLDA for input values provided</td>
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<tr>
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<td>dsq1_no_output_sqlda</td>
<td>No SQLDA for output values provided</td>
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<tr>
<td>-803</td>
<td>335544349</td>
<td>no_dup</td>
<td>attempt to store duplicate value (visible to active transactions) in unique index &quot;@1&quot;</td>
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</table>
### Appendix B: Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQL-CODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
</tr>
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<tbody>
<tr>
<td>-803</td>
<td>335544665</td>
<td>unique_key_violation</td>
<td>violation of PRIMARY or UNIQUE KEY constraint &quot;@1&quot; on table &quot;@2&quot;</td>
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<tr>
<td>-804</td>
<td>335544380</td>
<td>wronumarg</td>
<td>wrong number of arguments on call</td>
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<td>335544583</td>
<td>dsqsqlda_err</td>
<td>SQLDA error</td>
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<td>Count of read-write columns does not equal count of values</td>
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<td>dsqsql_function_err</td>
<td>Function unknown</td>
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<td>-804</td>
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<td>dsqsqlda_value_err</td>
<td>Incorrect values within SQLDA structure</td>
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<tr>
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<td>wrong_message_length</td>
<td>Message length passed from user application does not match set of columns</td>
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<td>no_output_format</td>
<td>Resultset is missing output format information</td>
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<tr>
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<td>item_finish</td>
<td>Message metadata not ready - item @1 is not finished</td>
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<td>335545100</td>
<td>interface_version_too_old</td>
<td>Interface @3 version too old: expected @1, found @2</td>
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<td>dsqsql_feature_not_supported_ods</td>
<td>Feature not supported on ODS version older than @1.@2</td>
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<td>ODS versions before ODS@1 are not supported</td>
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<td>col_name_err</td>
<td>Only simple column names permitted for VIEW WITH CHECK OPTION</td>
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<tr>
<td>-807</td>
<td>335544601</td>
<td>where_err</td>
<td>No WHERE clause for VIEW WITH CHECK OPTION</td>
</tr>
<tr>
<td>-808</td>
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<td>table_view_err</td>
<td>Only one table allowed for VIEW WITH CHECK OPTION</td>
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<tr>
<td>-809</td>
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<td>distinct_err</td>
<td>DISTINCT, GROUP or HAVING not permitted for VIEW WITH CHECK OPTION</td>
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<td>subquery_err</td>
<td>No subqueries permitted for VIEW WITH CHECK OPTION</td>
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<td>sing_select_err</td>
<td>multiple rows in singleton select</td>
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<tr>
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<td>merge_dup_update</td>
<td>Multiple source records cannot match the same target during MERGE</td>
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<td>ext_readonly_err</td>
<td>Cannot insert because the file is readonly or is on a read only medium.</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
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</tr>
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<td>335544715</td>
<td>extfile_uns_op</td>
<td>Operation not supported for EXTERNAL FILE table @1</td>
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<tr>
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<td>335544361</td>
<td>read_only_trans</td>
<td>attempted update during read-only transaction</td>
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<tr>
<td>-817</td>
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<td>segstr_no_write</td>
<td>attempted write to read-only BLOB</td>
</tr>
<tr>
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<td>read_only</td>
<td>operation not supported</td>
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<td>read_only_database</td>
<td>attempted update on read-only database</td>
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<td>must_be_dialect_2_and_up</td>
<td>SQL dialect @1 is not supported in this database</td>
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<td>ddl_not_allowed_by_db_sql_dial</td>
<td>Metadata update statement is not allowed by the current database SQL dialect @1</td>
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<td>DB dialect @1 and client dialect @2 conflict with respect to numeric precision @3.</td>
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<td>UPDATE OR INSERT without MATCHING could not be used with views based on more than one table</td>
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<td>Incompatible trigger type</td>
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<td>Invalid DROP SQL SECURITY clause</td>
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<td>obsolete_metadata</td>
<td>metadata is obsolete</td>
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<td>wrong_ods</td>
<td>unsupported on-disk structure for file @1; found @2.@3, support @4.@5</td>
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<td>wrodynver</td>
<td>wrong DYN version</td>
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<td>high_minor</td>
<td>minor version too high found @1 expected @2</td>
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<td>need_difference</td>
<td>Difference file name should be set explicitly for database on raw device</td>
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<td>invalid bookmark handle</td>
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<td>invalid lock level @1</td>
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<td>invalid direction for find operation</td>
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<td>invalid key position</td>
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<td>SQL-CODE</td>
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<td>Message Text</td>
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<td>New size specified for column @1 must be at least @2 characters.</td>
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<td>Cannot change datatype for @1. Conversion from base type @2 to @3 is not supported.</td>
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<td>max_coll_per_charset</td>
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<td>Invalid collation attributes</td>
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<td>New scale specified for column @1 must be at most @2.</td>
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<td>Attempt to define a second PRIMARY KEY for the same table</td>
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<td>FOREIGN KEY column count does not match PRIMARY KEY</td>
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<td>expression evaluation not supported</td>
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<td>value exceeds the range for valid dates</td>
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<td>value exceeds the range for a valid time</td>
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<td>value exceeds the range for valid timestamps</td>
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<td>Invalid data type in DATE/TIME/TIMESTAMP addition or subtraction in add_datettime()</td>
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<td>Only a TIME value can be added to a DATE value</td>
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<td>onlycan_add_datetotime</td>
<td>Only a DATE value can be added to a TIME value</td>
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<td>onlyc ansub_tstampfromtstamp</td>
<td>TIMESTAMP values can be subtracted only from another TIMESTAMP value</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>onlyoneop_mustbe_tstamp</td>
<td>Only one operand can be of type TIMESTAMP</td>
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<td>Only HOUR, MINUTE, SECOND and MILLISECOND can be extracted from TIME values</td>
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<td>invalidarg_extract</td>
<td>Invalid argument for EXTRACT() not being of DATE/TIME/TIMESTAMP type</td>
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<td>sysf_argmustbe_exact</td>
<td>Arguments for @1 must be integral types or NUMERIC/DECIMAL without scale</td>
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<td>sysf_argmustbe_exact_or_fp</td>
<td>First argument for @1 must be integral type or floating point type</td>
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<td>Human readable UUID argument for @1 must be of string type</td>
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<td>sysf_argviolates_uuidlen</td>
<td>Human readable UUID argument for @2 must be of exact length @1</td>
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<td>sysf_argviolates_uuidfmt</td>
<td>Human readable UUID argument for @3 must have &quot;-&quot; at position @2 instead of &quot;@1&quot;</td>
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<td>sysf_argviolates_guidigits</td>
<td>Human readable UUID argument for @3 must have hex digit at position @2 instead of &quot;@1&quot;</td>
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<td>sysf_invalid_addpart_time</td>
<td>Only HOUR, MINUTE, SECOND and MILLISECOND can be added to TIME values in @1</td>
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<td>sysf_invalid_add_datetime</td>
<td>Invalid data type in addition of part to DATE/TIME/TIMESTAMP in @1</td>
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<td>sysf_invalid_addpart_dtime</td>
<td>Invalid part @1 to be added to a DATE/TIME/TIMESTAMP value in @2</td>
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<td>Expected DATE/TIME/TIMESTAMP type in evlDateAdd() result</td>
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<td>sysf_invalid_diff_dtime</td>
<td>Expected DATE/TIME/TIMESTAMP type as first and second argument to @1</td>
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<tr>
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<td>sysf_invalid_timediff</td>
<td>The result of TIME-&lt;value&gt; in @1 cannot be expressed in YEAR, MONTH, DAY or WEEK</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
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<td>sysf_invalid_tstamptimediff</td>
<td>The result of TIME-TIMESTAMP or TIMESTAMP-TIME in @1 cannot be expressed in HOUR, MINUTE, SECOND or MILLISECOND</td>
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<td>The result of DATE-TIME or TIME-DATE in @1 cannot be expressed in HOUR, MINUTE, SECOND and MILLISECOND</td>
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<td>sysf_invalid_diffpart</td>
<td>Invalid part @1 to express the difference between two DATE/TIME/TIMESTAMP values in @2</td>
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<td>Argument for @1 must be positive</td>
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<tr>
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<td>sysf_basemustbe_positive</td>
<td>Base for @1 must be positive</td>
</tr>
<tr>
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<td>sysf_argnmustbe_nonneg</td>
<td>Argument #@1 for @2 must be zero or positive</td>
</tr>
<tr>
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<td>sysf_argmustbe_positive</td>
<td>Argument #@1 for @2 must be positive</td>
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<td>sysf_invalid_zeropowneg</td>
<td>Base for @1 cannot be zero if exponent is negative</td>
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<td>sysf_invalid_negpowfp</td>
<td>Base for @1 cannot be negative if exponent is not an integral value</td>
</tr>
<tr>
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<td>sysf_invalid_scale</td>
<td>The numeric scale must be between -128 and 127 in @1</td>
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<tr>
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<td>Binary UUID argument for @2 must use @1 bytes</td>
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<td>restart shared cache manager</td>
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<td>too many versions</td>
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<td>Scale must be between zero and precision</td>
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<td>Precision must be from @1 to @2</td>
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### Appendix B: Exception Codes and Messages

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<th>SQL-CODE</th>
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<th>Symbol</th>
<th>Message Text</th>
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<td>bad_dbkey</td>
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<td>unrecognized database parameter block</td>
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<td>bad_segstr_handle</td>
<td>invalid BLOB handle</td>
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<td>bad_segstr_id</td>
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<td>invalid parameter in transaction parameter block</td>
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<td>bad_tpb_form</td>
<td>invalid format for transaction parameter block</td>
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<td>invalid transaction handle (expecting explicit transaction start)</td>
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<td>attempt to start more than @1 transactions</td>
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<td>information type inappropriate for object specified</td>
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<td>no information of this type available for object specified</td>
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<td>unknown information item</td>
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<td>action cancelled by trigger (@1) to preserve data integrity</td>
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<td>lock conflict on no wait transaction</td>
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<td>transaction is not in limbo</td>
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<td>cannot disconnect database with open transactions (@1 active)</td>
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<td>Symbol</td>
<td>Message Text</td>
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<td>table @1 was omitted from the transaction reserving list</td>
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<td>request includes a DSRI extension not supported in this implementation</td>
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<td>blob_filter_exception</td>
<td>A fatal exception occurred during the execution of a blob filter.</td>
</tr>
<tr>
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<td>exception_access_vio</td>
<td>Access violation. The code attempted to access a virtual address without privilege to do so.</td>
</tr>
<tr>
<td>SQL- CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<tr>
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</tr>
<tr>
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<td>exception_datatype_misalignment</td>
<td>Datatype misalignment. The attempted to read or write a value that was not stored on a memory boundary.</td>
</tr>
<tr>
<td>-901</td>
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<td>exception_array_bounds_exceeded</td>
<td>Array bounds exceeded. The code attempted to access an array element that is out of bounds.</td>
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<tr>
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<td>335544771</td>
<td>exception_float_denormal_operand</td>
<td>Float denormal operand. One of the floating-point operands is too small to represent a standard float value.</td>
</tr>
<tr>
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<td>335544772</td>
<td>exception_float_divide_by_zero</td>
<td>Floating-point divide by zero. The code attempted to divide a floating-point value by zero.</td>
</tr>
<tr>
<td>-901</td>
<td>335544773</td>
<td>exception_float_inexact_result</td>
<td>Floating-point inexact result. The result of a floating-point operation cannot be represented as a decimal fraction.</td>
</tr>
<tr>
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<td>335544774</td>
<td>exception_float_invalid_operand</td>
<td>Floating-point invalid operand. An indeterminant error occurred during a floating-point operation.</td>
</tr>
<tr>
<td>-901</td>
<td>335544775</td>
<td>exception_float_overflow</td>
<td>Floating-point overflow. The exponent of a floating-point operation is greater than the magnitude allowed.</td>
</tr>
<tr>
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<td>335544776</td>
<td>exception_float_stack_check</td>
<td>Floating-point stack check. The stack overflowed or underflowed as the result of a floating-point operation.</td>
</tr>
<tr>
<td>-901</td>
<td>335544777</td>
<td>exception_float_underflow</td>
<td>Floating-point underflow. The exponent of a floating-point operation is less than the magnitude allowed.</td>
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<tr>
<td>-901</td>
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<td>exception_integer_divide_by_zero</td>
<td>Integer divide by zero. The code attempted to divide an integer value by an integer divisor of zero.</td>
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<td>exception_integer_overflow</td>
<td>Integer overflow. The result of an integer operation caused the most significant bit of the result to carry.</td>
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<td>335544780</td>
<td>exception_unknown</td>
<td>An exception occurred that does not have a description. Exception number @1.</td>
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<td>exception_stack_overflow</td>
<td>Stack overflow. The resource requirements of the runtime stack have exceeded the memory available to it.</td>
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<tr>
<td>SQLCODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<td>-----------------------------------------------------------------------------</td>
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<td>exception_sigsevg</td>
<td>Segmentation Fault. The code attempted to access memory without privileges.</td>
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<td>exception_sigill</td>
<td>Illegal Instruction. The Code attempted to perform an illegal operation.</td>
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<td>335544784</td>
<td>exception_sigbus</td>
<td>Bus Error. The Code caused a system bus error.</td>
</tr>
<tr>
<td>-901</td>
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<td>exception_sigfpe</td>
<td>Floating Point Error. The Code caused an Arithmetic Exception or a floating point exception.</td>
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<tr>
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<td>335544786</td>
<td>ext_file_delete</td>
<td>Cannot delete rows from external files.</td>
</tr>
<tr>
<td>-901</td>
<td>335544787</td>
<td>ext_file_modify</td>
<td>Cannot update rows in external files.</td>
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<td>335544788</td>
<td>adm_task_denied</td>
<td>Unable to perform operation</td>
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<td>-901</td>
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<td>cancelled</td>
<td>operation was cancelled</td>
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<td>335544797</td>
<td>svcnouser</td>
<td>user name and password are required while attaching to the services manager</td>
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<tr>
<td>-901</td>
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<td>datatype_notsup</td>
<td>data type not supported for arithmetic</td>
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<td>dialect_not_changed</td>
<td>Database dialect not changed.</td>
</tr>
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<td>335544804</td>
<td>database_create_failed</td>
<td>Unable to create database @1</td>
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<td>inv_dialect_specified</td>
<td>Database dialect @1 is not a valid dialect.</td>
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<td>335544806</td>
<td>valid_db_dialects</td>
<td>Valid database dialects are @1.</td>
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<td>inv_client_dialect_specified</td>
<td>passed client dialect @1 is not a valid dialect.</td>
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<td>valid_client_dialects</td>
<td>Valid client dialects are @1.</td>
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<td>335544814</td>
<td>service_not_supported</td>
<td>Services functionality will be supported in a later version of the product</td>
</tr>
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<td>-901</td>
<td>335544820</td>
<td>invalid_savepoint</td>
<td>Unable to find savepoint with name @1 in transaction context</td>
</tr>
<tr>
<td>-901</td>
<td>335544835</td>
<td>bad_shutdown_mode</td>
<td>Target shutdown mode is invalid for database &quot;@1&quot;</td>
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<tr>
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<td>335544840</td>
<td>no_update</td>
<td>cannot update</td>
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<td>335544842</td>
<td>stack_trace</td>
<td>@1</td>
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<td>335544843</td>
<td>ctx_var_not_found</td>
<td>Context variable '@1' is not found in namespace '@2'</td>
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<td>ctx_namespace_invalid</td>
<td>Invalid namespace name '@1' passed to '@2'</td>
</tr>
<tr>
<td>SQL CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
</tr>
<tr>
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<td>----------</td>
<td>---------------------</td>
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<td>ctx_too_big</td>
<td>Too many context variables</td>
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<td>335544846</td>
<td>ctx_bad_argument</td>
<td>Invalid argument passed to @1</td>
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<td>identifier_too_long</td>
<td>BLR syntax error. Identifier @1… is too long</td>
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<td>335544859</td>
<td>invalid_time_precision</td>
<td>Time precision exceeds allowed range (0-@1)</td>
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<td>-901</td>
<td>335544866</td>
<td>met_wrong_gtt_scope</td>
<td>@1 cannot depend on @2</td>
</tr>
<tr>
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<td>Procedure @1 is not selectable (it does not contain a SUSPEND statement)</td>
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<td>invalid_sort_datatype</td>
<td>Datatype @1 is not supported for sorting operation</td>
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<tr>
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<td>collation_name</td>
<td>COLLATION @1</td>
</tr>
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<td>domain_name</td>
<td>DOMAIN @1</td>
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<tr>
<td>-901</td>
<td>335544874</td>
<td>max_db_per_trans_allowed</td>
<td>A multi database transaction cannot span more than @1 databases</td>
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<tr>
<td>-901</td>
<td>335544876</td>
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<td>Error while parsing procedure @1’s BLR</td>
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<tr>
<td>-901</td>
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<td>key_too_big</td>
<td>index key too big</td>
</tr>
<tr>
<td>-901</td>
<td>335544885</td>
<td>bad_teb_form</td>
<td>Invalid TEB format</td>
</tr>
<tr>
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<td>335544886</td>
<td>tpb_multiple_txn_isolation</td>
<td>Found more than one transaction isolation in TPB</td>
</tr>
<tr>
<td>-901</td>
<td>335544887</td>
<td>tpb_reserv_before_table</td>
<td>Table reservation lock type @1 requires table name before in TPB</td>
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<tr>
<td>-901</td>
<td>335544888</td>
<td>tpb_multiple_spec</td>
<td>Found more than one @1 specification in TPB</td>
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<tr>
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<td>335544889</td>
<td>tpb_option_without_rc</td>
<td>Option @1 requires READ COMMITTED isolation in TPB</td>
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<tr>
<td>-901</td>
<td>335544890</td>
<td>tpb_conflicting_options</td>
<td>Option @1 is not valid if @2 was used previously in TPB</td>
</tr>
<tr>
<td>-901</td>
<td>335544891</td>
<td>tpb_reserv_missing_tlen</td>
<td>Table name length missing after table reservation @1 in TPB</td>
</tr>
<tr>
<td>-901</td>
<td>335544892</td>
<td>tpb_reserv_long_tlen</td>
<td>Table name length @1 is too long after table reservation @2 in TPB</td>
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<tr>
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<td>335544893</td>
<td>tpb_reserv_missing_tname</td>
<td>Table name length @1 without table name after table reservation @2 in TPB</td>
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<tr>
<td>-901</td>
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<td>tpb_reserv_corrup_tlen</td>
<td>Table name length @1 goes beyond the remaining TPB size after table reservation @2</td>
</tr>
</tbody>
</table>

Appendix B: Exception Codes and Messages
<table>
<thead>
<tr>
<th>SQLCODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
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</thead>
<tbody>
<tr>
<td>-901</td>
<td>335544895</td>
<td>tpb_reserv_null_tlen</td>
<td>Table name length is zero after table reservation @1 in TPB</td>
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<tr>
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<td>Table or view @1 not defined in system tables after table reservation @2 in TPB</td>
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<td>-901</td>
<td>335544897</td>
<td>tpb_reserv_baserelnotfound</td>
<td>Base table or view @1 for view @2 not defined in system tables after table reservation @3 in TPB</td>
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<tr>
<td>-901</td>
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<td>tpb_missing_len</td>
<td>Option length missing after option @1 in TPB</td>
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<tr>
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<td>335544899</td>
<td>tpb_missing_value</td>
<td>Option length @1 without value after option @2 in TPB</td>
</tr>
<tr>
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<td>Option length @1 goes beyond the remaining TPB size after option @2</td>
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<td>Option length is zero after table reservation @1 in TPB</td>
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<td>Option length @1 exceeds the range for option @2 in TPB</td>
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<td>Option value @1 is invalid for the option @2 in TPB</td>
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<td>335544904</td>
<td>tpb_reserv_stronger_wng</td>
<td>Preserving previous table reservation @1 for table @2, stronger than new @3 in TPB</td>
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<td>tpb_reserv_stronger</td>
<td>Table reservation @1 for table @2 already specified and is stronger than new @3 in TPB</td>
</tr>
<tr>
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<td>335544906</td>
<td>tpb_reserv_max_recursion</td>
<td>Table reservation reached maximum recursion of @1 when expanding views in TPB</td>
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<tr>
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<td>335544907</td>
<td>tpb_reserv_virtualtbl</td>
<td>Table reservation in TPB cannot be applied to @1 because it’s a virtual table</td>
</tr>
<tr>
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<td>335544908</td>
<td>tpb_reserv_systbl</td>
<td>Table reservation in TPB cannot be applied to @1 because it’s a system table</td>
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<td>335544909</td>
<td>tpb_reserv_temptbl</td>
<td>Table reservation @1 or @2 in TPB cannot be applied to @3 because it’s a temporary table</td>
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<td>tpb_readtxn_after_writelock</td>
<td>Cannot set the transaction in read only mode after a table reservation isc_tpb_lock_write in TPB</td>
</tr>
<tr>
<td>SQL-CODE</td>
<td>GDSCODE</td>
<td>Symbol</td>
<td>Message Text</td>
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<tr>
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</tr>
<tr>
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<td>335544911</td>
<td>tpb_writelock_after_readtxn</td>
<td>Cannot take a table reservation isc_tpb_lock_write in TPB because the transaction is in read only mode</td>
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<tr>
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<td>shutdown_timeout</td>
<td>Firebird shutdown is still in progress after the specified timeout</td>
</tr>
<tr>
<td>-901</td>
<td>335544918</td>
<td>att_handle_busy</td>
<td>Attachment handle is busy</td>
</tr>
<tr>
<td>-901</td>
<td>335544919</td>
<td>bad_udf_freeit</td>
<td>Bad written UDF detected: pointer returned in FREE_IT function was not allocated by ib_util_malloc</td>
</tr>
<tr>
<td>-901</td>
<td>335544920</td>
<td>eds_provider_not_found</td>
<td>External Data Source provider '@1' not found</td>
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<td>335544921</td>
<td>eds_connection</td>
<td>Execute statement error at @1 : @2Data source : @3</td>
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<tr>
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<td>335544922</td>
<td>eds_preprocess</td>
<td>Execute statement preprocess SQL error</td>
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<td>eds_stmt_expected</td>
<td>Statement expected</td>
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<td>eds_prm_name_expected</td>
<td>Parameter name expected</td>
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<td>eds_unclosed_comment</td>
<td>Unclosed comment found near '@1'</td>
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<tr>
<td>-901</td>
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<td>eds_statement</td>
<td>Execute statement error at @1 : @2Statement : @3 Data source : @4</td>
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<tr>
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<td>335544927</td>
<td>eds_input_prm_mismatch</td>
<td>Input parameters mismatch</td>
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<td>335544928</td>
<td>eds_output_prm_mismatch</td>
<td>Output parameters mismatch</td>
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<td>335544929</td>
<td>eds_input_prm_not_set</td>
<td>Input parameter '@1' have no value set</td>
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<td>nothing to cancel</td>
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<td>ib_util library has not been loaded to deallocate memory returned by FREE_IT function</td>
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<td>335544973</td>
<td>bad_epb_form</td>
<td>Unrecognized events block</td>
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<td>335544982</td>
<td>udf_fp_overflow</td>
<td>Floating point overflow in result from UDF @1</td>
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<td>udf_fp_nan</td>
<td>Invalid floating point value returned by UDF @1</td>
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<td>out_of_temp_space</td>
<td>No free space found in temporary directories</td>
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<td>eds_expl_tran_ctrl</td>
<td>Explicit transaction control is not allowed</td>
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<td>package_name</td>
<td>PACKAGE @1</td>
</tr>
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</table>

Appendix B: Exception Codes and Messages

684
<table>
<thead>
<tr>
<th>SQL-CODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
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<tr>
<td>-901</td>
<td>335544989</td>
<td>cannot_make_not_null</td>
<td>Cannot make field @1 of table @2 NOT NULL because there are NULLs present</td>
</tr>
<tr>
<td>-901</td>
<td>335544990</td>
<td>feature_removed</td>
<td>Feature @1 is not supported anymore</td>
</tr>
<tr>
<td>-901</td>
<td>335544991</td>
<td>view_name</td>
<td>VIEW @1</td>
</tr>
<tr>
<td>-901</td>
<td>335544993</td>
<td>invalid_fetch_option</td>
<td>Fetch option @1 is invalid for a non-scrollable cursor</td>
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<tr>
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<td>bad_fun_BLR</td>
<td>Error while parsing function @1’s BLR</td>
</tr>
<tr>
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<td>335544995</td>
<td>func_pack_not_implemented</td>
<td>Cannot execute function @1 of the unimplemented package @2</td>
</tr>
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<td>proc_pack_not_implemented</td>
<td>Cannot execute procedure @1 of the unimplemented package @2</td>
</tr>
<tr>
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<td>eem_func_not_returned</td>
<td>External function @1 not returned by the external engine plugin @2</td>
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<td>External procedure @1 not returned by the external engine plugin @2</td>
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<td>External trigger @1 not returned by the external engine plugin @2</td>
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<td>Incompatible plugin version @1 for external engine @2</td>
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<td>eem_engine_notfound</td>
<td>External engine @1 not found</td>
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<td>pman_cannot_load_plugin</td>
<td>Error loading plugin @1</td>
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<td>pman_module_notfound</td>
<td>Loadable module @1 not found</td>
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<td>Standard plugin entrypoint does not exist in module @1</td>
</tr>
<tr>
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<td>335545007</td>
<td>pman_module_bad</td>
<td>Module @1 exists but can not be loaded</td>
</tr>
<tr>
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<td>335545008</td>
<td>pman_plugin_notfound</td>
<td>Module @1 does not contain plugin @2 type @3</td>
</tr>
<tr>
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<td>unexpected_null</td>
<td>Value is NULL but isNull parameter was not informed</td>
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<td>Type @1 is incompatible with BLOB</td>
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<td>Libtommath error code @1 in function @2</td>
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<td>Crypt failed - already crypting database</td>
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<td>Crypt failed - database is already in requested state</td>
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<td>undefined variable number</td>
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<td>Attempt to get information about an unprepared dynamic SQL statement.</td>
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<td>idx_key_value</td>
<td>Problematic key value is @1</td>
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<td>Cannot select virtual table @1 for update WITH LOCK</td>
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<td>Cannot select system table @1 for update WITH LOCK</td>
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<td>Cannot select temporary table @1 for update WITH LOCK</td>
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<td>cant_modify_sysobj</td>
<td>System @1 @2 cannot be modified</td>
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<td>server_misconfigured</td>
<td>Server misconfigured - contact administrator please</td>
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<td>alter_role</td>
<td>Deprecated backward compatibility ALTER ROLE ... SET/DROP AUTO ADMIN mapping may be used only for RDB$ADMIN role</td>
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<td>Mapping @1 already exists</td>
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<td>map_load</td>
<td>@1 failed when loading mapping cache</td>
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### Appendix B: Exception Codes and Messages

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<th>SQLCODE</th>
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<th>Message Text</th>
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<td>map_aster</td>
<td>Invalid name &lt;*&gt; in authentication block</td>
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<td>map_multi</td>
<td>Multiple maps found for @1</td>
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<td>map_undefined</td>
<td>Undefined mapping result - more than one different results found</td>
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<td>map_nodb</td>
<td>Global mapping is not available when database @1 is not present</td>
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<td>map_notable</td>
<td>Global mapping is not available when table RDB$MAP is not present in database @1</td>
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<td>miss_trusted_role</td>
<td>Your attachment has no trusted role</td>
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<td>set_invalid_role</td>
<td>Role @1 is invalid or unavailable</td>
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<td>dup_attribute</td>
<td>Duplicated user attribute @1</td>
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<td>dyn_no_priv</td>
<td>There is no privilege for this operation</td>
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<td>Using GRANT OPTION on @1 not allowed</td>
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<td>crdb_load</td>
<td>@1 failed when working with CREATE DATABASE grants</td>
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<td>Error during savepoint backout - transaction invalidated</td>
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<td>Some database(s) were shutdown when trying to read mapping data</td>
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<td>encrypt_error</td>
<td>Page requires encryption but crypt plugin is missing</td>
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<td>System privilege @1 does not exist</td>
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<td>Cannot open cursor for non-SELECT statement</td>
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<td>Config level timeout expired.</td>
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<td>Decimal float divide by zero. The code attempted to divide a DECFLOAT value by zero.</td>
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<td>Decimal float inexact result. The result of an operation cannot be represented as a decimal fraction.</td>
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<td>Decimal float invalid operation. An indeterminant error occurred during an operation.</td>
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<td>Decimal float overflow. The exponent of a result is greater than the magnitude allowed.</td>
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<td>Decimal float underflow. The exponent of a result is less than the magnitude allowed.</td>
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<td>Sub-function @1 has not been defined</td>
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<td>subproc_notdef</td>
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<td>Sub-function @1 has a signature mismatch with its forward declaration</td>
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<td>Default values for parameters are not allowed in definition of the previously declared sub-function @1</td>
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<td>Invalid HASH algorithm @1</td>
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<td>Expression evaluation error for index &quot;@1&quot; on table &quot;@2&quot;</td>
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<td>Invalid decfloat trap state @1</td>
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<td>invalid batch handle</td>
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<td>Bad international character in tag @1</td>
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<td>Null data in parameters block with non-zero length</td>
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<td>mixed_info</td>
<td>Items working with running service and getting generic server information should not be mixed in single info block</td>
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<td>Unknown information item, code @1</td>
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<td>Wrong version of blob parameters block @1, should be @2</td>
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<td>User management plugin is missing or failed to load</td>
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<td>metadata_name</td>
<td>Name @1 not found in system MetadataBuilder</td>
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<td>Parse to tokens error</td>
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<td>Message @1 is out of range, only @2 messages in batch</td>
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<td>Detailed error info for message @1 is missing in batch</td>
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<td>Segment size (@1) should not exceed 65535 (64K - 1) when using segmented blob</td>
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<td>Can’t change default BPB after adding any data to batch</td>
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<td>Unexpected info buffer structure querying for server batch parameters</td>
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<td>Duplicated segment @1 in multisegment connect block parameter</td>
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<td>Message size (@1) in batch exceeds internal buffer size (@2)</td>
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<td>Batch already opened for this statement</td>
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<td>Invalid type of statement used in batch</td>
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<td>Statement used in batch must have parameters</td>
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<td>There are no blobs in associated with batch statement</td>
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<td>appendBlobData() is used to append data to last blob but no such blob was added to the batch</td>
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<td>Portions of data, passed as blob stream, should have size multiple to the alignment required for blobs</td>
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<td>Repeated blob id @1 in registerBlob()</td>
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<td>Blob buffer format error</td>
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<td>Unusable (too small) data remained in @1 buffer</td>
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<td>Blob continuation should not contain BPB</td>
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<td>Size of BPB (@1) greater than remaining data (@2)</td>
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<td>Size of segment (@1) greater than available data (@2)</td>
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<td>Unknown blob ID @1 in the batch message</td>
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<td>batch_too_big</td>
<td>Internal buffer overflow - batch too big</td>
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<td>Numeric literal too long</td>
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<td>hdr_overflow</td>
<td>Header page overflow - too many clumplets on it</td>
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<td>vld_plugins</td>
<td>No matching client/server authentication plugins configured for execute statement in embedded datasource</td>
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<td>Cannot reset user session</td>
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<td>ses_reset_open_trans</td>
<td>There are open transactions (@1 active)</td>
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<td>ses_reset_warn</td>
<td>Session was reset with warning(s)</td>
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<td>ses_reset_tran_rollback</td>
<td>Transaction is rolled back due to session reset, all changes are lost</td>
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<td>Starting page number for file @1 must be @2 or greater</td>
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<td>invalid_timezone_offset</td>
<td>Invalid time zone offset: @1 - must use format +/-hours:minutes and be between -14:00 and +14:00</td>
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<td>invalid_timezone_region</td>
<td>Invalid time zone region: @1</td>
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<td>invalid_timezone_id</td>
<td>Invalid time zone ID: @1</td>
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<td>tom_decode64len</td>
<td>Wrong base64 text length @1, should be multiple of 4</td>
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<td>tom_strblob</td>
<td>Invalid first parameter datatype - need string or blob</td>
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<td>tom_reg</td>
<td>Error registering @1 - probably bad tomcrypt library</td>
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<td>tom_algorithm</td>
<td>Unknown crypt algorithm @1 in USING clause</td>
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<td>tom_mode_miss</td>
<td>Should specify mode parameter for symmetric cipher</td>
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<td>Unknown symmetric crypt mode specified</td>
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<td>tom_no_mode</td>
<td>Mode parameter makes no sense for chosen cipher</td>
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<td>Should specify initialization vector (IV) for chosen cipher and/or mode</td>
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<td>Message Text</td>
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<td>Message Text</td>
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<td>Index not found</td>
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<td>Triggers created automatically cannot be modified</td>
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<td>Character set @1 not found</td>
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<td>column @1 does not exist in table/view @2</td>
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<td>SQL role @1 does not exist</td>
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<td>user @1 has no grant admin option on SQL role @2</td>
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<td>user @1 is not a member of SQL role @2</td>
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<td>dyn_delete_role_failed</td>
<td>@1 is not the owner of SQL role @2</td>
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### Exception Codes and Messages

<table>
<thead>
<tr>
<th>SQL-CODE</th>
<th>GDSCODE</th>
<th>Symbol</th>
<th>Message Text</th>
</tr>
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<tbody>
<tr>
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<td>336068800</td>
<td>dyn_grant_role_to_user</td>
<td>@1 is a SQL role and not a user</td>
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<td>dyn_inv_sql_role_name</td>
<td>user name @1 could not be used for SQL role</td>
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<td>dyn_dup_sql_role</td>
<td>SQL role @1 already exists</td>
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<td>dyn_kywd_spec_for_role</td>
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<td>SQL roles are not supported in on older versions of the database. A backup and restore of the database is required.</td>
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<td>Zero length identifiers are not allowed</td>
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<td>Sequence @1 not found</td>
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<td>dyn_wrong_gtt_scope</td>
<td>@1 cannot reference @2</td>
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<td>Collation @1 is used in table @2 (field name @3) and cannot be dropped</td>
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<td>Feature ‘@1’ is supported in ODS @2.@3</td>
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<td>Password should not be empty string</td>
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<td>Schema @1 not found</td>
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<td>Package body @1 already exists</td>
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<td>Cannot alter new style function @1 with ALTER EXTERNAL FUNCTION. Use ALTER FUNCTION instead.</td>
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<td>ALTER USER requires at least one clause to be specified</td>
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<td>Duplicate @1 @2</td>
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Appendix B: Exception Codes and Messages
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Appendix B: Exception Codes and Messages
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<td>an online dump is already in progress</td>
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<td>net_write_err</td>
<td>Error writing data to the connection.</td>
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<td>unsupported_network_drive</td>
<td>Access to databases on file servers is not supported.</td>
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<td>335544733</td>
<td>io_create_err</td>
<td>Error while trying to create file</td>
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<td>Error while trying to read from file</td>
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<td>Error while trying to write to file</td>
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<td>Your login @1 is same as one of the SQL role name. Ask your database administrator to set up a valid Firebird login.</td>
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<td>The file @1 is currently in use by another process. Try again later.</td>
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<td>unexpected item in service parameter block, expected @1</td>
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<td>Function @1 is in @2, which is not in a permitted directory for external functions.</td>
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<td>File exceeded maximum size of 2GB. Add another database file or use a 64 bit I/O version of Firebird.</td>
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<td>Use of @1 at location @2 is not allowed by server configuration</td>
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<td>Cursor is not open</td>
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<td>Login name too long (@1 characters, maximum allowed @2)</td>
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<td>Missing required item @1 in service parameter block</td>
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<td>net_server_shutdown</td>
<td>@1 server is shutdown</td>
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<td>Could not start first worker thread - shutdown server</td>
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<td>Timeout occurred while waiting for a secondary connection for event processing</td>
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<td>Shared memory area is probably already created by another engine instance in another Windows session</td>
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<td>Use of TRUSTED switches in spb_command_line is prohibited</td>
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<td>Install incomplete. To complete security database initialization please CREATE USER. For details read doc/README.security_database.txt.</td>
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<td>@1 operation is not allowed for system table @2</td>
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<td>unsupported BLR version (expected between @1 and @2, encountered @3)</td>
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<td>Missing crypt plugin, but page appears encrypted</td>
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<td>Missing configuration file: @1</td>
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<td>conf_line</td>
<td>@1: illegal line &lt;@2&gt;</td>
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<td>conf_include</td>
<td>Invalid include operator in @1 for &lt;@2&gt;</td>
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<td>Missing security context for @1</td>
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<td>Missing segment @1 in multisegment connect block parameter</td>
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<td>Different logins in connect and attach packets - client library error</td>
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<td>Exceeded exchange limit during authentication handshake</td>
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<td>Symbol</td>
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<td>Incompatible wire encryption levels requested on client and server</td>
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<td>Client attempted to attach unencrypted but wire encryption is required</td>
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<td>Client attempted to start wire encryption using unknown key @1</td>
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<td>Client attempted to start wire encryption using unsupported plugin @1</td>
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<td>Error getting security database name from configuration file</td>
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<td>Client authentication plugin is missing required data from server</td>
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<td>auth_datalength</td>
<td>Client authentication plugin expected @2 bytes of @3 from server, got @1</td>
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<td>Error occurred during login, please check server firebird.log for details</td>
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<td>already_opened</td>
<td>Database already opened with engine instance, incompatible with current</td>
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<td>Invalid crypt key @1</td>
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<td>miss_prvlg</td>
<td>System privilege @1 is missing</td>
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<td>crypt_checksum</td>
<td>Invalid or missing checksum of encrypted database</td>
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<td>not_dba</td>
<td>You must have SYSDBA rights at this server</td>
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<td>SQL statement is too long. Maximum size is @1 bytes.</td>
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<td>Killed by database administrator.</td>
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<td>Database is shutdown.</td>
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<td>Engine is shutdown.</td>
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<td>OVERRIDING clause can be used only when an identity column is present in the INSERT's field list for table/view @1</td>
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<td>OVERRIDING SYSTEM VALUE can be used only for identity column defined as 'GENERATED ALWAYS' in INSERT for table/view @1</td>
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<td>GDSCODE</td>
<td>Symbol</td>
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<td>OVERRIDING USER VALUE can be used only for identity column defined as 'GENERATED BY DEFAULT' in INSERT for table/view @1</td>
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<td>OVERRIDING SYSTEM VALUE should be used to override the value of an identity column defined as 'GENERATED ALWAYS' in table/view @1</td>
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<td>Missing entrypoint @1 in ICU library</td>
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<td>icu_library</td>
<td>Could not find acceptable ICU library</td>
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<td>icnv_open</td>
<td>Error opening international conversion descriptor from @1 to @2</td>
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<td>deflate_init</td>
<td>Compression stream init error @1</td>
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<td>inflate_init</td>
<td>Decompression stream init error @1</td>
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<td>Plugin not supported by network protocol</td>
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<td>map_event</td>
<td>Error using events in mapping shared memory: @1</td>
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<td>map_overflow</td>
<td>Global mapping memory overflow</td>
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<td>db_crypt_key</td>
<td>Missing database encryption key for your attachment</td>
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<td>bind_err</td>
<td>Error processing isc_dpb_set_bind clumplet &quot;@1&quot;</td>
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<td>bind_statement</td>
<td>The following statement failed: @1</td>
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<td>RDB$PAGES written by non-system transaction, DB appears to be damaged</td>
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<td>Replication error</td>
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<td>Reset of user session failed. Connection is shut down.</td>
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<td>File size is less than expected</td>
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<td>wrong_shmem_ver</td>
<td>@1: inconsistent shared memory type/version; found @2, expected @3</td>
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<td>@1-bit engine can’t open database already opened by @2-bit engine</td>
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<td>Definition of index expression is not found for index @1</td>
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<td>Message Text</td>
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<td>unavailable database</td>
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<td>unable to allocate memory from operating system</td>
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<td>update conflicts with concurrent update</td>
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<td>object @1 is in use</td>
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<td>cannot attach active shadow file</td>
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<td>a file in manual shadow @1 is unavailable</td>
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<td>index_root_page_full</td>
<td>cannot add index, index root page is full.</td>
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<td>sort error: not enough memory</td>
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<td>request depth exceeded. (Recursive definition?)</td>
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<td>sort record size of @1 bytes is too big</td>
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<td>too many open handles to database</td>
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<td>size of optimizer block exceeded</td>
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<td>Cannot attach to services manager</td>
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<td>The service name was not specified.</td>
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<td>Unsupported field type specified in BETWEEN predicate.</td>
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<td>Invalid argument in EXECUTE STATEMENT - cannot convert to string</td>
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<td>exec_sql_invalid_req</td>
<td>Wrong request type in EXECUTE STATEMENT '@1'</td>
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<td>Symbol</td>
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<td>Variable type (position @1) in EXECUTE STATEMENT '@2' INTO does not match returned column type</td>
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<td>Too many recursion levels of EXECUTE STATEMENT</td>
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<td>Cannot change difference file name while database is in backup mode</td>
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<td>Physical backup is not allowed while Write-Ahead Log is in use</td>
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<td>partner index segment no @1 has incompatible data type</td>
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<td>Maximum BLOB size exceeded</td>
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<td>Stream does not support record locking</td>
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<td>Cannot create foreign key constraint @1. Partner index does not exist or is inactive.</td>
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<td>Transactions count exceeded. Perform backup and restore to make database operable again</td>
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<td>Column has been unexpectedly deleted</td>
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<td>concurrent_transaction</td>
<td>concurrent transaction number is @1</td>
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<td>Cannot have circular dependencies with computed fields</td>
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<td>Can not access lock files directory @1</td>
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<td>request_outdated</td>
<td>Request can’t access new records in relation @1 and should be recompiled</td>
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<td>read_conflict</td>
<td>read conflicts with concurrent update</td>
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<td>Maximum index depth (@1 levels) is reached</td>
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<td>unlicensed</td>
<td>product @1 is not licensed</td>
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<td>max_att_exceeded</td>
<td>Maximum user count exceeded. Contact your database administrator.</td>
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Appendix C: Reserved Words and Keywords

Reserved words are part of the Firebird SQL language. They cannot be used as identifiers (e.g. as table or procedure names), except when enclosed in double quotes in Dialect 3. However, you should avoid this unless you have a compelling reason.

Non-reserved keywords are also part of the language. They have a special meaning when used in the proper context, but they are not reserved for Firebird’s own and exclusive use. You can use them as identifiers without double-quoting.

Since Firebird 5.0, the reserved words and keywords can be queried from the virtual table `RDB$KEYWORDS`.

Reserved words

Full list of reserved words in Firebird 5.0:

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**Keywords**

The following terms have a special meaning in Firebird 5.0 SQL. This lists all keywords, reserved and non-reserved.

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Appendix C: Reserved Words and Keywords

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<th>Word</th>
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Appendix C: Reserved Words and Keywords

OS_NAME OTHERS OUTER
OUTPUT_TYPE OVER OVERFLOW
OVERLAY OVERRIDING PACKAGE
PAD PAGE PAGES
PAGE_SIZE PARAMETER PARTITION
PASSWORD PERCENT_RANK PI
PKCS_1_5 PLACING PLAN
PLUGIN POOL POSITION
POST_EVENT POWER PRECEDING
PRECISION PRESERVE PRIMARY
PRIOR PRIVILEGE PRIVILEGES
PROCEDURE PROTECTED PUBLICATION
QUANTIZE QUARTER RAND
RANGE RANK RDB$DB_KEY
RDB$ERROR RDB$GET_CONTEXT RDB$GET_TRANSACTION_CN
RDB$RECORD_VERSION RDB$ROLE_IN_USE RDB$SET_CONTEXT
RDB$SYSTEM_PRIVILEGE READ REAL
RECORD_VERSION RECREATE RECURSIVE
REFERENCES REGR_AVGX REGR_AVGY
REGR_COUNT REGR_INTERCEPT REGR_R2
REGR_SLOPE REGR_SXX REGR_SXY
REGR_SYY RELATIVE RELEASE
REPLACE REQUESTS RESERV
RESERVING RESET RESETTING
RESTART RESTRICT RETAIN
RETURN RETURNING RETURNING_VALUES
RETURNS REVERSE REVOKE
RIGHT ROLE ROLLBACK
ROUND ROW ROWS
ROW_COUNT ROW_NUMBER RPAD
RSA_DECRYPT RSA_ENCRYPT RSA_PRIVATE
RSA_PUBLIC RSA_SIGN_HASH RSA_VERIFY_HASH
SALT_LENGTH SAVEPOINT SCALAR_ARRAY
SCHEMA SCROLL SECOND
SECURITY SEGMENT SELECT
SENSITIVE SEQUENCE SERVERWIDE
SESSION SET SHADOW
SHARED SIGN SIGNATURE
SIMILAR SIN SINGULAR
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<td>WRITE</td>
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<tr>
<td>YEAR</td>
<td>YEARDAY</td>
<td>ZONE</td>
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Appendix D: System Tables

When you create a database, the Firebird engine creates a lot of system tables. Metadata—the descriptions and attributes of all database objects—are stored in these system tables.

System table identifiers all begin with the prefix RDB$.

List of System Tables

RDB$AUTH_MAPPING
  Stores authentication and other security mappings

RDB$BACKUP_HISTORY
  History of backups performed using nBackup

RDB$CHARACTER_SETS
  Names and describes the character sets available in the database

RDB$CHECK_CONSTRAINTS
  Cross-references between the names of constraints (NOT NULL constraints, CHECK constraints and ON UPDATE and ON DELETE clauses in foreign key constraints) and their associated system-generated triggers

RDB$COLLATIONS
  Collations for all character sets

RDB$CONFIG
  Virtual table with configuration settings applied for the current database

RDB$DATABASE
  Basic information about the database

RDB$DB_CREATORS
  A list of users granted the CREATE DATABASE privilege when using the specified database as a security database

RDB$DEPENDENCIES
  Information about dependencies between database objects

RDB$EXCEPTIONS
  Custom database exceptions

RDB$FIELDS
  Column and domain definitions, both system and custom

RDB$FIELD_DIMENSIONS
  Dimensions of array columns
RDB$FILES
Information about secondary files and shadow files

RDB$FILTERS
Information about BLOB filters

RDB$FORMATS
Information about changes in the formats of tables

RDB$FUNCTIONS
Information about external functions

RDB$FUNCTION_ARGUMENTS
Attributes of the parameters of external functions

RDB$GENERATORS
Information about generators (sequences)

RDB$INDEX_SEGMENTS
Segments and index positions

RDB$INDICES
Definitions of all indexes in the database (system- or user-defined)

RDB$LOG_FILES
Not used in the current version

RDB$PACKAGES
Stores the definition (header and body) of SQL packages

RDB$PAGES
Information about database pages

RDB$PROCEDURES
Definitions of stored procedures

RDB$PROCEDURE_PARAMETERS
Parameters of stored procedures

RDB$REF_CONSTRAINTS
Definitions of referential constraints (foreign keys)

RDB$RELATIONS
Headers of tables and views

RDB$RELATION_CONSTRAINTS
Definitions of all table-level constraints
**RDB$RELATION_FIELDS**
Top-level definitions of table columns

**RDB$ROLES**
Role definitions

**RDB$SECURITY_CLASSES**
Access control lists

**RDB$TIME_ZONES**
Time zones

**RDB$TRANSACTIONS**
State of multi-database transactions

**RDB$TRIGGERS**
Trigger definitions

**RDB$TRIGGER_MESSAGES**
Trigger messages

**RDB$TYPES**
Definitions of enumerated data types

**RDB$USER_PRIVILEGES**
SQL privileges granted to system users

**RDB$VIEW_RELATIONS**
Tables that are referred to in view definitions: one record for each table in a view

**RDB$AUTH_MAPPING**

RDB$AUTH_MAPPING stores authentication and other security mappings.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$MAP_NAME</td>
<td>CHAR(63)</td>
<td>Name of the mapping</td>
</tr>
<tr>
<td>RDB$MAP_USING</td>
<td>CHAR(1)</td>
<td>Using definition:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P - plugin (specific or any)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S - any plugin serverwide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M - mapping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* - any method</td>
</tr>
<tr>
<td>RDB$MAP_PLUGIN</td>
<td>CHAR(63)</td>
<td>Mapping applies for authentication information from this specific plugin</td>
</tr>
<tr>
<td>RDB$MAP_DB</td>
<td>CHAR(63)</td>
<td>Mapping applies for authentication information from this specific database</td>
</tr>
</tbody>
</table>
### Column Name | Data Type | Description
--- | --- | ---
RDB$MAP_FROM_TYPE | CHAR(63) | The type of authentication object (defined by plugin) to map from, or * for any type
RDB$MAP_FROM | CHAR(255) | The name of the authentication object to map from
RDB$MAP_TO_TYPE | SMALLINT | The type to map to
0 - USER
1 - ROLE
RDB$MAP_TO | CHAR(63) | The name to map to
RDB$SYSTEM_FLAG | SMALLINT | Flag:
0 - user-defined
1 or higher - system-defined
RDB$DESCRIPTION | BLOB TEXT | Optional description of the mapping (comment)

### RDB$BACKUP_HISTORY

RDB$BACKUP_HISTORY stores the history of backups performed using the \textit{nBackup} utility.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
</table>
RDB$BACKUP_ID | INTEGER | The identifier assigned by the engine
RDB$TIMESTAMP | TIMESTAMP WITH TIME ZONE | Backup date and time
RDB$BACKUP_LEVEL | INTEGER | Backup level
RDB$GUID | CHAR(38) | Unique identifier
RDB$SCN | INTEGER | System (scan) number
RDB$FILE_NAME | VARCHAR(255) | Full path and file name of backup file

### RDB$CHARACTER_SETS

RDB$CHARACTER_SETS names and describes the character sets available in the database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
</table>
RDB$CHARACTER_SET_NAME | CHAR(63) | Character set name
RDB$FORM_OF_USE | CHAR(63) | Not used
RDB$NUMBER_OF_CHARACTERS | INTEGER | The number of characters in the set. Not used for existing character sets
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$DEFAULT_COLLATE_NAME</td>
<td>CHAR(63)</td>
<td>The name of the default collation for the character set</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>Unique character set identifier</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>System flag: value is 1 if the character set is defined in the system when the database is created; value is 0 for a user-defined character set</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store text description of the character set</td>
</tr>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>For a user-defined character set that is accessed via an external function, the name of the external function</td>
</tr>
<tr>
<td>RDB$BYTES_PER_CHARACTER</td>
<td>SMALLINT</td>
<td>The maximum number of bytes representing one character</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, to apply access control limits to all users of this character set</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the character set originally</td>
</tr>
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</table>

**RDB$CHECK_CONSTRAINTS**

RDB$CHECK_CONSTRAINTS provides the cross-references between the names of system-generated triggers for constraints and the names of the associated constraints (NOT NULL constraints, CHECK constraints and the ON UPDATE and ON DELETE clauses in foreign key constraints).

<table>
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<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
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</thead>
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<td>RDB$CONSTRAINT_NAME</td>
<td>CHAR(63)</td>
<td>Constraint name, defined by the user or automatically generated by the system</td>
</tr>
<tr>
<td>RDB$TRIGGER_NAME</td>
<td>CHAR(63)</td>
<td>For CHECK constraints, the name of the trigger that enforces the constraint. For NOT NULL constraints, the name of the affected column. For foreign key constraints, the name of the trigger that enforces the ON UPDATE and ON DELETE clauses.</td>
</tr>
</tbody>
</table>

**RDB$COLLATIONS**

RDB$COLLATIONS stores collations for all character sets.
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$COLLATION_NAME</td>
<td>CHAR(63)</td>
<td>Collation name</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>Collation identifier. Together with the character set identifier, it is a unique collation identifier</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>Character set identifier. Together with the collection sequence identifier, it is a unique identifier</td>
</tr>
<tr>
<td>RDB$COLLATION_ATTRIBUTES</td>
<td>SMALLINT</td>
<td>Collation attributes. It is a bit mask where the first bit shows whether trailing spaces should be taken into account in collations (0 - NO PAD; 1 - PAD SPACE); the second bit shows whether the collation is case-sensitive (0 - CASE SENSITIVE, 1 - CASE INSENSITIVE); the third bit shows whether the collation is accent-sensitive (0 - ACCENT SENSITIVE, 1 - ACCENT SENSITIVE). Thus, the value of 5 means that the collation does not take into account trailing spaces and is accent-insensitive</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: the value of 0 means it is user-defined; the value of 1 means it is system-defined</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store text description of the collation</td>
</tr>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>Not currently used</td>
</tr>
<tr>
<td>RDB$BASE_COLLATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the base collation for this collation</td>
</tr>
<tr>
<td>RDB$SPECIFIC_ATTRIBUTES</td>
<td>BLOB TEXT</td>
<td>Describes specific attributes</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, to apply access control limits to all users of this collation</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the collation originally</td>
</tr>
</tbody>
</table>

**RDB$CONFIG**

RDB$CONFIG is a virtual table showing the configuration settings of the current database for the current connection.
Table RDB$CONFIG is populated from in-memory structures upon request and its instance is preserved for the SQL query lifetime. For security reasons, access to this table is allowed for administrators only. Non-privileged users see no rows in this table (and no error is raised).

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$CONFIG_ID</td>
<td>INTEGER</td>
<td>Unique row identifier, no special meaning</td>
</tr>
<tr>
<td>RDB$CONFIG_NAME</td>
<td>VARCHAR(63)</td>
<td>Setting name (e.g. TempCacheLimit)</td>
</tr>
<tr>
<td>RDB$CONFIG_VALUE</td>
<td>VARCHAR(255)</td>
<td>Actual value of setting</td>
</tr>
<tr>
<td>RDB$CONFIG_DEFAULT</td>
<td>VARCHAR(255)</td>
<td>Default value of setting (defined in the Firebird code)</td>
</tr>
<tr>
<td>RDB$CONFIG_IS_SET</td>
<td>BOOLEAN</td>
<td>TRUE if value is explicitly configured, FALSE when default</td>
</tr>
<tr>
<td>RDB$CONFIG_SOURCE</td>
<td>VARCHAR(255)</td>
<td>Name of the configuration file (relative to the Firebird root directory) where this setting was taken from, or special value DPB if the setting was specified by the client application via API.</td>
</tr>
</tbody>
</table>

**RDB$DATABASE**

RDB$DATABASE stores basic information about the database. It contains only one record.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Database comment text</td>
</tr>
<tr>
<td>RDB$RELATION_ID</td>
<td>SMALLINT</td>
<td>A number that steps up by one each time a table or view is added to the database</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>The security class defined in RDB$SECURITY_CLASSES to apply access control limits common to the entire database</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_NAME</td>
<td>CHAR(63)</td>
<td>The name of the default character set for the database set in the DEFAULT CHARACTER SET clause when the database is created. NULL for character set NONE.</td>
</tr>
<tr>
<td>RDB$LINGER</td>
<td>INTEGER</td>
<td>Number of seconds &quot;delay&quot; (established with the ALTER DATABASE SET LINGER statement) until the database file is closed after the last connection to this database is closed (in SuperServer). NULL if no delay is set.</td>
</tr>
</tbody>
</table>
### Column Name | Data Type | Description
--- | --- | ---
RDB$SQL_SECURITY | BOOLEAN | The default SQL SECURITY mode (DEFINER or INVOKER) applied to newly created objects: NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER

**RDB$DB_CREATORS**

*RDB$DB_CREATORS* contains a list of users granted the CREATE DATABASE privilege when using the specified database as a security database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$USER</td>
<td>CHAR(63)</td>
<td>User or role name</td>
</tr>
<tr>
<td>RDB$USER_TYPE</td>
<td>SMALLINT</td>
<td>Type of user</td>
</tr>
<tr>
<td>8 - user</td>
<td>13 - role</td>
<td></td>
</tr>
</tbody>
</table>

**RDB$DEPENDENCIES**

*RDB$DEPENDENCIES* stores the dependencies between database objects.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$DEPENDENT_NAME</td>
<td>CHAR(63)</td>
<td>The name of the view, procedure, trigger, CHECK constraint or computed column the dependency is defined for, i.e., the dependent object</td>
</tr>
<tr>
<td>RDB$DEPENDED_ON_NAME</td>
<td>CHAR(63)</td>
<td>The name of the object that the defined object — the table, view, procedure, trigger, CHECK constraint or computed column — depends on</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The column name in the depended-on object that is referred to by the dependent view, procedure, trigger, CHECK constraint or computed column</td>
</tr>
</tbody>
</table>
### Appendix D: System Tables

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$DEPENDENT_TYPE</td>
<td>SMALLINT</td>
<td>Identifies the type of the dependent object:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - trigger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - computed column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - CHECK constraint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 - index expression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - exception</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 - column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - index</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 - stored function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 - package header</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 - package body</td>
</tr>
<tr>
<td>RDB$DEPENDED_ON_TYPE</td>
<td>SMALLINT</td>
<td>Identifies the type of the object depended on:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - table (or a column in it)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - trigger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - computed column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - CHECK constraint</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - procedure (or its parameter(s))</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 - index expression</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - exception</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 - column</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - index</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - generator (sequence)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 - UDF or stored function</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 - collation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 - package header</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 - package body</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>The package of a procedure or function for which this describes the dependency.</td>
</tr>
</tbody>
</table>

**RDB$EXCEPTIONS**

RDB$EXCEPTIONS stores custom database exceptions.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$EXCEPTION_NAME</td>
<td>CHAR(63)</td>
<td>Custom exception name</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$EXCEPTION_NUMBER</td>
<td>INTEGER</td>
<td>The unique number of the exception assigned by the system</td>
</tr>
<tr>
<td>RDB$MESSAGE</td>
<td>VARCHAR(1021)</td>
<td>Exception message text</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store text description of the exception</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: 0 - user-defined 1 or higher - system-defined</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, to apply access control limits to all users of this exception</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the exception originally</td>
</tr>
</tbody>
</table>

**RDB$FIELDS**

RDB$FIELDS stores definitions of columns and domains, both system and custom. This is where the detailed data attributes are stored for all columns.

> The column RDB$FIELDS.RDB$FIELD_NAME links to RDB$RELATION_FIELDS.RDB$FIELD_SOURCE, not to RDB$RELATION_FIELDS.RDB$FIELD_NAME.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The unique name of the domain created by the user or of the domain automatically built for the table column by the system. System-created domain names start with the “RDB$” prefix</td>
</tr>
<tr>
<td>RDB$QUERY_NAME</td>
<td>CHAR(63)</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$VALIDATION_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the expression of the CHECK constraint of a domain</td>
</tr>
<tr>
<td>RDB$VALIDATION_SOURCE</td>
<td>BLOB TEXT</td>
<td>The original source text in the SQL language specifying the check of the CHECK value</td>
</tr>
<tr>
<td>RDB$COMPUTED_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the expression of a COMPUTED BY column, used to calculate the value of a computed column when it is accessed.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$COMPUTED_SOURCE</td>
<td>BLOB TEXT</td>
<td>The original source text of the expression that defines a COMPUTED BY column</td>
</tr>
<tr>
<td>RDB$DEFAULT_VALUE</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the default value for the field or domain</td>
</tr>
<tr>
<td>RDB$DEFAULT_SOURCE</td>
<td>BLOB TEXT</td>
<td>The default value in the source code, as an SQL constant or expression</td>
</tr>
<tr>
<td>RDB$FIELD_LENGTH</td>
<td>SMALLINT</td>
<td>Column size in bytes. BOOLEAN occupies 1 byte. FLOAT, DATE, TIME, INTEGER occupy 4 bytes. DOUBLE PRECISION, BIGINT, TIMESTAMP, TIME WITH TIME ZONE, DECIMAL(16) and BLOB identifiers occupy 8 bytes. TIMESTAMP WITH TIME ZONE occupies 12 bytes. INT128 and DECIMAL(34) occupy 16 bytes. For the CHAR and VARCHAR data types, the column stores the maximum number of bytes specified when a string domain (column) is defined</td>
</tr>
<tr>
<td>RDB$FIELD_SCALE</td>
<td>SMALLINT</td>
<td>The negative number that specifies the scale for DECIMAL and NUMERIC columns — the number of digits after the decimal point</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>--------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_TYPE</td>
<td>SMALLINT</td>
<td>Data type code for the column:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - SMALLINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - INTEGER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - FLOAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 - DATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - TIME</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - CHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - BIGINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 - BOOLEAN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 - DECFLOAT(16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 - DECFLOAT(34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 - INT128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 - DOUBLE PRECISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 - TIME WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29 - TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35 - TIMESTAMP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 - VARCHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>261 - BLOB</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Codes for DECIMAL and NUMERIC are the same as for the integer types used for storage.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_SUB_TYPE</td>
<td>SMALLINT</td>
<td>Specifies the subtype for the BLOB data type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0  - untyped (binary)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1  - text</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2  - BLR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3  - access control list</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4  - reserved for future use</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5  - encoded table metadata description</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6  - for storing the details of a cross-database transaction that ends abnormally</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7  - external file description</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8  - debug information (for PSQL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt; 0 - user-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specifies for the CHAR data type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0  - untyped data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1  - fixed binary data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Specifies the particular data type for the integer data types (SMALLINT, INTEGER, BIGINT, INT128) and for fixed-point numbers (NUMERIC, DECIMAL):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 or NULL - the data type matches the value in the RDB$FIELD_TYPE field</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - NUMERIC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - DECIMAL</td>
</tr>
<tr>
<td>RDB$MISSING_VALUE</td>
<td>BLOB BLR</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$MISSING_SOURCE</td>
<td>BLOB TEXT</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Any domain (table column) comment text</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: the value of 1 means the domain is automatically created by the system, the value of 0 means that the domain is defined by the user</td>
</tr>
<tr>
<td>RDB$QUERY_HEADER</td>
<td>BLOB TEXT</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$SEGMENT_LENGTH</td>
<td>SMALLINT</td>
<td>Specifies the length of the BLOB buffer in bytes for BLOB columns. Stores NULL for all other data types</td>
</tr>
<tr>
<td>RDB$EDIT_STRING</td>
<td>VARCHAR(127)</td>
<td>Not used</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$EXTERNAL_LENGTH</td>
<td>SMALLINT</td>
<td>The length of the column in bytes if it belongs to an external table. Always NULL for regular tables</td>
</tr>
<tr>
<td>RDB$EXTERNAL_SCALE</td>
<td>SMALLINT</td>
<td>The scale factor of an integer-type field in an external table; represents the power of 10 by which the integer is multiplied</td>
</tr>
<tr>
<td>RDB$EXTERNAL_TYPE</td>
<td>SMALLINT</td>
<td>The data type of the field as it is represented in an external table:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - SMALLINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - INTEGER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - FLOAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 - DATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - TIME</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - CHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - BIGINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 - BOOLEAN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 - DECFLOAT(16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 - DECFLOAT(34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 - INT128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 - DOUBLE PRECISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 - TIME WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29 - TIMESTAMP WITH TIME ZONE 35 - TIMESTAMP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 - VARCHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>261 - BLOB</td>
</tr>
<tr>
<td>RDB$DIMENSIONS</td>
<td>SMALLINT</td>
<td>Defines the number of dimensions in an array if the column is defined as an array. Always NULL for columns that are not arrays</td>
</tr>
<tr>
<td>RDB$NULL_FLAG</td>
<td>SMALLINT</td>
<td>Specifies whether the column can take an empty value (the field will contain NULL) or not (the field will contain the value of 1)</td>
</tr>
<tr>
<td>RDB$CHARACTER_LENGTH</td>
<td>SMALLINT</td>
<td>The length of CHAR or VARCHAR columns in characters (not in bytes)</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the collation for a character column or domain. If it is not defined, the value of the field will be 0</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>The identifier of the character set for a character column, BLOB TEXT column or domain</td>
</tr>
</tbody>
</table>
### RDB$FIELD_PRECISION

**Column Name**: RDB$FIELD_PRECISION  
**Data Type**: SMALLINT  
**Description**: Specifies the total number of digits for the fixed-point numeric data type (DECIMAL and NUMERIC). The value is 0 for the integer data types, NULL is for other data types.

### RDB$SECURITY_CLASS

**Column Name**: RDB$SECURITY_CLASS  
**Data Type**: CHAR(63)  
**Description**: May reference a security class defined in the table RDB$SECURITY_CLASSES, to apply access control limits to all users of this domain.

### RDB$OWNER_NAME

**Column Name**: RDB$OWNER_NAME  
**Data Type**: CHAR(63)  
**Description**: The username of the user who created the domain originally.

## RDB$FIELD_DIMENSIONS

RDB$FIELD_DIMENSIONS stores the dimensions of array columns.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of the array column. It must be present in the RDB$FIELD_NAME field of the RDB$FIELDS table</td>
</tr>
<tr>
<td>RDB$DIMENSION</td>
<td>SMALLINT</td>
<td>Identifies one dimension in the array column. The numbering of dimensions starts with 0</td>
</tr>
<tr>
<td>RDB$LOWER_BOUND</td>
<td>INTEGER</td>
<td>The lower bound of this dimension</td>
</tr>
<tr>
<td>RDB$UPPER_BOUND</td>
<td>INTEGER</td>
<td>The upper bound of this dimension</td>
</tr>
</tbody>
</table>

## RDB$FILES

RDB$FILES stores information about secondary files and shadow files.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FILE_NAME</td>
<td>VARCHAR(255)</td>
<td>The full path to the file and the name of either</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• the database secondary file in a multi-file database, or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• the shadow file</td>
</tr>
<tr>
<td>RDB$FILE_SEQUENCE</td>
<td>SMALLINT</td>
<td>The sequential number of the secondary file in a sequence or of the shadow file in a shadow file set</td>
</tr>
<tr>
<td>RDB$FILE_START</td>
<td>INTEGER</td>
<td>The initial page number in the secondary file or shadow file</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FILE_LENGTH</td>
<td>INTEGER</td>
<td>File length in database pages</td>
</tr>
<tr>
<td>RDB$FILE_FLAGS</td>
<td>SMALLINT</td>
<td>For internal use</td>
</tr>
<tr>
<td>RDB$SHADOW_NUMBER</td>
<td>SMALLINT</td>
<td>Shadow set number. If the row describes a database secondary file, the field will be NULL or its value will be 0</td>
</tr>
</tbody>
</table>

**RDB$FILTERS**

RDB$FILTERS stores information about BLOB filters.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>The unique identifier of the BLOB filter</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Documentation about the BLOB filter and the two subtypes it is used with, written by the user</td>
</tr>
<tr>
<td>RDB$MODULE_NAME</td>
<td>VARCHAR(255)</td>
<td>The name of the dynamic library or shared object where the code of the BLOB filter is located</td>
</tr>
<tr>
<td>RDB$ENTRYPOINT</td>
<td>CHAR(255)</td>
<td>The exported name of the BLOB filter in the filter library. Note, this is often not the same as RDB$FUNCTION_NAME, which is the identifier with which the BLOB filter is declared to the database</td>
</tr>
<tr>
<td>RDB$INPUT_SUB_TYPE</td>
<td>SMALLINT</td>
<td>The BLOB subtype of the data to be converted by the function</td>
</tr>
<tr>
<td>RDB$OUTPUT_SUB_TYPE</td>
<td>SMALLINT</td>
<td>The BLOB subtype of the converted data</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag indicating whether the filter is user-defined or internally defined: 0 - user-defined 1 or greater - internally defined</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, to apply access control limits to all users of this filter</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the filter originally</td>
</tr>
</tbody>
</table>

**RDB$FORMATS**

RDB$FORMATS stores information about changes in tables. Each time any metadata change to a table is committed, it gets a new format number. When the format number of any table reaches 255, or any
view 32,000, the entire database becomes inoperable. To return to normal, the database must be backed up with the `gbak` utility and restored from that backup copy.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$RELATION_ID</td>
<td>SMALLINT</td>
<td>Table or view identifier</td>
</tr>
<tr>
<td>RDB$FORMAT</td>
<td>SMALLINT</td>
<td>Table format identifier — maximum 255 for tables, 32,000 for views. The critical time comes when this number approaches 255 for any table or 32,000 for any view</td>
</tr>
<tr>
<td>RDB$DESCRIPTOR</td>
<td>BLOB FORMAT</td>
<td>Stores column names and data attributes as BLOB, as they were at the time the format record was created</td>
</tr>
</tbody>
</table>

**RDB$FUNCTIONS**

RDB$FUNCTIONS stores the information needed by the engine about stored functions and external functions (user-defined functions, UDFs).

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>The unique (declared) name of the external function</td>
</tr>
<tr>
<td>RDB$FUNCTION_TYPE</td>
<td>SMALLINT</td>
<td>Not currently used</td>
</tr>
<tr>
<td>RDB$QUERY_NAME</td>
<td>CHAR(63)</td>
<td>Not currently used</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Any text with comments related to the external function</td>
</tr>
<tr>
<td>RDB$MODULE_NAME</td>
<td>VARCHAR(255)</td>
<td>The name of the dynamic library or shared object where the code of the external function is located</td>
</tr>
<tr>
<td>RDB$ENTRYPOINT</td>
<td>CHAR(255)</td>
<td>The exported name of the external function in the function library. Note, this is often not the same as RDB$FUNCTION_NAME, which is the identifier with which the external function is declared to the database</td>
</tr>
<tr>
<td>RDB$RETURN_ARGUMENT</td>
<td>SMALLINT</td>
<td>The position number of the returned argument in the list of parameters corresponding to input arguments</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag indicating whether the filter is user-defined or internally defined: 0 = user-defined, 1 = internally defined</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$ENGINE_NAME</td>
<td>CHAR(63)</td>
<td>Engine for external functions. 'UDR' for UDR functions. NULL for legacy UDF or PSQL functions</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package that contains this function (or NULL)</td>
</tr>
<tr>
<td>RDB$PRIVATE_FLAG</td>
<td>SMALLINT</td>
<td>NULL for normal (top-level) functions, 0 for package function defined in the header, 1 for package function only defined in the package body.</td>
</tr>
<tr>
<td>RDB$FUNCTION_SOURCE</td>
<td>BLOB TEXT</td>
<td>The PSQL sourcecode of the function</td>
</tr>
<tr>
<td>RDB$FUNCTION_ID</td>
<td>SMALLINT</td>
<td>Unique identifier of the function</td>
</tr>
<tr>
<td>RDB$FUNCTION_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the function code (PSQL function only)</td>
</tr>
<tr>
<td>RDB$VALID_BLR</td>
<td>SMALLINT</td>
<td>Indicates whether the source PSQL of the stored procedure remains valid after the latest ALTER FUNCTION modification</td>
</tr>
<tr>
<td>RDB$DEBUG_INFO</td>
<td>BLOB DEBUG_INFORMATION</td>
<td>Contains debugging information about variables used in the function (PSQL function only)</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, to apply access control limits to all users of this function</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the function originally</td>
</tr>
<tr>
<td>RDB$LEGACY_FLAG</td>
<td>SMALLINT</td>
<td>The legacy style attribute of the function. 1 - if the function is described in legacy style (DECLARE EXTERNAL FUNCTION), otherwise CREATE FUNCTION.</td>
</tr>
<tr>
<td>RDB$DETERMINISTIC_FLAG</td>
<td>SMALLINT</td>
<td>Deterministic flag. 1 - if function is deterministic</td>
</tr>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - initial default (INVOKER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FALSE - INVOKER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TRUE - DEFINER</td>
</tr>
</tbody>
</table>
### RDB$FUNCTION_ARGUMENTS

RDB$FUNCTION_ARGUMENTS stores the parameters of functions and their attributes.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FUNCTION_NAME</td>
<td>CHAR(63)</td>
<td>The unique name (declared identifier) of the function</td>
</tr>
<tr>
<td>RDB$ARGUMENT_POSITION</td>
<td>SMALLINT</td>
<td>The position of the argument in the list of arguments</td>
</tr>
<tr>
<td>RDB$MECHANISM</td>
<td>SMALLINT</td>
<td>Flag: how this argument is passed:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - by value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - by reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - by descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - by BLOB descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - by scalar array</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - by reference with null</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$FIELD_TYPE</td>
<td>SMALLINT</td>
<td>Data type code defined for the column:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - SMALLINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - INTEGER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - FLOAT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 - DATE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - TIME</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - CHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - BIGINT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 - BOOLEAN</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 - DECFLOAT(16)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 - DECFLOAT(34)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 - INT128</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 - DOUBLE PRECISION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 - TIME WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>29 - TIMESTAMP WITH TIME ZONE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35 - TIMESTAMP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37 - VARCHAR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 - CSTRING (null-terminated text)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45 - BLOB_ID</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$FIELD_SCALE</td>
<td>SMALLINT</td>
<td>The scale of an integer or a fixed-point argument. It is an exponent of 10.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_LENGTH</td>
<td>SMALLINT</td>
<td>Argument length in bytes:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BOOLEAN = 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMALLINT = 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INTEGER = 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DATE = 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIME = 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BIGINT = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DECFLOAT(16) = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DOUBLE PRECISION = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIMESTAMP = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIME WITH TIME ZONE = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BLOB_ID = 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TIMESTAMP WITH TIME ZONE = 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INT128 = 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DECFLOAT(34) = 16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$FIELD_SUB_TYPE</td>
<td>SMALLINT</td>
<td>Stores the BLOB subtype for an argument of a BLOB data type.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>The identifier of the character set for a character argument.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$FIELD_PRECISION</td>
<td>SMALLINT</td>
<td>The number of digits of precision available for the data type of the argument.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$CHARACTER_LENGTH</td>
<td>SMALLINT</td>
<td>The length of a CHAR or VARCHAR argument in characters (not in bytes).</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Only for legacy external functions.</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name of the function (or NULL for a top-level function)</td>
</tr>
<tr>
<td>RDB$ARGUMENT_NAME</td>
<td>CHAR(63)</td>
<td>Parameter name</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>----------------------</td>
<td>---------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_SOURCE</td>
<td>CHAR(63)</td>
<td>The name of the user-created domain, when a domain is referenced instead of a data type. If the name starts with the prefix “RDB$”, it is the name of the domain automatically generated by the system for the parameter.</td>
</tr>
<tr>
<td>RDB$DEFAULT_VALUE</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the default value of the parameter</td>
</tr>
<tr>
<td>RDB$DEFAULT_SOURCE</td>
<td>BLOB TEXT</td>
<td>The default value for the parameter, in PSQL code</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the collation used for a character parameter</td>
</tr>
<tr>
<td>RDB$NULL_FLAG</td>
<td>SMALLINT</td>
<td>The flag indicating whether NULL is allowable</td>
</tr>
<tr>
<td>RDB$ARGUMENT MECHANISM</td>
<td>SMALLINT</td>
<td>Parameter passing mechanism for non-legacy functions:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - by value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - by reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - through a descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - via the BLOB descriptor</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of the column the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type. Used in conjunction with RDB$RELATION_NAME (see next).</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - user-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or higher - system-defined</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Optional description of the function argument (comment)</td>
</tr>
</tbody>
</table>

**RDB$GENERATORS**

RDB$GENERATORS stores the metadata of sequences (generators).
### RDB$GENERATOR_NAME

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$GENERATOR_NAME</td>
<td>CHAR(63)</td>
<td>The unique name of the generator</td>
</tr>
<tr>
<td>RDB$GENERATOR_ID</td>
<td>SMALLINT</td>
<td>The unique identifier assigned to the generator by the system</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - user-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or greater - system-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 - internal generator for identity column</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the generator</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>apply access control limits to all users of this generator</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the generator originally</td>
</tr>
<tr>
<td>RDB$INITIAL_VALUE</td>
<td>BIGINT</td>
<td>Stores the initial value (START WITH value) of the generator</td>
</tr>
<tr>
<td>RDB$GENERATOR_INCREMENT</td>
<td>INTEGER</td>
<td>Stores the increment of the value (INCREMENT BY value) of the generator</td>
</tr>
</tbody>
</table>

### RDB$INDEX_SEGMENTS

RDB$INDEX_SEGMENTS stores the segments (table columns) of indexes and their positions in the key. A separate row is stored for each column in an index.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$INDEX_NAME</td>
<td>CHAR(63)</td>
<td>The name of the index this segment is related to. The master record is RDB$INDICES.RDB$INDEX_NAME.</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of a column belonging to the index, corresponding to an identifier for the table and that column in RDB$RELATION_FIELDS.RDB$FIELD_NAME.</td>
</tr>
<tr>
<td>RDB$FIELD_POSITION</td>
<td>SMALLINT</td>
<td>The column position in the index. Positions are numbered left-to-right, starting at zero</td>
</tr>
<tr>
<td>RDB$STATISTICS</td>
<td>DOUBLE PRECISION</td>
<td>The last known (calculated) selectivity of this column in the index. The higher the number, the lower the selectivity.</td>
</tr>
</tbody>
</table>
RDB$INDICES stores definitions of both system- and user-defined indexes. The attributes of each column belonging to an index are stored in one row of the table RDB$INDEX_SEGMENTS.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$INDEX_NAME</td>
<td>CHAR(63)</td>
<td>The unique name of the index specified by the user or automatically generated by the system</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table to which the index belongs. It corresponds to an identifier in RDB$RELATION_NAME.RDB$RELATIONS</td>
</tr>
<tr>
<td>RDB$INDEX_ID</td>
<td>SMALLINT</td>
<td>The internal (system) identifier of the index</td>
</tr>
<tr>
<td>RDB$UNIQUE_FLAG</td>
<td>SMALLINT</td>
<td>Specifies whether the index is unique:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - not unique</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - unique</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments concerning the index</td>
</tr>
<tr>
<td>RDB$SEGMENT_COUNT</td>
<td>SMALLINT</td>
<td>The number of segments (columns) in the index</td>
</tr>
<tr>
<td>RDB$INDEX_INACTIVE</td>
<td>SMALLINT</td>
<td>Indicates whether the index is currently active:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - active</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - inactive</td>
</tr>
<tr>
<td>RDB$INDEX_TYPE</td>
<td>SMALLINT</td>
<td>Distinguishes between an ascending (0 or NULL) and descending index (1). Not used in databases created before Firebird 2.0; hence, indexes in upgraded databases are more likely to store NULL in this column</td>
</tr>
<tr>
<td>RDB$FOREIGN_KEY</td>
<td>CHAR(63)</td>
<td>The name of the primary or unique key index referenced by the foreign key backed by this index; NULL if this index is not used by a foreign key.</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the index is system-defined or user-defined:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - user-defined</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or greater - system-defined</td>
</tr>
</tbody>
</table>
### Appendix D: System Tables

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$EXPRESSION_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the expression of an expression index, used for calculating the values for the index at runtime.</td>
</tr>
<tr>
<td>RDB$EXPRESSION_SOURCE</td>
<td>BLOB TEXT</td>
<td>The source code of the expression of an expression index</td>
</tr>
<tr>
<td>RDB$STATISTICS</td>
<td>DOUBLE PRECISION</td>
<td>Stores the last known selectivity of the entire index, calculated by execution of a \texttt{SET STATISTICS} statement over the index. It is also recalculated whenever the database is first opened by the server. The selectivity of each separate segment of the index is stored in RDB$INDEX_SEGMENTS.</td>
</tr>
<tr>
<td>RDB$CONDITION_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the \texttt{WHERE} condition of a partial index, used for filtering the values for the index at runtime, and optimizer decisions to use the index.</td>
</tr>
<tr>
<td>RDB$CONDITION_SOURCE</td>
<td>BLOB TEXT</td>
<td>The source code of the \texttt{WHERE} condition of a partial index</td>
</tr>
</tbody>
</table>

#### RDB$KEYWORDS

RDB$KEYWORDS is a virtual table listing the keywords used by the Firebird SQL parser. If a keyword is reserved, it cannot be used as a regular identifier, but only as a delimited (quoted) identifier.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$KEYWORD_NAME</td>
<td>VARCHAR(63)</td>
<td>Keyword</td>
</tr>
<tr>
<td>RDB$KEYWORD_RESERVED</td>
<td>BOOLEAN</td>
<td>true if this a reserved word, false otherwise</td>
</tr>
</tbody>
</table>

#### RDB$LOG_FILES

RDB$LOG_FILES is not currently used.

#### RDB$PACKAGES

RDB$PACKAGES stores the definition (header and body) of SQL packages.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Name of the package</td>
</tr>
</tbody>
</table>
### Column Names and Descriptions

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>RDB$PACKAGE_HEADER_SOURCE</code></td>
<td>BLOB TEXT</td>
<td>The PSQL sourcecode of the package header</td>
</tr>
<tr>
<td><code>RDB$PACKAGE_BODY_SOURCE</code></td>
<td>BLOB TEXT</td>
<td>The PSQL sourcecode of the package body</td>
</tr>
<tr>
<td><code>RDB$VALID_BODY_FLAG</code></td>
<td>SMALLINT</td>
<td>Indicates whether the body of the package is still valid. NULL or 0 indicates the body is not valid.</td>
</tr>
<tr>
<td><code>RDB$SECURITY_CLASS</code></td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table <code>RDB$SECURITY_CLASSES</code>, to apply access control limits to all users of this package</td>
</tr>
<tr>
<td><code>RDB$OWNER_NAME</code></td>
<td>CHAR(63)</td>
<td>The username of the user who created the package originally</td>
</tr>
<tr>
<td><code>RDB$SYSTEM_FLAG</code></td>
<td>SMALLINT</td>
<td>Flag: 0 - user-defined 1 or higher - system-defined</td>
</tr>
<tr>
<td><code>RDB$DESCRIPTION</code></td>
<td>BLOB TEXT</td>
<td>Optional description of the package (comment)</td>
</tr>
<tr>
<td><code>RDB$SQL_SECURITY</code></td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER):  NULL - initial default (INVOKER)  FALSE - INVOKER  TRUE - DEFINER</td>
</tr>
</tbody>
</table>

### RDB$PAGES

RDB$PAGES stores and maintains information about database pages and their usage.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>RDB$PAGE_NUMBER</code></td>
<td>INTEGER</td>
<td>The unique number of a physically created database page</td>
</tr>
<tr>
<td><code>RDB$RELATION_ID</code></td>
<td>SMALLINT</td>
<td>The identifier of the table to which the page is allocated</td>
</tr>
<tr>
<td><code>RDB$PAGE_SEQUENCE</code></td>
<td>INTEGER</td>
<td>The number of the page in the sequence of all pages allocated to this table</td>
</tr>
<tr>
<td><code>RDB$PAGE_TYPE</code></td>
<td>SMALLINT</td>
<td>Indicates the page type (data, index, BLOB, etc.). For system use</td>
</tr>
</tbody>
</table>
RDB$PROCEDURES

RDB$PROCEDURES stores the definitions of stored procedures, including their PSQL source code and its binary language representation (BLR). The next table, RDB$PROCEDURE_PARAMETERS, stores the definitions of input and output parameters.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PROCEDURE_NAME</td>
<td>CHAR(63)</td>
<td>Stored procedure name (identifier)</td>
</tr>
<tr>
<td>RDB$PROCEDURE_ID</td>
<td>SMALLINT</td>
<td>The procedure’s unique, system-generated identifier</td>
</tr>
<tr>
<td>RDB$PROCEDURE_INPUTS</td>
<td>SMALLINT</td>
<td>Indicates the number of input parameters. NULL if there are none</td>
</tr>
<tr>
<td>RDB$PROCEDURE_OUTPUTS</td>
<td>SMALLINT</td>
<td>Indicates the number of output parameters. NULL if there are none</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Any text comments related to the procedure</td>
</tr>
<tr>
<td>RDB$PROCEDURE_SOURCE</td>
<td>BLOB TEXT</td>
<td>The PSQL source code of the procedure</td>
</tr>
<tr>
<td>RDB$PROCEDURE_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the procedure code (PSQL procedures only)</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May point to the security class defined in the system table RDB$SECURITY_CLASSES to apply access control limits</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the procedure’s Owner — the user who was CURRENT_USER when the procedure was first created. It may or may not be the username of the author.</td>
</tr>
<tr>
<td>RDB$RUNTIME</td>
<td>BLOB</td>
<td>A metadata description of the procedure, used internally for optimization</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the procedure is defined by a user (value 0) or by the system (a value of 1 or greater)</td>
</tr>
<tr>
<td>RDB$PROCEDURE_TYPE</td>
<td>SMALLINT</td>
<td>Procedure type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - selectable stored procedure (contains a SUSPEND statement)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - executable stored procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - not known *</td>
</tr>
</tbody>
</table>

* for procedures created before Firebird 1.5
<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$VALID_BLR</td>
<td>SMALLINT</td>
<td>Indicates whether the source PSQL of the stored procedure remains valid after the latest ALTER PROCEDURE modification</td>
</tr>
<tr>
<td>RDB$DEBUG_INFO</td>
<td>BLOB</td>
<td>Contains debugging information about variables used in the stored procedure</td>
</tr>
<tr>
<td>RDB$ENGINE_NAME</td>
<td>CHAR(63)</td>
<td>Engine for external functions. 'UDR' for UDR procedures. NULL for PSQL stored procedures</td>
</tr>
<tr>
<td>RDB$ENTRYPOINT</td>
<td>CHAR(255)</td>
<td>The exported name of the external function in the procedure library. Note, this is often not the same as RDB$PROCEDURE_NAME, which is the identifier with which the external stored procedure is declared to the database</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name of the procedure (or NULL for a top-level stored procedure)</td>
</tr>
<tr>
<td>RDB$PRIVATE_FLAG</td>
<td>SMALLINT</td>
<td>NULL for normal (top-level) stored procedures, 0 for package procedures defined in the header, 1 for package procedures only defined in the package body.</td>
</tr>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER): NULL - initial default (INVOKER) FALSE - INVOKER TRUE - DEFINER</td>
</tr>
</tbody>
</table>

**RDB$PROCEDURE_PARAMETERS**

**RDB$PROCEDURE_PARAMETERS** stores the parameters of stored procedures and their attributes. It holds one row for each parameter.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PARAMETER_NAME</td>
<td>CHAR(63)</td>
<td>Parameter name</td>
</tr>
<tr>
<td>RDB$PROCEDURE_NAME</td>
<td>CHAR(63)</td>
<td>The name of the procedure where the parameter is defined</td>
</tr>
<tr>
<td>RDB$PARAMETER_NUMBER</td>
<td>SMALLINT</td>
<td>The sequential number of the parameter</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$PARAMETER_TYPE</td>
<td>SMALLINT</td>
<td>Indicates whether the parameter is for input (value 0) or output (value 1)</td>
</tr>
<tr>
<td>RDB$FIELD_SOURCE</td>
<td>CHAR(63)</td>
<td>The name of the user-created domain, when a domain is referenced instead of a data type. If the name starts with the prefix “RDB$”, it is the name of the domain automatically generated by the system for the parameter.</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the parameter</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the parameter was defined by the system (value or greater) or by a user (value 0)</td>
</tr>
<tr>
<td>RDB$DEFAULT_VALUE</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the default value of the parameter</td>
</tr>
<tr>
<td>RDB$DEFAULT_SOURCE</td>
<td>BLOB TEXT</td>
<td>The default value for the parameter, in PSQL code</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the collation used for a character parameter</td>
</tr>
<tr>
<td>RDB$NULL_FLAG</td>
<td>SMALLINT</td>
<td>The flag indicating whether NULL is allowable</td>
</tr>
<tr>
<td>RDB$PARAMETER_MECHANISM</td>
<td>SMALLINT</td>
<td>Flag: indicates how this parameter is passed:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - by value</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - by reference</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - by descriptor</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - by BLOB descriptor</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of the column the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type. Used in conjunction with RDB$RELATION_NAME (see next).</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table the parameter references, if it was declared using TYPE OF COLUMN instead of a regular data type</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name of the procedure (or NULL for a top-level stored procedure)</td>
</tr>
</tbody>
</table>
RDB$PUBLICATIONS

RDB$PUBLICATIONS stores the replication publications defined in the database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PUBLICATION_NAME</td>
<td>CHAR(63)</td>
<td>Publication name</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the publication</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: 0 - user-defined, 1 or higher - system-defined</td>
</tr>
<tr>
<td>RDB$ACTIVE_FLAG</td>
<td>SMALLINT</td>
<td>Inactive (0) or active (1)</td>
</tr>
<tr>
<td>RDB$AUTO_ENABLE</td>
<td>SMALLINT</td>
<td>Automatically add new tables to publication: 0 - disabled, 1 - enabled</td>
</tr>
</tbody>
</table>

In Firebird 5.0 there is a single (pre-defined) publication named RDB$DEFAULT. User-defined publications will be available in future Firebird releases.

RDB$PUBLICATION_TABLES

RDB$PUBLICATION_TABLES stores the names of tables that are replicated as part of a publication.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$PUBLICATION_NAME</td>
<td>CHAR(63)</td>
<td>Publication name</td>
</tr>
<tr>
<td>RDB$TABLE_NAME</td>
<td>CHAR(63)</td>
<td>Table name</td>
</tr>
</tbody>
</table>

RDB$REF_CONSTRAINTS

RDB$REF_CONSTRAINTS stores the attributes of the referential constraints — Foreign Key relationships and referential actions.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$CONSTRAINT_NAME</td>
<td>CHAR(63)</td>
<td>Foreign key constraint name, defined by the user or automatically generated by the system</td>
</tr>
<tr>
<td>RDB$CONST_NAME_UQ</td>
<td>CHAR(63)</td>
<td>The name of the primary or unique key constraint linked by the REFERENCES clause in the constraint definition</td>
</tr>
</tbody>
</table>
### RDB$MATCH_OPTION
- **Column Name**: RDB$MATCH_OPTION
- **Data Type**: CHAR(7)
- **Description**: Not used. The current value is FULL in all cases

### RDB$UPDATE_RULE
- **Column Name**: RDB$UPDATE_RULE
- **Data Type**: CHAR(11)
- **Description**: Referential integrity actions applied to the foreign key record(s) when the primary (unique) key of the parent table is updated: RESTRICT, NO ACTION, CASCADE, SET NULL, SET DEFAULT

### RDB$DELETE_RULE
- **Column Name**: RDB$DELETE_RULE
- **Data Type**: CHAR(11)
- **Description**: Referential integrity actions applied to the foreign key record(s) when the primary (unique) key of the parent table is deleted: RESTRICT, NO ACTION, CASCADE, SET NULL, SET DEFAULT

### RDB$RELATIONS
RDB$RELATIONS stores the top-level definitions and attributes of all tables and views in the system.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$VIEW_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the query specification of a view. The field stores NULL for a table</td>
</tr>
<tr>
<td>RDB$VIEW_SOURCE</td>
<td>BLOB TEXT</td>
<td>Contains the original source text of the query for a view, in SQL language. User comments are included. The field stores NULL for a table</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the table or view</td>
</tr>
<tr>
<td>RDB$RELATION_ID</td>
<td>SMALLINT</td>
<td>Internal identifier of the table or view</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>indicates whether the table or view is user-defined (value 0) or system-defined (value 1 or greater)</td>
</tr>
<tr>
<td>RDB$DBKEY_LENGTH</td>
<td>SMALLINT</td>
<td>The total length of the database key. For a table: 8 bytes. For a view, the length is 8 multiplied by the number of tables referenced by the view</td>
</tr>
<tr>
<td>RDB$FORMAT</td>
<td>SMALLINT</td>
<td>Internal use, points to the relation’s record in RDB$FORMATS — do not modify</td>
</tr>
<tr>
<td>RDB$FIELD_ID</td>
<td>SMALLINT</td>
<td>The field ID for the next column to be added. The number is not decremented when a column is dropped.</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>Table or view name</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$EXTERNAL_FILE to apply access control limits to all users of this table or view</td>
</tr>
<tr>
<td>RDB$EXTERNAL_FILE</td>
<td>VARCHAR(255)</td>
<td>The full path to the external data file if the table is defined with the EXTERNAL FILE clause</td>
</tr>
<tr>
<td>RDB$RUNTIME</td>
<td>BLOB</td>
<td>Table metadata description, used internally for optimization</td>
</tr>
<tr>
<td>RDB$EXTERNAL_DESCRIPTION</td>
<td>BLOB</td>
<td>Could store comments related to the external file of an external table</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the user who created the table or view originally</td>
</tr>
<tr>
<td>RDB$DEFAULT_CLASS</td>
<td>CHAR(63)</td>
<td>Default security class, used when a new column is added to the table</td>
</tr>
<tr>
<td>RDB$FLAGS</td>
<td>SMALLINT</td>
<td>Internal flags</td>
</tr>
<tr>
<td>RDB$RELATION_TYPE</td>
<td>SMALLINT</td>
<td>The type of the relation object being described:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - system or user-defined table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - external table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - monitoring table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - connection-level GTT (PRESERVE ROWS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - transaction-level GTT (DELETE ROWS)</td>
</tr>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - initial default (INVOKER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FALSE - INVOKER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TRUE - DEFINER</td>
</tr>
</tbody>
</table>

**RDB$RELATION_CONSTRAINTS**

RDB$RELATION_CONSTRAINTS stores the definitions of all table-level constraints: primary, unique, foreign key, CHECK, NOT NULL constraints.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$CONSTRAINT_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table-level constraint defined by the user, or otherwise automatically generated by the system</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$CONSTRAINT_TYPE</td>
<td>CHAR(11)</td>
<td>The name of the constraint type: PRIMARY KEY, UNIQUE, FOREIGN KEY, CHECK or NOT NULL</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table this constraint applies to</td>
</tr>
<tr>
<td>RDB$DEFERRABLE</td>
<td>CHAR(3)</td>
<td>Currently NO in all cases: Firebird does not yet support deferrable constraints</td>
</tr>
<tr>
<td>RDB$INITIALLY_DEFERRED</td>
<td>CHAR(3)</td>
<td>Currently NO in all cases</td>
</tr>
<tr>
<td>RDB$INDEX_NAME</td>
<td>CHAR(63)</td>
<td>The name of the index that supports this constraint. For a CHECK or a NOT NULL constraint, it is NULL.</td>
</tr>
</tbody>
</table>

### RDB$RELATION_FIELDS

RDB$RELATION_FIELDS stores the definitions of table and view columns.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELDS_NAME</td>
<td>CHAR(63)</td>
<td>Column name</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table or view that the column belongs to</td>
</tr>
<tr>
<td>RDB$FIELD_SOURCE</td>
<td>CHAR(63)</td>
<td>Domain name on which the column is based, either a user-defined one specified in the table definition or one created automatically by the system using the set of attributes defined. The attributes are in the table RDB$FIELDS: this column matches RDB$FIELDS.RDB$FIELNAME.</td>
</tr>
<tr>
<td>RDB$QUERY_NAME</td>
<td>CHAR(63)</td>
<td>Not currently used</td>
</tr>
<tr>
<td>RDB$BASE_FIELD</td>
<td>CHAR(63)</td>
<td>Only populated for a view, it is the name of the column from the base table</td>
</tr>
<tr>
<td>RDB$EDIT_STRING</td>
<td>VARCHAR(127)</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$FIELDPOSITION</td>
<td>SMALLINT</td>
<td>The zero-based ordinal position of the column in the table or view, numbering from left to right</td>
</tr>
<tr>
<td>RDB$QUERY_HEADER</td>
<td>BLOB TEXT</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$UPDATE_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the column is a regular one (value 1) or a computed one (value 0)</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------</td>
<td>--------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$FIELD_ID</td>
<td>SMALLINT</td>
<td>An ID assigned from RDB$RELATIONS.RDB$FIELD_ID at the time the column was added to the table or view. It should always be treated as transient.</td>
</tr>
<tr>
<td>RDB$VIEW_CONTEXT</td>
<td>SMALLINT</td>
<td>For a view column, the internal identifier of the base table from which this field derives.</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Comments related to the table or view column.</td>
</tr>
<tr>
<td>RDB$DEFAULT_VALUE</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the default value of the column.</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the column is user-defined (value 0) or system-defined (value 1 or greater).</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in RDB$SECURITY_CLASSES, to apply access control limits to all users of this column.</td>
</tr>
<tr>
<td>RDB$COMPLEX_NAME</td>
<td>CHAR(63)</td>
<td>Not used.</td>
</tr>
<tr>
<td>RDB$NULL_FLAG</td>
<td>SMALLINT</td>
<td>Indicates whether the column is nullable (NULL) non-nullable (value 1).</td>
</tr>
<tr>
<td>RDB$DEFAULT_SOURCE</td>
<td>BLOB TEXT</td>
<td>The source text of the DEFAULT clause, if any.</td>
</tr>
<tr>
<td>RDB$COLLATION_ID</td>
<td>SMALLINT</td>
<td>The identifier of the collation in the character set for the column, if it is not the default collation.</td>
</tr>
<tr>
<td>RDB$GENERATOR_NAME</td>
<td>CHAR(63)</td>
<td>Internal generator name for generating an identity value for the column.</td>
</tr>
<tr>
<td>RDB$IDENTITY_TYPE</td>
<td>SMALLINT</td>
<td>The identity type of the column.</td>
</tr>
</tbody>
</table>

**RDB$ROLES**

RDB$ROLES stores the roles that have been defined in this database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$ROLE_NAME</td>
<td>CHAR(63)</td>
<td>Role name</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$OWNER_NAME</td>
<td>CHAR(63)</td>
<td>The username of the role owner</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the role</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>System flag</td>
</tr>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>May reference a security class defined in the table RDB$SECURITY_CLASSES, to apply access control limits to all users of this role</td>
</tr>
<tr>
<td>RDB$SYSTEM_PRIVILEGES</td>
<td>BINARY(8)</td>
<td>Bitset with the system privileges granted to a role, with the following bits</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - unused</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - USER_MANAGEMENT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - READ_RAW_PAGES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - CREATE_USER_TYPES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - USE_NBACKUP.Utility</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - CHANGE_SHUTDOWN_MODE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 - TRACE_ANY_ATTACHMENT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 - MONITOR_ANY_ATTACHMENT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - ACCESS_SHUTDOWN_DATABASE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 - CREATE_DATABASE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 - DROP_DATABASE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11 - USE_GBAK_UTILITY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12 - USE_GSTAT_UTILITY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - USE_GFIX_UTILITY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>14 - IGNORE_DB_TRIGGERS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 - CHANGE_HEADER_SETTINGS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16 - SELECT_ANY_OBJECT_IN_DATABASE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>17 - ACCESS_ANY_OBJECT_IN_DATABASE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>18 - MODIFY_ANY_OBJECT_IN_DATABASE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>19 - CHANGE_MAPPING_RULES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 - USE_GRANTED_BY_CLAUSE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>21 - GRANT_REVOKE_ON_ANY_OBJECT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22 - GRANT_REVOKE_ANY_DDL_RIGHT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>23 - CREATE_PRIVILEGED_ROLES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24 - GET_DBCRYPT_INFO</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25 - MODIFY_EXT_CONN_POOL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26 - REPLICATE_INTO_DATABASE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 - PROFILE_ANY_ATTACHMENT</td>
</tr>
</tbody>
</table>

**RDB$SECURITY_CLASSES**

RDB$SECURITY_CLASSES stores the access control lists
Appendix D: System Tables

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$SECURITY_CLASS</td>
<td>CHAR(63)</td>
<td>Security class name</td>
</tr>
<tr>
<td>RDB$ACL</td>
<td>BLOB ACL</td>
<td>The access control list related to the security class. It enumerates users and their privileges</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Could store comments related to the security class</td>
</tr>
</tbody>
</table>

**RDB$TIME_ZONES**

RDB$TIME_ZONES lists the named time zones supported by the engine. It is a virtual table that is populated using the current time zone database of the Firebird engine.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TIME_ZONE_ID</td>
<td>INTEGER</td>
<td>The unique identifier of the time zone as used by Firebird. For example, this identifier is used in the time_zone field of the ISC_TIMESTAMP_TZ struct if the value has a named zone instead of an offset.</td>
</tr>
<tr>
<td>RDB$TIME_ZONE_NAME</td>
<td>CHAR(63)</td>
<td>Name of the time zone as specified by the time zone database</td>
</tr>
</tbody>
</table>

**RDB$TRANSACTIONS**

RDB$TRANSACTIONS stores the states of distributed transactions and other transactions that were prepared for two-phase commit with an explicit prepare message.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TRANSACTION_ID</td>
<td>INTEGER</td>
<td>The unique identifier of the transaction being tracked</td>
</tr>
<tr>
<td>RDB$TRANSACTION_STATE</td>
<td>SMALLINT</td>
<td>Transaction state:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - in limbo</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - committed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - rolled back</td>
</tr>
<tr>
<td>RDB$TIMESTAMP</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Not used</td>
</tr>
<tr>
<td>RDB$TRANSACTION_DESCRIPTION</td>
<td>BLOB</td>
<td>Describes the prepared transaction and could be a custom message supplied to isc_prepare_transaction2, even if it is not a distributed transaction. It may be used when a lost connection cannot be restored</td>
</tr>
</tbody>
</table>
**RDB$TRIGGERS**

RDB$TRIGGERS stores the trigger definitions for all tables and views.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TRIGGER_NAME</td>
<td>CHAR(63)</td>
<td>Trigger name</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table or view the trigger applies to. NULL if the trigger is applicable to a database event (“database trigger”)</td>
</tr>
<tr>
<td>RDB$TRIGGER_SEQUENCE</td>
<td>SMALLINT</td>
<td>Position of this trigger in the sequence. Zero usually means that no sequence position is specified</td>
</tr>
<tr>
<td>RDB$TRIGGER_TYPE</td>
<td>BIGINT</td>
<td>The event the trigger fires on, see RDB$TRIGGER_TYPE Value</td>
</tr>
<tr>
<td>RDB$TRIGGER_SOURCE</td>
<td>BLOB TEXT</td>
<td>Stores the source code of the trigger in PSQL</td>
</tr>
<tr>
<td>RDB$TRIGGER_BLR</td>
<td>BLOB BLR</td>
<td>The binary language representation (BLR) of the trigger code (PSQL trigger only)</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Trigger comment text</td>
</tr>
<tr>
<td>RDB$TRIGGER_INACTIVE</td>
<td>SMALLINT</td>
<td>Indicates whether the trigger is currently inactive (1) or active (0)</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: indicates whether the trigger is user-defined (value 0) or system-defined (value 1 or greater)</td>
</tr>
<tr>
<td>RDB$FLAGS</td>
<td>SMALLINT</td>
<td>Internal use</td>
</tr>
<tr>
<td>RDB$VALID_BLR</td>
<td>SMALLINT</td>
<td>Indicates whether the text of the trigger remains valid after the latest modification by the ALTER TRIGGER statement</td>
</tr>
<tr>
<td>RDB$DEBUG_INFO</td>
<td>BLOB</td>
<td>Contains debugging information about variables used in the trigger</td>
</tr>
<tr>
<td>RDB$ENGINE_NAME</td>
<td>CHAR(63)</td>
<td>Engine for external triggers. 'UDR' for UDR triggers. NULL for PSQL triggers</td>
</tr>
<tr>
<td>RDB$ENTRYPOINT</td>
<td>CHAR(255)</td>
<td>The exported name of the external trigger in the trigger library. Note, this is often not the same as RDB$TRIGGER_NAME, which is the identifier with which the trigger is declared to the database</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------</td>
<td>-----------</td>
<td>--------------------------------------------------</td>
</tr>
<tr>
<td>RDB$SQL_SECURITY</td>
<td>BOOLEAN</td>
<td>The SQL SECURITY mode (DEFINER or INVOKER):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NULL - initial default (INVOKER)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FALSE - INVOKER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>TRUE - DEFINER</td>
</tr>
</tbody>
</table>

**RDB$TRIGGER_TYPE Value**

The value of RDB$TRIGGER_TYPE is built from:

1. before insert
2. after insert
3. before update
4. after update
5. before delete
6. after delete
7. before insert or update
8. after insert or update
9. before insert or delete
10. after insert or delete
11. before update or delete
12. after update or delete
13. before insert or update or delete
14. after insert or update or delete
15. on connect
16. on disconnect
17. on transaction start
18. on transaction commit
19. on transaction rollback

Identification of the exact RDB$TRIGGER_TYPE code is a little more complicated, since
it is a bitmap, calculated according to which phase and events are covered and the order in which they are defined. For the curious, the calculation is explained in this code comment by Mark Rotteveel.

For DDL triggers, the trigger type is obtained by bitwise OR above the event phase (0 — BEFORE, 1 — AFTER) and all listed types events:

```
0x0000000000004002 CREATE TABLE
0x0000000000004004 ALTER TABLE
0x0000000000004008 DROP TABLE
0x0000000000004010 CREATE PROCEDURE
0x0000000000004020 ALTER PROCEDURE
0x0000000000004040 DROP PROCEDURE
0x0000000000004080 CREATE FUNCTION
0x0000000000004100 ALTER FUNCTION
0x0000000000004200 DROP FUNCTION
0x0000000000004400 CREATE TRIGGER
0x0000000000004800 ALTER TRIGGER
0x0000000000005000 DROP TRIGGER
0x0000000000014000 CREATE EXCEPTION
0x0000000000024000 ALTER EXCEPTION
0x0000000000044000 DROP EXCEPTION
0x0000000000084000 CREATE VIEW
0x0000000000104000 ALTER VIEW
0x0000000000204000 DROP VIEW
0x0000000000404000 CREATE DOMAIN
0x0000000000804000 ALTER DOMAIN
0x0000000001004000 DROP DOMAIN
0x0000000002004000 CREATE ROLE
0x0000000004004000 ALTER ROLE
0x0000000008004000 DROP ROLE
0x0000000010004000 CREATE INDEX
0x0000000020004000 ALTER INDEX
0x0000000040004000 DROP INDEX
```
For example a trigger with
BEFORE CREATE PROCEDURE OR CREATE FUNCTION will be of type 0x0000000000004090,
AFTER CREATE PROCEDURE OR CREATE FUNCTION — 0x0000000000004091,
BEFORE DROP FUNCTION OR DROP EXCEPTION — 0x00000000000044200,
AFTER DROP FUNCTION OR DROP EXCEPTION — 0x00000000000044201,
BEFORE DROP TRIGGER OR DROP DOMAIN — 0x00000000001005000,
AFTER DROP TRIGGER OR DROP DOMAIN — 0x00000000001005001.

**RDB$TRIGGER_MESSAGES**

RDB$TRIGGER_MESSAGES stores the trigger messages.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$TRIGGER_NAME</td>
<td>CHAR(63)</td>
<td>The name of the trigger the message is associated with</td>
</tr>
<tr>
<td>RDB$MESSAGE_NUMBER</td>
<td>SMALLINT</td>
<td>The number of the message within this trigger (from 1 to 32,767)</td>
</tr>
<tr>
<td>RDB$MESSAGE</td>
<td>VARCHAR(1023)</td>
<td>Text of the trigger message</td>
</tr>
</tbody>
</table>
### RDB$TYPES

**RDB$TYPES** stores the defining sets of enumerated types used throughout the system.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>Enumerated type name. Each type name masters its own set of types, e.g., object types, data types, character sets, trigger types, blob subtypes, etc.</td>
</tr>
<tr>
<td>RDB$TYPE</td>
<td>SMALLINT</td>
<td>The object type identifier. A unique series of numbers is used within each separate enumerated type. For example, for the RDB$OBJECT_TYPE enumerated type, examples of object types are: 0 - TABLE 1 - VIEW 2 - TRIGGER ...</td>
</tr>
<tr>
<td>RDB$TYPE_NAME</td>
<td>CHAR(63)</td>
<td>The name of a member of an enumerated type, e.g., TABLE, VIEW, TRIGGER, etc. in the example above. In the RDB$CHARACTER_SET enumerated type, RDB$TYPE_NAME stores the names of the character sets.</td>
</tr>
<tr>
<td>RDB$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Any text comments related to the enumerated type</td>
</tr>
<tr>
<td>RDB$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag: indicates whether the type-member is user-defined (value 0) or system-defined (value 1 or greater)</td>
</tr>
</tbody>
</table>

### RDB$USER_PRIVILEGES

**RDB$USER_PRIVILEGES** stores the SQL access privileges for Firebird users and privileged objects.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$USER</td>
<td>CHAR(63)</td>
<td>The user or object that is granted this privilege</td>
</tr>
<tr>
<td>RDB$GRANTOR</td>
<td>CHAR(63)</td>
<td>The user who grants the privilege</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>RDB$PRIVILEGE</td>
<td>CHAR(6)</td>
<td>The privilege granted hereby:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>A - all (all privileges)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S - select (selecting data)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>I - insert (inserting rows)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D - delete (deleting rows)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R - references (foreign key)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>U - update (updating data)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>X - executing (procedure)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>G - usage (of other object types)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M - role membership</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C - DDL privilege create</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L - DDL privilege alter</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - DDL privilege drop</td>
</tr>
<tr>
<td>RDB$GRANT_OPTION</td>
<td>SMALLINT</td>
<td>Whether the WITH GRANT OPTION authority is included with the privilege:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - not included</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - included</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the object (table, view, procedure or role) the privilege is</td>
</tr>
<tr>
<td></td>
<td></td>
<td>granted ON</td>
</tr>
<tr>
<td>RDB$FIELD_NAME</td>
<td>CHAR(63)</td>
<td>The name of the column the privilege is applicable to, for a column-level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>privilege (an UPDATE or REFERENCES privilege)</td>
</tr>
<tr>
<td>RDB$USER_TYPE</td>
<td>SMALLINT</td>
<td>Identifies the type of user the privilege is granted TO (a user, a procedure,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>a view, etc.)</td>
</tr>
</tbody>
</table>
### RDB$OBJECT_TYPE

Identifies the type of the object the privilege is granted ON.

- 0 - table
- 1 - view
- 2 - trigger
- 5 - procedure
- 7 - exception
- 8 - user
- 9 - domain
- 11 - character set
- 13 - role
- 14 - generator (sequence)
- 15 - function
- 16 - BLOB filter
- 17 - collation
- 18 - package

### RDB$VIEW_RELATIONS

RDB$VIEW_RELATIONS stores the tables that are referred to in view definitions. There is one record for each table in a view.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>RDB$VIEW_NAME</td>
<td>CHAR(63)</td>
<td>View name</td>
</tr>
<tr>
<td>RDB$RELATION_NAME</td>
<td>CHAR(63)</td>
<td>The name of the table, view or stored procedure the view references</td>
</tr>
<tr>
<td>RDB$VIEW_CONTEXT</td>
<td>SMALLINT</td>
<td>The alias used to reference the view column in the BLR code of the query definition</td>
</tr>
<tr>
<td>RDB$CONTEXT_NAME</td>
<td>CHAR(255)</td>
<td>The text associated with the alias reported in the RDB$VIEW_CONTEXT column</td>
</tr>
<tr>
<td>RDB$CONTEXT_TYPE</td>
<td>SMALLINT</td>
<td>Context type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - table</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - view</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - stored procedure</td>
</tr>
<tr>
<td>RDB$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name for a stored procedure in a package</td>
</tr>
</tbody>
</table>
Appendix E: Monitoring Tables

The Firebird engine can monitor activities in a database and make them available for user queries via the monitoring tables. The definitions of these tables are always present in the database, all named with the prefix MON$. The tables are virtual: they are populated with data only at the moment when the user queries them. That is also one good reason why it is no use trying to create triggers for them!

The key notion in understanding the monitoring feature is an activity snapshot. The activity snapshot represents the current state of the database at the start of the transaction in which the monitoring table query runs. It delivers a lot of information about the database itself, active connections, users, transactions prepared, running queries and more.

The snapshot is created when any monitoring table is queried for the first time. It is preserved until the end of the current transaction to maintain a stable, consistent view for queries across multiple tables, such as a master-detail query. In other words, monitoring tables always behave as though they were in SNAPSHOT TABLE STABILITY (“consistency”) isolation, even if the current transaction is started with a lower isolation level.

To refresh the snapshot, the current transaction must be completed and the monitoring tables must be re-queried in a new transaction context.

Access Security

- SYSDBA and the database owner have full access to all information available from the monitoring tables
- Regular users can see information about their own connections; other connections are not visible to them

WARNING: In a highly loaded environment, collecting information via the monitoring tables could have a negative impact on system performance.

List of Monitoring Tables

**MON$ATTACHMENTS**

Information about active attachments to the database

**MON$CALL_STACK**

Calls to the stack by active queries of stored procedures and triggers

**MON$COMPILED_STATEMENTS**

Virtual table listing compiled statements

**MON$CONTEXT_VARIABLES**

Information about custom context variables

**MON$DATABASE**

Information about the database to which the CURRENT_CONNECTION is attached
**MON$IO_STATS**  
Input/output statistics

**MON$MEMORY_USAGE**  
Memory usage statistics

**MON$RECORD_STATS**  
Record-level statistics

**MON$STATEMENTS**  
Statements prepared for execution

**MON$TABLE_STATS**  
Table-level statistics

**MON$TRANSACTIONS**  
Started transactions

**MON$ATTACHMENTS**

**MON$ATTACHMENTS** displays information about active attachments to the database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Connection identifier</td>
</tr>
<tr>
<td>MON$SERVER_PID</td>
<td>INTEGER</td>
<td>Server process identifier</td>
</tr>
<tr>
<td>MON$STATE</td>
<td>SMALLINT</td>
<td>Connection state:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - idle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - active</td>
</tr>
<tr>
<td>MON$ATTACHMENT_NAME</td>
<td>VARCHAR(255)</td>
<td>Connection string — the file name and full path to the primary database file</td>
</tr>
<tr>
<td>MON$USER</td>
<td>CHAR(63)</td>
<td>The name of the user who is using this connection</td>
</tr>
<tr>
<td>MON$ROLE</td>
<td>CHAR(63)</td>
<td>The role name specified when the connection was established. If no role</td>
</tr>
<tr>
<td></td>
<td></td>
<td>was specified when the connection was established, the field contains the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>text NONE</td>
</tr>
<tr>
<td>MON$REMOTE_PROTOCOL</td>
<td>VARCHAR(10)</td>
<td>Remote protocol name</td>
</tr>
<tr>
<td>MON$REMOTE_ADDRESS</td>
<td>VARCHAR(255)</td>
<td>Remote address (address and server name)</td>
</tr>
<tr>
<td>MON$REMOTE_PID</td>
<td>INTEGER</td>
<td>Remote client process identifier</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>MON$CHARACTER_SET_ID</td>
<td>SMALLINT</td>
<td>Connection character set identifier (see RDB$CHARACTER_SET in system table RDB$TYPES)</td>
</tr>
<tr>
<td>MON$TIMESTAMP</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>The date and time when the connection was started</td>
</tr>
<tr>
<td>MON$GARbage_COLLECTION</td>
<td>SMALLINT</td>
<td>Garbage collection flag (as specified in the attachment’s DPB): 1=allowed, 0=not allowed</td>
</tr>
<tr>
<td>MON$REMOTE_PROCESS</td>
<td>VARCHAR(255)</td>
<td>The full file name and path to the executable file that established this connection</td>
</tr>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$CLIENT_VERSION</td>
<td>VARCHAR(255)</td>
<td>Client library version</td>
</tr>
<tr>
<td>MON$REMOTE_VERSION</td>
<td>VARCHAR(255)</td>
<td>Remote protocol version</td>
</tr>
<tr>
<td>MON$REMOTE_HOST</td>
<td>VARCHAR(255)</td>
<td>Name of the remote host</td>
</tr>
<tr>
<td>MON$REMOTE_OS_USER</td>
<td>VARCHAR(255)</td>
<td>Name of remote user</td>
</tr>
<tr>
<td>MON$AUTH_METHOD</td>
<td>VARCHAR(255)</td>
<td>Name of authentication plugin used to connect</td>
</tr>
<tr>
<td>MON$SYSTEM_FLAG</td>
<td>SMALLINT</td>
<td>Flag that indicates the type of connection:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - normal connection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - system connection</td>
</tr>
<tr>
<td>MON$IDLE_TIMEOUT</td>
<td>INTEGER</td>
<td>Connection-level idle timeout in seconds. When 0 is reported the database ConnectionIdleTimeout from databases.conf or firebird.conf applies.</td>
</tr>
<tr>
<td>MON$IDLE_TIMER</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Idle timer expiration time</td>
</tr>
<tr>
<td>MON$STATEMENT_TIMEOUT</td>
<td>INTEGER</td>
<td>Connection-level statement timeout in milliseconds. When 0 is reported the database StatementTimeout from databases.conf or firebird.conf applies.</td>
</tr>
<tr>
<td>MON$WIRE_COMPRESSED</td>
<td>BOOLEAN</td>
<td>Wire compression active (TRUE) or inactive (FALSE)</td>
</tr>
<tr>
<td>MON$WIRE_ENCRYPTED</td>
<td>BOOLEAN</td>
<td>Wire encryption active (TRUE) or inactive (FALSE)</td>
</tr>
<tr>
<td>MON$WIRE_CRYPT_PLUGIN</td>
<td>VARCHAR(63)</td>
<td>Name of the wire encryption plugin used</td>
</tr>
<tr>
<td>MON$SESSION_TIMEZONE</td>
<td>CHAR(63)</td>
<td>Name of the session time zone</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>MON$PARALLEL_WORKERS</td>
<td>INTEGER</td>
<td>Maximum number of parallel workers for this connection, 1 means no parallel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>workers. “Garbage Collector” and “Cache Writer” connections may report 0.</td>
</tr>
</tbody>
</table>

Retrieving information about client applications

```
SELECT MON$USER, MON$REMOTE_ADDRESS, MON$REMOTE_PID, MON$TIMESTAMP
FROM MON$ATTACHMENTS
WHERE MON$ATTACHMENT_ID <> CURRENT_CONNECTION
```

Using **MON$ATTACHMENTS** to Kill a Connection

Monitoring tables are read-only. However, the server has a built-in mechanism for deleting (and only deleting) records in the **MON$ATTACHMENTS** table, which makes it possible to close a connection to the database.

**Notes**

- All the current activity in the connection being deleted is immediately stopped and all active transactions are rolled back
- The closed connection will return an error with the *isc_att_shutdown* code to the application
- Subsequent attempts to use this connection (i.e., use its handle in API calls) will return errors
- Termination of system connections (**MON$SYSTEM_FLAG = 1**) is not possible. The server will skip system connections in a `DELETE FROM MON$ATTACHMENTS`.

Closing all connections except for your own (current):

```
DELETE FROM MON$ATTACHMENTS
WHERE MON$ATTACHMENT_ID <> CURRENT_CONNECTION
```

**MON$COMPILLED_STATEMENTS**

Virtual table listing compiled statements.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$COMPILLED_STATEMENT_ID</td>
<td>BIGINT</td>
<td>Compiled statement id</td>
</tr>
<tr>
<td>MON$SQL_TEXT</td>
<td>BLOB TEXT</td>
<td>Statement text</td>
</tr>
<tr>
<td>MON$EXPLAINED_PLAN</td>
<td>BLOB TEXT</td>
<td>Explained query plan</td>
</tr>
<tr>
<td>MON$OBJECT_NAME</td>
<td>CHAR(63)</td>
<td>PSQL object name</td>
</tr>
</tbody>
</table>
### Appendix E: Monitoring Tables

**MON$CALL_STACK**

MON$CALL_STACK displays calls to the stack from queries executing in stored procedures and triggers.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$CALL_ID</td>
<td>BIGINT</td>
<td>Call identifier</td>
</tr>
<tr>
<td>MON$STATEMENT_ID</td>
<td>BIGINT</td>
<td>The identifier of the top-level SQL statement, the one that initiated the chain of calls. Use this identifier to find the records about the active statement in the MON$STATEMENTS table</td>
</tr>
<tr>
<td>MON$CALLER_ID</td>
<td>BIGINT</td>
<td>The identifier of the calling trigger or stored procedure</td>
</tr>
<tr>
<td>MON$OBJECT_NAME</td>
<td>CHAR(63)</td>
<td>PSQL object name</td>
</tr>
<tr>
<td>MON$OBJECT_TYPE</td>
<td>SMALLINT</td>
<td>PSQL object type:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - trigger</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 - stored procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15 - stored function</td>
</tr>
<tr>
<td>MON$TIMESTAMP</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>The date and time when the call was started</td>
</tr>
<tr>
<td>MON$SOURCE_LINE</td>
<td>INTEGER</td>
<td>The number of the source line in the SQL statement being executed at the moment of the snapshot</td>
</tr>
<tr>
<td>MON$SOURCE_COLUMN</td>
<td>INTEGER</td>
<td>The number of the source column in the SQL statement being executed at the moment of the snapshot</td>
</tr>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name for stored procedures or functions in a package</td>
</tr>
<tr>
<td>MON$COMPILED_STATEMENT_ID</td>
<td>BIGINT</td>
<td>Compiled statement id</td>
</tr>
</tbody>
</table>
does not get into the call stack.

Get the call stack for all connections except your own

```
WITH RECURSIVE
    HEAD AS (
        SELECT
            CALL.MON$STATEMENT_ID, CALL.MON$CALL_ID,
            CALL.MON$OBJECT_NAME, CALL.MON$OBJECT_TYPE
        FROM MON$CALL_STACK CALL
        WHERE CALL.MON$CALLER_ID IS NULL
        UNION ALL
        SELECT
            CALL.MON$STATEMENT_ID, CALL.MON$CALL_ID,
            CALL.MON$OBJECT_NAME, CALL.MON$OBJECT_TYPE
        FROM MON$CALL_STACK CALL
        JOIN HEAD ON CALL.MON$CALLER_ID = HEAD.MON$CALL_ID
    )

    SELECT MON$ATTACHMENT_ID, MON$OBJECT_NAME, MON$OBJECT_TYPE
    FROM HEAD
    JOIN MON$STATEMENTS STMT ON STMT.MON$STATEMENT_ID = HEAD.MON$STATEMENT_ID
    WHERE STMT.MON$ATTACHMENT_ID <> CURRENT_CONNECTION
```

**MON$CONTEXT_VARIABLES**

**MON$CONTEXT_VARIABLES** displays information about custom context variables.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Connection identifier. It contains a valid value only for a connection-level context variable. For transaction-level variables it is NULL.</td>
</tr>
<tr>
<td>MON$TRANSACTION_ID</td>
<td>BIGINT</td>
<td>Transaction identifier. It contains a valid value only for transaction-level context variables. For connection-level variables it is NULL.</td>
</tr>
<tr>
<td>MON$VARIABLE_NAME</td>
<td>VARCHAR(80)</td>
<td>Context variable name</td>
</tr>
<tr>
<td>MON$VARIABLE_VALUE</td>
<td>VARCHAR(32765)</td>
<td>Context variable value</td>
</tr>
</tbody>
</table>

Retrieving all session context variables for the current connection

```
SELECT
    VAR.MON$VARIABLE_NAME,
    VAR.MON$VARIABLE_VALUE
FROM MON$CONTEXT_VARIABLES VAR
WHERE VAR.MON$ATTACHMENT_ID = CURRENT_CONNECTION
```
**MON$DATABASE**

*MON$DATABASE* displays the header information from the database the current user is connected to.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$DATABASE_NAME</td>
<td>VARCHAR(255)</td>
<td>The file name and full path of the primary database file, or the database alias</td>
</tr>
<tr>
<td>MON$PAGE_SIZE</td>
<td>SMALLINT</td>
<td>Database page size in bytes</td>
</tr>
<tr>
<td>MON$ODS_MAJOR</td>
<td>SMALLINT</td>
<td>Major ODS version, e.g., 11</td>
</tr>
<tr>
<td>MON$ODS_MINOR</td>
<td>SMALLINT</td>
<td>Minor ODS version, e.g., 2</td>
</tr>
<tr>
<td>MON$OLDEST_TRANSACTION</td>
<td>BIGINT</td>
<td>The number of the oldest [interesting] transaction (OIT)</td>
</tr>
<tr>
<td>MON$OLDEST_ACTIVE</td>
<td>BIGINT</td>
<td>The number of the oldest active transaction (OAT)</td>
</tr>
<tr>
<td>MON$OLDEST_SNAPSHOT</td>
<td>BIGINT</td>
<td>The number of the transaction that was active at the moment when the OAT was started — oldest snapshot transaction (OST)</td>
</tr>
<tr>
<td>MON$NEXT_TRANSACTION</td>
<td>BIGINT</td>
<td>The number of the next transaction, as it stood when the monitoring snapshot was taken</td>
</tr>
<tr>
<td>MON$PAGE_BUFFERS</td>
<td>INTEGER</td>
<td>The number of pages allocated in RAM for the database page cache</td>
</tr>
<tr>
<td>MON$SQL_DIALECT</td>
<td>SMALLINT</td>
<td>Database SQL Dialect: 1 or 3</td>
</tr>
<tr>
<td>MON$SHUTDOWN_MODE</td>
<td>SMALLINT</td>
<td>The current shutdown state of the database:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - the database is online</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - multi-user shutdown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - single-user shutdown</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - full shutdown</td>
</tr>
<tr>
<td>MON$SWEEP_INTERVAL</td>
<td>INTEGER</td>
<td>Sweep interval</td>
</tr>
<tr>
<td>MON$READ_ONLY</td>
<td>SMALLINT</td>
<td>Flag indicating whether the database is read-only (value 1) or read-write (value 0)</td>
</tr>
<tr>
<td>MON$FORCED_WRITES</td>
<td>SMALLINT</td>
<td>Indicates whether the write mode of the database is set for synchronous write (forced writes ON, value is 1) or asynchronous write (forced writes OFF, value is 0)</td>
</tr>
<tr>
<td>Column Name</td>
<td>Data Type</td>
<td>Description</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------</td>
<td>----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>MON$RESERVE_SPACE</td>
<td>SMALLINT</td>
<td>The flag indicating reserve_space (value 1) or use_all_space (value 0) for filling database pages</td>
</tr>
<tr>
<td>MON$CREATION_DATE</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>The date and time when the database was created or was last restored</td>
</tr>
<tr>
<td>MON$PAGES</td>
<td>BIGINT</td>
<td>The number of pages allocated for the database on an external device</td>
</tr>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$BACKUP_STATE</td>
<td>SMALLINT</td>
<td>Current physical backup (nBackup) state:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - normal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - stalled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - merge</td>
</tr>
<tr>
<td>MON$CRYPT_PAGE</td>
<td>BIGINT</td>
<td>Number of encrypted pages</td>
</tr>
<tr>
<td>MON$OWNER</td>
<td>CHAR(63)</td>
<td>Username of the database owner</td>
</tr>
<tr>
<td>MON$SEC_DATABASE</td>
<td>CHAR(7)</td>
<td>Displays what type of security database is used:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Default - default security database, i.e. security5.fdb</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Self - current database is used as security database</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other - another database is used as security database (not itself or security5.fdb)</td>
</tr>
<tr>
<td>MON$CRYPT_STATE</td>
<td>SMALLINT</td>
<td>Current state of database encryption</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - not encrypted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - encrypted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - decryption in progress</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - encryption in progress</td>
</tr>
<tr>
<td>MON$GUID</td>
<td>CHAR(38)</td>
<td>Database GUID (persistent until restore/fixup)</td>
</tr>
<tr>
<td>MON$FILE_ID</td>
<td>VARCHAR(255)</td>
<td>Unique ID of the database file at the filesystem level</td>
</tr>
<tr>
<td>MON$NEXT_ATTACHMENT</td>
<td>BIGINT</td>
<td>Current value of the next attachment ID counter</td>
</tr>
<tr>
<td>MON$NEXT_STATEMENT</td>
<td>BIGINT</td>
<td>Current value of the next statement ID counter</td>
</tr>
</tbody>
</table>
## MON$REPLICA_MODE

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$REPLICA_MODE</td>
<td>SMALLINT</td>
<td>Database replica mode</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - not a replica</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - read-only replica</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - read-write replica</td>
</tr>
</tbody>
</table>

### MON$IO_STATS

MON$IO_STATS displays input/output statistics. The counters are cumulative, by group, for each group of statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$STAT_GROUP</td>
<td>SMALLINT</td>
<td>Statistics group:</td>
</tr>
<tr>
<td>MON$PAGE_READS</td>
<td>BIGINT</td>
<td>Count of database pages read</td>
</tr>
<tr>
<td>MON$PAGE_WRITES</td>
<td>BIGINT</td>
<td>Count of database pages written to</td>
</tr>
<tr>
<td>MON$PAGE_FETCHES</td>
<td>BIGINT</td>
<td>Count of database pages fetched</td>
</tr>
<tr>
<td>MON$PAGE_MARKS</td>
<td>BIGINT</td>
<td>Count of database pages marked</td>
</tr>
</tbody>
</table>

## MON$MEMORY_USAGE

MON$MEMORY_USAGE displays memory usage statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$STAT_GROUP</td>
<td>SMALLINT</td>
<td>Statistics group:</td>
</tr>
<tr>
<td>MON$PAGE_READS</td>
<td>BIGINT</td>
<td>Count of database pages read</td>
</tr>
<tr>
<td>MON$PAGE_WRITES</td>
<td>BIGINT</td>
<td>Count of database pages written to</td>
</tr>
<tr>
<td>MON$PAGE_FETCHES</td>
<td>BIGINT</td>
<td>Count of database pages fetched</td>
</tr>
<tr>
<td>MON$PAGE_MARKS</td>
<td>BIGINT</td>
<td>Count of database pages marked</td>
</tr>
</tbody>
</table>
### Column Name | Data Type | Description
---|---|---
MON$MEMORY_USED | BIGINT | The amount of memory in use, in bytes. This data is about the high-level memory allocation performed by the server. It can be useful to track down memory leaks and excessive memory usage in connections, procedures, etc.

MON$MEMORY_ALLOCATED | BIGINT | The amount of memory allocated by the operating system, in bytes. This data is about the low-level memory allocation performed by the Firebird memory manager — the amount of memory allocated by the operating system — which can allow you to control the physical memory usage.

MON$MAX_MEMORY_USED | BIGINT | The maximum number of bytes used by this object

MON$MAX_MEMORY_ALLOCATED | BIGINT | The maximum number of bytes allocated for this object by the operating system

Counters associated with database-level records MON$DATABASE (MON$STAT_GROUP = 0), display memory allocation for all connections. In the Classic and SuperClassic zero values of the counters indicate that these architectures have no common cache.

Minor memory allocations are not accrued here but are added to the database memory pool instead.

**Getting 10 requests consuming the most memory**

```sql
SELECT
  STMT.MON$ATTACHMENT_ID,
  STMT.MON$SQL_TEXT,
  MEM.MON$MEMORY_USED
FROM MON$MEMORY_USAGE MEM
  NATURAL JOIN MON$STATEMENTS STMT
ORDER BY MEM.MON$MEMORY_USED DESC
FETCH FIRST 10 ROWS ONLY
```

**MON$RECORD_STATS**

MON$RECORD_STATS displays record-level statistics. The counters are cumulative, by group, for each group of statistics.
### Column Name | Data Type | Description
--- | --- | ---
MON$STAT_ID | INTEGER | Statistics identifier
MON$STAT_GROUP | SMALLINT | Statistics group:
| 0 - database |
| 1 - connection |
| 2 - transaction |
| 3 - statement |
| 4 - call |
MON$RECORD_SEQ_READS | BIGINT | Count of records read sequentially
MON$RECORD_IDX_READS | BIGINT | Count of records read via an index
MON$RECORD_INSERTS | BIGINT | Count of inserted records
MON$RECORD_UPDATES | BIGINT | Count of updated records
MON$RECORD_DELETES | BIGINT | Count of deleted records
MON$RECORD_BACKOUTS | BIGINT | Count of records backed out
MON$RECORD_PURGES | BIGINT | Count of records purged
MON$RECORD_EXPUNGES | BIGINT | Count of records expunged
MON$RECORD_LOCKS | BIGINT | Number of records locked
MON$RECORD_WAITS | BIGINT | Number of update, delete or lock attempts on records owned by other active transactions. Transaction is in **WAIT** mode.
MON$RECORD_CONFLICTS | BIGINT | Number of unsuccessful update, delete or lock attempts on records owned by other active transactions. These are reported as update conflicts.
MON$BACKVERSION_READS | BIGINT | Number of back-versions read to find visible records
MON$FRAGMENT_READS | BIGINT | Number of fragmented records read
MON$RECORD_RPT_READS | BIGINT | Number of repeated reads of records
MON$RECORD_IMGC | BIGINT | Number of records processed by the intermediate garbage collector

### MON$STATEMENTS

**MON$STATEMENTS** displays statements prepared for execution.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement identifier</td>
</tr>
<tr>
<td>MON$ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Connection identifier</td>
</tr>
</tbody>
</table>
### Column Name | Data Type | Description
--- | --- | ---
MON$TRANSACTION_ID | BIGINT | Transaction identifier
MON$STATE | SMALLINT | Statement state:
- 0 - idle
- 1 - active
- 2 - stalled
MON$TIMESTAMP | TIMESTAMP WITH TIME ZONE | The date and time when the statement was prepared
MON$SQL_TEXT | BLOB TEXT | Statement text in SQL
MON$STAT_ID | INTEGER | Statistics identifier
MON$EXPLAINED_PLAN | BLOB TEXT | Explained execution plan
MON$STATEMENT_TIMEOUT | INTEGER | Connection-level statement timeout in milliseconds. When 0 is reported the timeout of MON$ATTACHMENT.MON$STATEMENT_TIMEOUT for this connection applies.
MON$STATEMENT_TIMER | TIMESTAMP WITH TIME ZONE | Statement timer expiration time
MON$COMPILED_STATEMENT_ID | BIGINT | Compiled statement id

The STALLED state indicates that, at the time of the snapshot, the statement had an open cursor and was waiting for the client to resume fetching rows.

**Display active queries, excluding those running in your connection**

```sql
SELECT
  ATT.MON$USER,
  ATT.MON$REMOTE_ADDRESS,
  STMT.MON$SQL_TEXT,
  STMT.MON$TIMESTAMP
FROM MON$ATTACHMENTS ATT
JOIN MON$STATEMENTS STMT ON ATT.MON$ATTACHMENT_ID = STMT.MON$ATTACHMENT_ID
WHERE ATT.MON$ATTACHMENT_ID <> CURRENT_CONNECTION
AND STMT.MON$STATE = 1
```

**Using MON$STATEMENTS to Cancel a Query**

Monitoring tables are read-only. However, the server has a built-in mechanism for deleting (and only deleting) records in the MON$STATEMENTS table, which makes it possible to cancel a running query.

**Notes**
- If no statements are currently being executed in the connection, any attempt to
cancel queries will not proceed

- After a query is cancelled, calling execute/fetch API functions will return an error with the \texttt{isc\_cancelled} code
- Subsequent queries from this connection will proceed as normal
- Cancellation of the statement does not occur synchronously, it only marks the request for cancellation, and the cancellation itself is done asynchronously by the server

\textit{Example}

Cancelling all active queries for the specified connection:

\begin{verbatim}
DELETE FROM MON$STATEMENTS
  WHERE MON$ATTACHMENT_ID = 32
\end{verbatim}

\textbf{MON$TABLE_STATS}

\texttt{MON$TABLE_STATS} reports table-level statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
<tr>
<td>MON$STAT_GROUP</td>
<td>SMALLINT</td>
<td>Statistics group:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - database</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - connection</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - transaction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - statement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - call</td>
</tr>
<tr>
<td>MON$TABLE_NAME</td>
<td>CHAR(63)</td>
<td>Name of the table</td>
</tr>
<tr>
<td>MON$RECORD_STAT_ID</td>
<td>INTEGER</td>
<td>Link to \texttt{MON$RECORD_STATS}</td>
</tr>
</tbody>
</table>

\textit{Getting statistics at the record level for each table for the current connection}

\begin{verbatim}
SELECT
t.mon$table_name,
r.mon$record_inserts,
r.mon$record_updates,
r.mon$record_deletes,
r.mon$record_backouts,
r.mon$record_purges,
r.mon$record_expunges,
------------------------
r.mon$record_seq_reads,
r.mon$record_idx_reads,
r.mon$record_rpt_reads,
r.mon$backversion_reads,
\end{verbatim}
r.mon$fragment_reads,
"------------------------"
    r.mon$record_locks,
    r.mon$record_waits,
    r.mon$record_conflicts,
"------------------------"
    a.mon$stat_id
FROM mon$record_stats r
JOIN mon$table_stats t ON r.mon$stat_id = t.mon$record_stat_id
JOIN mon$attachments a ON t.mon$stat_id = a.mon$stat_id
WHERE a.mon$attachment_id = CURRENT_CONNECTION

**MON$TRANSACTIONS**

*MON$TRANSACTIONS* reports started transactions.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$TRANSACTION_ID</td>
<td>BIGINT</td>
<td>Transaction identifier (number)</td>
</tr>
<tr>
<td>MON$ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Connection identifier</td>
</tr>
<tr>
<td>MON$STATE</td>
<td>SMALLINT</td>
<td>Transaction state:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - idle</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - active</td>
</tr>
<tr>
<td>MON$TIMESTAMP</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>The date and time when the transaction was started</td>
</tr>
<tr>
<td>MON$TOP_TRANSACTION</td>
<td>BIGINT</td>
<td>Top-level transaction identifier (number)</td>
</tr>
<tr>
<td>MON$OLDEST_TRANSACTION</td>
<td>BIGINT</td>
<td>Transaction ID of the oldest [interesting] transaction (OIT)</td>
</tr>
<tr>
<td>MON$OLDEST_ACTIVE</td>
<td>BIGINT</td>
<td>Transaction ID of the oldest active transaction (OAT)</td>
</tr>
<tr>
<td>MON$ISOLATION_MODE</td>
<td>SMALLINT</td>
<td>Isolation mode (level):</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - consistency (snapshot table stability)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - concurrency (snapshot)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 - read committed record version</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 - read committed no record version</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4 - read committed read consistency</td>
</tr>
<tr>
<td>MON$LOCK_TIMEOUT</td>
<td>SMALLINT</td>
<td>Lock timeout:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-1 - wait forever</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - no waiting</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 or greater - lock timeout in seconds</td>
</tr>
</tbody>
</table>
### Appendix E: Monitoring Tables

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MON$READ_ONLY</td>
<td>SMALLINT</td>
<td>Flag indicating whether the transaction is read-only (value 1) or read-write (value 0)</td>
</tr>
<tr>
<td>MON$AUTO_COMMIT</td>
<td>SMALLINT</td>
<td>Flag indicating whether automatic commit is used for the transaction (value 1) or not (value 0)</td>
</tr>
<tr>
<td>MON$AUTO_UNDO</td>
<td>SMALLINT</td>
<td>Flag indicating whether the logging mechanism <em>automatic undo</em> is used for the transaction (value 1) or not (value 0)</td>
</tr>
<tr>
<td>MON$STAT_ID</td>
<td>INTEGER</td>
<td>Statistics identifier</td>
</tr>
</tbody>
</table>

**Getting all connections that started Read Write transactions with isolation level above Read Committed**

```sql
SELECT DISTINCT a. *
FROM mon$attachments a
JOIN mon$transactions t ON a.mon$attachment_id = t.mon$attachment_id
WHERE NOT (t.mon$read_only = 1 AND t.mon$isolation_mode >= 2)
```
Appendix F: Security tables

The names of the security tables have SEC$ as prefix. They display data from the current security database. These tables are virtual in the sense that before access by the user, no data is recorded in them. They are filled with data at the time of user request. However, the descriptions of these tables are constantly present in the database. In this sense, these virtual tables are like tables of the MON$-family used to monitor the server.

Security

• SYSDBA, users with the RDB$ADMIN role in the security database and the current database, and the owner of the security database have full access to all information provided by the security tables.

• Regular users can only see information on themselves, other users are not visible.

These features are highly dependent on the user management plugin. Keep in mind that some options are ignored when using a legacy control plugin users.

List of security tables

SEC$DB_CREATORS

Lists users and roles granted the CREATE DATABASE privilege

SEC$GLOBAL_AUTH_MAPPING

Information about global authentication mappings

SEC$USERS

Lists users in the current security database

SEC$USER_ATTRIBUTES

Additional attributes of users

SEC$DB_CREATORS

Lists users and roles granted the CREATE DATABASE privilege.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC$USER</td>
<td>CHAR(63)</td>
<td>Name of the user or role</td>
</tr>
<tr>
<td>SEC$USER_TYPE</td>
<td>SMALLINT</td>
<td>Type of user:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 - user</td>
</tr>
<tr>
<td></td>
<td></td>
<td>13 - role</td>
</tr>
</tbody>
</table>

SEC$GLOBAL_AUTH_MAPPING

Lists users and roles granted the CREATE DATABASE privilege.
### SEC$MAP

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC$MAP_NAME</td>
<td>CHAR(63)</td>
<td>Name of the mapping</td>
</tr>
<tr>
<td>SEC$MAP_USING</td>
<td>CHAR(1)</td>
<td>Using definition:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P - plugin (specific or any)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>S - any plugin serverwide</td>
</tr>
<tr>
<td></td>
<td></td>
<td>M - mapping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>* - any method</td>
</tr>
<tr>
<td>SEC$MAP_PLUGIN</td>
<td>CHAR(63)</td>
<td>Mapping applies for authentication information from this specific plugin</td>
</tr>
<tr>
<td>SEC$MAP_DB</td>
<td>CHAR(63)</td>
<td>Mapping applies for authentication information from this specific database</td>
</tr>
<tr>
<td>SEC$MAP_FROM_TYPE</td>
<td>CHAR(63)</td>
<td>The type of authentication object (defined by plugin) to map from, or * for any type</td>
</tr>
<tr>
<td>SEC$MAP_FROM</td>
<td>CHAR(255)</td>
<td>The name of the authentication object to map from</td>
</tr>
<tr>
<td>SEC$MAP_TO_TYPE</td>
<td>SMALLINT Nullable</td>
<td>The type to map to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0 - USER</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 - ROLE</td>
</tr>
<tr>
<td>SEC$MAP_TO</td>
<td>CHAR(63)</td>
<td>The name to map to</td>
</tr>
<tr>
<td>SEC$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Comment on the mapping</td>
</tr>
</tbody>
</table>

### SEC$USERS

Lists users in the current security database.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC$USER_NAME</td>
<td>CHAR(63)</td>
<td>Username</td>
</tr>
<tr>
<td>SEC$FIRST_NAME</td>
<td>VARCHAR(32)</td>
<td>First name</td>
</tr>
<tr>
<td>SEC$MIDDLE_NAME</td>
<td>VARCHAR(32)</td>
<td>Middle name</td>
</tr>
<tr>
<td>SEC$LAST_NAME</td>
<td>VARCHAR(32)</td>
<td>Last name</td>
</tr>
<tr>
<td>SEC$ACTIVE</td>
<td>BOOLEAN</td>
<td>true - active, false - inactive</td>
</tr>
<tr>
<td>SEC$ADMIN</td>
<td>BOOLEAN</td>
<td>true - user has admin role in security database, false otherwise</td>
</tr>
<tr>
<td>SEC$DESCRIPTION</td>
<td>BLOB TEXT</td>
<td>Description (comment) on the user</td>
</tr>
<tr>
<td>SEC$PLUGIN</td>
<td>CHAR(63)</td>
<td>Authentication plugin name that manages this user</td>
</tr>
</tbody>
</table>

⚠️ Multiple users can exist with the same username, each managed by a different
SEC$USER_ATTRIBUTES

Additional attributes of users

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEC$USER_NAME</td>
<td>CHAR(63)</td>
<td>Username</td>
</tr>
<tr>
<td>SEC$KEY</td>
<td>VARCHAR(63)</td>
<td>Attribute name</td>
</tr>
<tr>
<td>SEC$VALUE</td>
<td>VARCHAR(255)</td>
<td>Attribute value</td>
</tr>
<tr>
<td>SEC$PLUGIN</td>
<td>CHAR(63)</td>
<td>Authentication plugin name that manages this user</td>
</tr>
</tbody>
</table>

Displaying a list of users and their attributes

```
SELECT 
  U.SEC$USER_NAME AS LOGIN,
  A.SEC$KEY AS TAG,
  A.SEC$VALUE AS "VALUE",
  U.SEC$PLUGIN AS "PLUGIN"
FROM SEC$USERS U
LEFT JOIN SEC$USER_ATTRIBUTES A
  ON U.SEC$USER_NAME = A.SEC$USER_NAME
  AND U.SEC$PLUGIN = A.SEC$PLUGIN;
```

<table>
<thead>
<tr>
<th>LOGIN</th>
<th>TAG</th>
<th>VALUE</th>
<th>PLUGIN</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSDBA</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>Srp</td>
</tr>
<tr>
<td>ALEX</td>
<td>B</td>
<td>x</td>
<td>Srp</td>
</tr>
<tr>
<td>ALEX</td>
<td>C</td>
<td>sample</td>
<td>Srp</td>
</tr>
<tr>
<td>SYSDBA</td>
<td>&lt;null&gt;</td>
<td>&lt;null&gt;</td>
<td>Legacy_UserManager</td>
</tr>
</tbody>
</table>

authentication plugin.
Appendix G: Plugin tables

Plugin tables are tables—or views—created for or by various plugins to the Firebird engine. The standard plugin tables have the prefix PLG$.

The plugin tables do not always exist. For example, some tables only exist in the security database, and other tables will only be created on first use of a plugin.

This appendix only documents plugin tables which are created by plugins included in a standard Firebird 5.0 deployment.

Plugin tables are not considered system tables.

Profiler table names are plugin-specific

The tables listed in this appendix for the profiler (starting with PLG$PROF_) are created by the Default_Profiler plugin. If a custom profiler plugin is created, it may use different table names.

List of plugin tables

**PLG$PROF_CURSORS**
Profiler information on cursors

**PLG$PROF_PSQL_STATS**
Profiler PSQL statistics

**PLG$PROF_PSQL_STATS_VIEW**
Profiler aggregated view for PSQL statistics

**PLG$PROF_RECORD_SOURCES**
Profiler information on record sources

**PLG$PROF_RECORD_SOURCE_STATS**
Profiler record source statistics

**PLG$PROF_RECORD_SOURCE_STATS_VIEW**
Profiler aggregated view for record source statistics

**PLG$PROF_REQUESTS**
Profiler information on requests

**PLG$PROF_SESSIONS**
Profiler sessions

**PLG$PROF_STATEMENTS**
Profiler information on statements
Appendix G: Plugin tables

**PLG$PROF_STATEMENT_STATS_VIEW**
Profiler aggregated view for statement statistics

**PLG$SRP**
Users and authentication information of the *Sr* user manager

**PLG$USERS**
User and authentication information of the *Legacy_UserManager* user manager

**PLG$PROF_CURSORS**
Profiler information on cursors.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement id</td>
</tr>
<tr>
<td>CURSOR_ID</td>
<td>INTEGER</td>
<td>Cursor id</td>
</tr>
<tr>
<td>NAME</td>
<td>CHAR(63)</td>
<td>Name of explicit cursor</td>
</tr>
<tr>
<td>LINE_NUM</td>
<td>INTEGER</td>
<td>PSQL line number of the cursor</td>
</tr>
<tr>
<td>COLUMN_NUM</td>
<td>INTEGER</td>
<td>PSQL column number of the cursor</td>
</tr>
</tbody>
</table>

**PLG$PROF_PSQL_STATS**
Profiler PSQL statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement id</td>
</tr>
<tr>
<td>REQUEST_ID</td>
<td>BIGINT</td>
<td>Request id</td>
</tr>
<tr>
<td>LINE_NUM</td>
<td>INTEGER</td>
<td>PSQL line number of the statement</td>
</tr>
<tr>
<td>COLUMN_NUM</td>
<td>INTEGER</td>
<td>PSQL column number of the statement</td>
</tr>
<tr>
<td>COUNTER</td>
<td>BIGINT</td>
<td>Number of executed times of the line/column</td>
</tr>
<tr>
<td>MIN_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Minimal elapsed time (in nanoseconds) of a line/column execution</td>
</tr>
<tr>
<td>MAX_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Maximum elapsed time (in nanoseconds) of a line/column execution</td>
</tr>
<tr>
<td>TOTAL_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Accumulated elapsed time (in nanoseconds) of the line/column executions</td>
</tr>
</tbody>
</table>
## PLG$PROF_PSQL_STATS_VIEW

Profiler aggregated view for PSQL statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement id</td>
</tr>
<tr>
<td>STATEMENT_TYPE</td>
<td>VARCHAR(20)</td>
<td>Statement type: BLOCK, FUNCTION, Procedure or TRIGGER</td>
</tr>
<tr>
<td>PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name</td>
</tr>
<tr>
<td>ROUTINE_NAME</td>
<td>CHAR(63)</td>
<td>Routine name</td>
</tr>
<tr>
<td>PARENT_STATEMENT_ID</td>
<td>BIGINT</td>
<td>Parent statement id</td>
</tr>
<tr>
<td>PARENT_STATEMENT_TYPE</td>
<td>VARCHAR(20)</td>
<td>Statement type: BLOCK, FUNCTION, Procedure or TRIGGER</td>
</tr>
<tr>
<td>PARENT_ROUTINE_NAME</td>
<td>CHAR(63)</td>
<td>Parent routine name</td>
</tr>
<tr>
<td>SQL_TEXT</td>
<td>BLOB TEXT</td>
<td>SQL text (if statement type is BLOCK)</td>
</tr>
<tr>
<td>LINE_NUM</td>
<td>INTEGER</td>
<td>PSQL line number of the statement</td>
</tr>
<tr>
<td>COLUMN_NUM</td>
<td>INTEGER</td>
<td>PSQL column number of the statement</td>
</tr>
<tr>
<td>COUNTER</td>
<td>BIGINT</td>
<td>Number of executed times of the line/column</td>
</tr>
<tr>
<td>MIN_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Minimal elapsed time (in nanoseconds) of a line/column execution</td>
</tr>
<tr>
<td>MAX_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Maximum elapsed time (in nanoseconds) of a line/column execution</td>
</tr>
<tr>
<td>TOTAL_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Accumulated elapsed time (in nanoseconds) of the line/column executions</td>
</tr>
<tr>
<td>AVG_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Average elapsed time (in nanoseconds) of the line/column executions</td>
</tr>
</tbody>
</table>

## PLG$PROF_RECORD_SOURCES

Profiler information on record sources.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement id</td>
</tr>
<tr>
<td>CURSOR_ID</td>
<td>INTEGER</td>
<td>Cursor id</td>
</tr>
<tr>
<td>RECORD_SOURCE_ID</td>
<td>INTEGER</td>
<td>Record source id</td>
</tr>
</tbody>
</table>
### PLG$PROF_RECORD_SOURCE_STATS

Profiler record sources statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
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<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement id</td>
</tr>
<tr>
<td>REQUEST_ID</td>
<td>BIGINT</td>
<td>Request id</td>
</tr>
<tr>
<td>CURSOR_ID</td>
<td>INTEGER</td>
<td>Cursor id</td>
</tr>
<tr>
<td>RECORD_SOURCE_ID</td>
<td>INTEGER</td>
<td>Record source id</td>
</tr>
<tr>
<td>OPEN_COUNTER</td>
<td>BIGINT</td>
<td>Number of times the record source was opened</td>
</tr>
<tr>
<td>OPEN_MIN_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Minimal elapsed time (in nanoseconds) of a record source open</td>
</tr>
<tr>
<td>OPEN_MAX_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Maximum elapsed time (in nanoseconds) of a record source open</td>
</tr>
<tr>
<td>OPEN_TOTAL_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Accumulated elapsed time (in nanoseconds) of record source opens</td>
</tr>
<tr>
<td>FETCH_COUNTER</td>
<td>BIGINT</td>
<td>Number of fetches from the record source</td>
</tr>
<tr>
<td>FETCH_MIN_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Minimal elapsed time (in nanoseconds) of a record source fetch</td>
</tr>
<tr>
<td>FETCH_MAX_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Maximum elapsed time (in nanoseconds) of a record source fetch</td>
</tr>
<tr>
<td>FETCH_TOTAL_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Accumulated elapsed time (in nanoseconds) of record source fetches</td>
</tr>
</tbody>
</table>

### PLG$PROF_RECORD_SOURCE_STATS_VIEW

Profiler aggregated view for record source statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement id</td>
</tr>
</tbody>
</table>
## Appendix G: Plugin tables

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATEMENT_TYPE</td>
<td>VARCHAR(20)</td>
<td>Statement type: BLOCK, FUNCTION, PROCEDURE or TRIGGER</td>
</tr>
<tr>
<td>PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name</td>
</tr>
<tr>
<td>ROUTINE_NAME</td>
<td>CHAR(63)</td>
<td>Routine name</td>
</tr>
<tr>
<td>PARENT_STATEMENT_ID</td>
<td>BIGINT</td>
<td>Parent statement id</td>
</tr>
<tr>
<td>PARENT_STATEMENT_TYPE</td>
<td>VARCHAR(20)</td>
<td>Statement type: BLOCK, FUNCTION, PROCEDURE or TRIGGER</td>
</tr>
<tr>
<td>PARENT_ROUTINE_NAME</td>
<td>CHAR(63)</td>
<td>Parent routine name</td>
</tr>
<tr>
<td>SQL_TEXT</td>
<td>BLOB TEXT</td>
<td>SQL text (if statement type is BLOCK)</td>
</tr>
<tr>
<td>CURSOR_ID</td>
<td>INTEGER</td>
<td>Cursor id</td>
</tr>
<tr>
<td>CURSOR_NAME</td>
<td>CHAR(63)</td>
<td>Name of explicit cursor</td>
</tr>
<tr>
<td>CURSOR_LINE_NUM</td>
<td>INTEGER</td>
<td>PSQL line number of the cursor</td>
</tr>
<tr>
<td>CURSOR_COLUMN_NUM</td>
<td>INTEGER</td>
<td>PSQL column number of the cursor</td>
</tr>
<tr>
<td>RECORD_SOURCE_ID</td>
<td>INTEGER</td>
<td>Record source id</td>
</tr>
<tr>
<td>PARENT_RECORD_SOURCE_ID</td>
<td>INTEGER</td>
<td>Parent record source id</td>
</tr>
<tr>
<td>LEVEL</td>
<td>INTEGER</td>
<td>Indentation level for the record source</td>
</tr>
<tr>
<td>ACCESS_PATH</td>
<td>VARCHAR(255)</td>
<td>Access path of the record source</td>
</tr>
<tr>
<td>OPEN_COUNTER</td>
<td>BIGINT</td>
<td>Number of times the record source was opened</td>
</tr>
<tr>
<td>OPEN_MIN_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Minimal elapsed time (in nanoseconds) of a record source open</td>
</tr>
<tr>
<td>OPEN_MAX_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Maximum elapsed time (in nanoseconds) of a record source open</td>
</tr>
<tr>
<td>OPEN_TOTAL_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Accumulated elapsed time (in nanoseconds) of record source opens</td>
</tr>
<tr>
<td>OPEN_AVG_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Average elapsed time (in nanoseconds) of record source opens</td>
</tr>
<tr>
<td>FETCH_COUNTER</td>
<td>BIGINT</td>
<td>Number of fetches from the record source</td>
</tr>
<tr>
<td>FETCH_MIN_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Minimal elapsed time (in nanoseconds) of a record source fetch</td>
</tr>
<tr>
<td>FETCH_MAX_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Maximum elapsed time (in nanoseconds) of a record source fetch</td>
</tr>
<tr>
<td>FETCH_TOTAL_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Accumulated elapsed time (in nanoseconds) of record source fetches</td>
</tr>
<tr>
<td>FETCH_AVG_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Average elapsed time (in nanoseconds) of record source fetches</td>
</tr>
</tbody>
</table>
### Column Name | Data Type | Description
--- | --- | ---
OPEN_FETCH_TOTAL_ELAPSED_TIME | BIGINT | Total elapsed time (in nanoseconds) or record source opens and fetches

**PLG$PROF_REQUESTS**

Profiler information on requests.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement id</td>
</tr>
<tr>
<td>REQUEST_ID</td>
<td>BIGINT</td>
<td>Request id</td>
</tr>
<tr>
<td>CALLER_STATEMENT_ID</td>
<td>BIGINT</td>
<td>Caller statement id</td>
</tr>
<tr>
<td>CALLER_REQUEST_ID</td>
<td>BIGINT</td>
<td>Caller request id</td>
</tr>
<tr>
<td>START_TIMESTAMP</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Instant when request started</td>
</tr>
<tr>
<td>FINISH_TIMESTAMP</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Instant when request finished</td>
</tr>
<tr>
<td>TOTAL_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Accumulated elapsed time (in nanoseconds) of the request</td>
</tr>
</tbody>
</table>

**PLG$PROF_SESSIONS**

Profiler sessions.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>ATTACHMENT_ID</td>
<td>BIGINT</td>
<td>Attachment id</td>
</tr>
<tr>
<td>USER_NAME</td>
<td>CHAR(63)</td>
<td>User which started the profile session</td>
</tr>
<tr>
<td>DESCRIPTION</td>
<td>VARCHAR(255)</td>
<td>Description of the profile session (parameter of RDB$PROFILER.START_SESSION)</td>
</tr>
<tr>
<td>START_TIMESTAMP</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Instant when session started</td>
</tr>
<tr>
<td>FINISH_TIMESTAMP</td>
<td>TIMESTAMP WITH TIME ZONE</td>
<td>Instant when session finished</td>
</tr>
</tbody>
</table>

**PLG$PROF_STATEMENTS**

Profiler information on statements.
### PLG$PROF_STATEMENT_STATS_VIEW
Profiler aggregated view for statement statistics.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PROFILE_ID</td>
<td>BIGINT</td>
<td>Profile session id</td>
</tr>
<tr>
<td>STATEMENT_ID</td>
<td>BIGINT</td>
<td>Statement id</td>
</tr>
<tr>
<td>STATEMENT_TYPE</td>
<td>VARCHAR(20)</td>
<td>Statement type: BLOCK, FUNCTION, PROCEDURE or TRIGGER</td>
</tr>
<tr>
<td>PACKAGE_NAME</td>
<td>CHAR(63)</td>
<td>Package name</td>
</tr>
<tr>
<td>ROUTINE_NAME</td>
<td>CHAR(63)</td>
<td>Routine name</td>
</tr>
<tr>
<td>SQL_TEXT</td>
<td>BLOB TEXT</td>
<td>SQL text (if statement type is BLOCK)</td>
</tr>
<tr>
<td>COUNTER</td>
<td>BIGINT</td>
<td>Number of executed times of the line/column</td>
</tr>
<tr>
<td>MIN_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Minimal elapsed time (in nanoseconds) of a statement execution</td>
</tr>
<tr>
<td>MAX_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Maximum elapsed time (in nanoseconds) of a statement execution</td>
</tr>
<tr>
<td>TOTAL_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Accumulated elapsed time (in nanoseconds) of statement executions</td>
</tr>
<tr>
<td>AVG_ELAPSED_TIME</td>
<td>BIGINT</td>
<td>Average elapsed time (in nanoseconds) of statement executions</td>
</tr>
</tbody>
</table>
**PLG$SRP**

User and authentication information of the *Sr* user manager, used for authentication by the *Sr* family of authentication plugins.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLG$USER_NAME</td>
<td>VARCHAR(63)</td>
<td>Username</td>
</tr>
<tr>
<td>PLG$VERIFIER</td>
<td>VARBINARY(128)</td>
<td>SRP verifier[^1]</td>
</tr>
<tr>
<td>PLG$SALT</td>
<td>VARBINARY(32)</td>
<td>User-specific salt</td>
</tr>
<tr>
<td>PLG$COMMENT</td>
<td>BLOB TEXT</td>
<td>Comment text</td>
</tr>
<tr>
<td>PLG$FIRST</td>
<td>VARCHAR(32)</td>
<td>Firstname</td>
</tr>
<tr>
<td>PLG$MIDDLE</td>
<td>VARCHAR(32)</td>
<td>Middle name</td>
</tr>
<tr>
<td>PLG$LAST</td>
<td>VARCHAR(32)</td>
<td>Lastname</td>
</tr>
<tr>
<td>PLG$ATTRIBUTES</td>
<td>BLOB TEXT</td>
<td>User attributes (a.k.a. tags)</td>
</tr>
<tr>
<td>PLG$ACTIVE</td>
<td>BOOLEAN</td>
<td>Active or inactive user</td>
</tr>
</tbody>
</table>

[^1] See [http://srp.stanford.edu/design.html](http://srp.stanford.edu/design.html) for details

**PLG$USERS**

User and authentication information of the *Legacy_UserManager* user manager, used for authentication by the *Legacy_Auth* authentication plugins.

<table>
<thead>
<tr>
<th>Column Name</th>
<th>Data Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLG$USER_NAME</td>
<td>VARCHAR(63)</td>
<td>Username</td>
</tr>
<tr>
<td>PLG$GROUP_NAME</td>
<td>VARCHAR(63)</td>
<td>Group name</td>
</tr>
<tr>
<td>PLG$UID</td>
<td>INTEGER</td>
<td>User id</td>
</tr>
<tr>
<td>PLG$GID</td>
<td>INTEGER</td>
<td>Group id</td>
</tr>
<tr>
<td>PLG$PASSWD</td>
<td>VARBINARY(64)</td>
<td>Password hash</td>
</tr>
<tr>
<td>PLG$COMMENT</td>
<td>BLOB TEXT</td>
<td>Comment text</td>
</tr>
<tr>
<td>PLG$FIRST_NAME</td>
<td>VARCHAR(32)</td>
<td>Firstname</td>
</tr>
<tr>
<td>PLG$MIDDLE_NAME</td>
<td>VARCHAR(32)</td>
<td>Middle name</td>
</tr>
<tr>
<td>PLG$LAST_NAME</td>
<td>VARCHAR(32)</td>
<td>Lastname</td>
</tr>
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</table>
# Appendix H: Character Sets and Collations

Table 275. Character Sets and Collations

<table>
<thead>
<tr>
<th>Character Set</th>
<th>ID</th>
<th>Bytes per Char</th>
<th>Collation</th>
<th>Language</th>
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<tbody>
<tr>
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<td>2</td>
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<td>ASCII</td>
<td>English</td>
</tr>
<tr>
<td>BIG_5</td>
<td>56</td>
<td>2</td>
<td>BIG_5</td>
<td>Chinese, Vietnamese, Korean</td>
</tr>
<tr>
<td>CP943C</td>
<td>68</td>
<td>2</td>
<td>CP943C</td>
<td>Japanese</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CP943C_UNICODE</td>
<td>Japanese</td>
</tr>
<tr>
<td>CYRL</td>
<td>50</td>
<td>1</td>
<td>CYRL</td>
<td>Russian</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_RUS</td>
<td>Russian dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PDOX_CYRL</td>
<td>Russian Paradox</td>
</tr>
<tr>
<td>DOS437</td>
<td>10</td>
<td>1</td>
<td>DOS437</td>
<td>U.S. English</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_DEU437</td>
<td>German dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_ESP437</td>
<td>Spanish dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_FIN437</td>
<td>Finnish dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_FRA437</td>
<td>French dBase</td>
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<td></td>
<td>DB_ITA437</td>
<td>Italian dBase</td>
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<td>DB_NLD437</td>
<td>Dutch dBase</td>
</tr>
<tr>
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<td></td>
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<td>DB_SVE437</td>
<td>Swedish dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_UK437</td>
<td>English (Great Britain) dBase</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_US437</td>
<td>U.S. English dBase</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>PDOX_ASCII</td>
<td>Code page Paradox-ASCII</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>PDOX_INTL</td>
<td>International English Paradox</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>PDOX_SWEDFIN</td>
<td>Swedish / Finnish Paradox</td>
</tr>
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<td>DOS737</td>
<td>Greek</td>
</tr>
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<td>DOS775</td>
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<td>Baltic</td>
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<td>DOS850</td>
<td>Latin I (no Euro symbol)</td>
</tr>
<tr>
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<td>DB_DEU850</td>
<td>German</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>DB_ESP850</td>
<td>Spanish</td>
</tr>
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<td></td>
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<td>DB_FRA850</td>
<td>French</td>
</tr>
<tr>
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<td>DB_FRC850</td>
<td>French-Canada</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_ITA850</td>
<td>Italian</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>DB_NLD850</td>
<td>Dutch</td>
</tr>
</tbody>
</table>
### Appendix H: Character Sets and Collations

<table>
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## Appendix H: Character Sets and Collations

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## Appendix H: Character Sets and Collations

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The Original Documentation is titled Firebird 5.0 Language Reference. This Documentation was derived from Firebird 4.0 Language Reference.

The Initial Writers of the Original Documentation are: Paul Vinkenoog, Dmitry Yemanov, Thomas Woinke and Mark Rotteveel. Writers of text originally in Russian are Denis Simonov, Dmitry Filippov, Alexander Karpeykin, Alexey Kovyazin and Dmitry Kuzmenko.

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Contributor(s): Mark Rotteveel.

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# Appendix J: Document History

The exact file history is recorded in our git repository; see [https://github.com/FirebirdSQL/firebird-documentation](https://github.com/FirebirdSQL/firebird-documentation)

## Revision History

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<td>• Changed note regarding SKIP LOCKED to (once again) match release notes</td>
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<td>• Added columns RDB$CONDITION_BLR and RDB$CONDITION_SOURCE to RDB$INDICES (#198)</td>
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<td>• Misc. copy editing of BLR column descriptions for consistent language</td>
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<td>• Removed ALTER PACKAGE BODY documentation, as this feature doesn’t exist (#200)</td>
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<td>15 Dec 2023</td>
<td>M</td>
<td>• Fixed incorrect syntax documentation of forward declaration of subroutines (#188)</td>
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<td>R</td>
<td>• Wrong link from ALTER TRIGGER to CREATE TRIGGER (#189)</td>
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<td>• Fixed description of RDB$INDICES.RDB$FOREIGN_KEY (#191)</td>
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<td>• Updated keywords with state as of snapshot 5.0.0.1271</td>
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<td>• Added types 4 and 5 to RDB$FUNCTION_ARGUMENTS.RDB$MECHANISM (#192)</td>
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<td></td>
<td>• Fixed formatting of RDB$FUNCTION_ARGUMENTS.RDB$FIELD_TYPE</td>
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<td></td>
<td>(<a href="https://github.com/FirebirdSQL/firebird-documentation/issues/194">https://github.com/FirebirdSQL/firebird-documentation/issues/194</a>)</td>
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<tr>
<td>Revision History</td>
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<tr>
<td>0.5 29 Sep 2023</td>
<td>M R</td>
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<tr>
<td>• Removed unnecessary references to older Firebird versions</td>
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<tr>
<td>• Misc. copy-editing</td>
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<tr>
<td>• CHAR_LENGTH, OCTET_LENGTH and BIT_LENGTH use BIGINT for BLOB</td>
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<td>• Fixed incorrect &quot;equivalent&quot; for REGR_COUNT</td>
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<td>• Fixed incorrect references to idle timeout in SET STATEMENT TIMEOUT</td>
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<tr>
<td>• Documented that OVERRIDING USER VALUE also works for GENERATED ALWAYS identity columns</td>
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<td>• Document QUARTER for EXTRACT, FIRST_DAY, and LAST_DAY</td>
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<tr>
<td>• Document DECFLOAT_ROUND and DECFLOAT_TRAPS for RDB$GET_CONTEXT</td>
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<td>• Document LEVEL in PLG$PROF_RECORD_SOURCES and PLG$PROF_RECORD_SOURCE_STATS_VIEW, order of columns for profiler tables</td>
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<td>• Document new limit for IN-list</td>
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<td>• Document OPTIMIZE FOR {FIRST</td>
<td>ALL} ROWS on SELECT and SET OPTIMIZE</td>
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<tr>
<td>• Added negative subtype to RDB$FIELDS.RDB$FIELD_SUB_TYPE, and fixed formatting</td>
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<tr>
<td>0.4 20 Jun 2023</td>
<td>M R</td>
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<tr>
<td>• Computed columns can be indexed with expression indexes</td>
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<tr>
<td>• Fixed wrong section levels for subsections of SET DECFLOAT</td>
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<tr>
<td>• Replaced firebird-docs references with firebird-devel</td>
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<tr>
<td>• Updated SQLCODE and GDSCODE Error Codes and Message Texts with error information from 5.0.0.1068</td>
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<tr>
<td>• Add caution about relying on ordered derived tables for LIST()</td>
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</tbody>
</table>
Revision History

0.3 26 May 2023  M R

- Added missing context variable names for RDB$GET_CONTEXT()
- Documented hex-literal support for INT128
- CURRENT_CONNECTION returns BIGINT
- PLG$PROF_RECORD_SOURCES.ACCESS_PATH changed to VARCHAR(255)
- Example for RDB$ROLE_IN_USE() should use RDB$ROLES (#184)
- Changed explanation of maximum blob size (#160)
- Notes on RETURNING and updatable views (#95)
- Replaced occurrence of “collation sequence” with “collation”
- Removed section Joins with stored procedures as it no longer applies
- Replaced mention that implicit join is deprecated and might get removed; its use is merely discouraged.
- Removed “Available in” sections if they listed both DSQL and PSQL
- Replaced “Used for” paragraphs with a plain paragraph (so, without explicit “Used for” title)
- Rewrote function descriptions to include a short description at the top of each function section
- Added note in Encryption Algorithm Requirements about AES variants
- Replaced incorrect ROLE keyword with DEFAULT in example in Granting the RDB$ADMIN Role in a Regular Database
- Miscellaneous copy-editing
<table>
<thead>
<tr>
<th>Revision History</th>
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<tbody>
<tr>
<td><strong>0.2</strong></td>
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<tr>
<td>• Documented “standard” plugin tables in new appendix <strong>Plugin tables</strong></td>
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<tr>
<td>• Removed <em>Upgraders: PLEASE READ!</em> sidebar from <strong>Built-in Scalar Functions</strong>, the <em>Possible name conflict</em> sections from function descriptions and the <em>Name Clash</em> note on LOWER()</td>
</tr>
<tr>
<td>• Integrated (most) changes from the Firebird 5.0 beta 1 release notes</td>
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<tr>
<td>• Added new chapter <strong>System Packages</strong>, and moved <strong>RDB$TIME_ZONE_UTIL</strong> documentation to it, and added <strong>RDB$BLOB_UTIL</strong> and <strong>RDB$PROFILER</strong> documentation</td>
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<tr>
<td>• Documented that subroutines can access variables of their parent</td>
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<tr>
<td>• Simplified <strong>CONTINUE</strong> and <strong>LEAVE</strong> examples, by removing unnecessary <strong>ELSE</strong></td>
</tr>
<tr>
<td>• Documented <strong>PLAN</strong>, <strong>ORDER BY</strong> and <strong>ROWS</strong> for <strong>UPDATE OR INSERT</strong> and <strong>PLAN</strong> and <strong>ORDER BY</strong> for <strong>MERGE</strong></td>
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<tr>
<td>• Added <strong>Full SELECT Syntax</strong> as a first step to address current incomplete/simplified syntax used in <strong>SELECT</strong></td>
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<tr>
<td>• Removed incorrect <code>&lt;common-table-expression&gt;</code> production in <strong>SELECT</strong> syntax</td>
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<tr>
<td>• Revised syntax used in <strong>SELECT</strong> and <strong>Window (Analytical) Functions</strong> for completeness and correctness</td>
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<tr>
<td>• Documented <code>&lt;parenthesized-joined-table&gt;</code> in <strong>SELECT</strong></td>
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<td><strong>0.1</strong></td>
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<tr>
<td>Copied the <strong>Firebird 4.0 Language Reference</strong> as a starting point:</td>
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<tr>
<td>• renamed files and reference using <em>fblangref40</em> to <em>fblangref50</em></td>
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<tr>
<td>• where applicable, replaced reference to Firebird 4.0 with Firebird 5.0, or rephrased sentences referencing Firebird 4.0</td>
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