



Firebird Null Guide

NULL behaviour and pitfalls in Firebird SQL

Paul Vinkenoog

Version 1.2, 30 June 2020

Table of Contents

1. What is NULL?	4
1.1. NULL as a default state	4
2. NULL support in Firebird SQL	6
2.1. Disallowing NULL	6
2.2. Testing for NULL	6
2.3. Assigning NULL	7
2.4. Testing DISTINCTness (Firebird 2+)	7
2.5. The NULL literal	8
2.5.1. Firebird 1.5 and below	8
2.5.2. Firebird 2.0 and up	8
3. NULL in operations	9
3.1. Mathematical and string operations	9
3.2. Boolean operations	10
3.3. More logic (or not)	11
4. Internal functions and directives	13
4.1. Internal functions	13
4.2. FIRST, SKIP and ROWS	13
5. Predicates	14
5.1. The IN predicate	14
5.1.1. With an empty list	14
5.1.2. With a NULL test expression	15
5.1.3. With NULLs in the list	15
5.1.4. IN() results	16
5.1.5. IN() in CHECK constraints	17
5.2. The ANY, SOME and ALL quantifiers	17
5.2.1. Result values	18
5.3. EXISTS and SINGULAR	20
5.3.1. EXISTS	20
5.3.2. SINGULAR	20
6. Searches	22
7. Sorts	24
8. Aggregate functions	25
8.1. The GROUP BY clause	26
8.1.1. Counting frequencies	27
8.2. The HAVING clause	27
9. Conditional statements and loops	29
9.1. IF statements	29
9.2. CASE expression	30

9.3. WHILE loops	31
9.4. FOR loops	31
10. Keys and unique indices	33
10.1. Primary keys	33
10.2. Unique keys and indices	33
10.2.1. Firebird 1.0	33
10.2.2. Firebird 1.5 and higher	33
10.3. Foreign keys	33
11. CHECK constraints	35
12. SELECT DISTINCT	37
13. User-Defined Functions (UDFs)	38
13.1. NULL <=> non-NULL conversions you didn't ask for	38
13.2. Descriptors	38
13.3. Improvements in Firebird 2	39
13.3.1. "Upgrading" ib_udf functions in an existing database	39
13.4. Being prepared for undesired conversions	40
13.5. More on UDFs	40
14. Converting to and from NULL	41
14.1. Substituting NULL with a value	41
14.1.1. The COALESCE function	41
14.1.2. Firebird 1.0: the *NVL functions	41
14.2. Converting values to NULL	42
14.2.1. Firebird 1.5 and up: the NULLIF function	42
14.2.2. Firebird 1.0: the *nullif UDFs	43
15. Altering populated tables	44
15.1. Adding a non-nullable field to a populated table	44
15.1.1. Adding a NOT NULL field	44
15.1.2. Adding a CHECKed column	46
15.1.3. Using domains to add a non-nullable field	47
15.2. Making existing columns non-nullable	47
15.2.1. Making an existing column NOT NULL	48
15.2.2. Adding a CHECK constraint to an existing column	48
15.3. Making non-nullable columns nullable again	48
15.3.1. Removing a NOT NULL constraint	49
15.3.2. Removing a CHECK constraint	50
16. Changing the nullability of a domain	52
16.1. Adding and removing domain-level CHECK constraints	52
16.2. Altering a domain's NOT NULL setting	52
17. Testing for NULL and equality in practice	54
17.1. Testing for NULL — if it matters	54
17.2. Equality tests	55

17.2.1. Firebird 2.0 and up	55
17.2.2. Earlier Firebird versions	55
17.2.3. Summary of (in)equality tests	56
17.3. Finding out if a field has changed	57
18. Summary	58
Appendix A: NULL-related bugs in Firebird	60
Bugs that crash the server	60
EXECUTE STATEMENT with NULL argument	60
EXTRACT from NULL date	60
FIRST and SKIP with NULL argument	60
LIKE with NULL escape	60
Other bugs	60
NULLs in NOT NULL columns	60
Illegal NULLs returned as 0, '', etc.	60
Primary key with NULL entries	61
SUBSTRING results described as non-nullable	61
Gbak -n restoring NOT NULL	61
IN, = ANY and = SOME with indexed subselect	61
ALL with indexed subselect	61
SELECT DISTINCT with wrong NULLS FIRST LAST ordering	62
UDFs returning values when they should return NULL	62
UDFs returning NULL when they should return a value	62
SINGULAR inconsistent with NULL results	62
Appendix B: Document history	63
Appendix C: License notice	65
Alphabetical index	66

Chapter 1. What is NULL?

Time and again, support questions pop up on the Firebird mailing lists about “strange things” happening with NULLs. The concept seems difficult to grasp — perhaps partly because of the name, which suggests a kind of “nothing” that won’t do any harm if you add it to a number or stick it to the back of a string. In reality, performing such operations will render the entire expression NULL.

This guide explores the behaviour of NULL in Firebird SQL, points out common pitfalls and shows you how to deal safely with expressions that contain NULL or may resolve to NULL.

If you only need a quick reference to refresh your memory, go to the [summary](#) at the end of the guide.

So — what is it?

In SQL, NULL is not a value. It is a *state* indicating that an item’s value is unknown or nonexistent. It is not zero or blank or an “empty string” and it does not behave like any of these values. Few things in SQL lead to more confusion than NULL, and yet its workings shouldn’t be hard to understand as long as you stick to the following simple definition: NULL means *unknown*.

Let me repeat that:

NULL means UNKNOWN

Keep this line in mind as you read through the rest of the guide, and most of the seemingly illogical results you can get with NULL will practically explain themselves.



A few sentences and examples in this guide were taken from the *Firebird Quick Start Guide*, first published by IBPhoenix, now part of the Firebird Project.

1.1. NULL as a default state

Because NULL means “value unknown”, it is the logical default state for any field or variable that has been created but not provided with a value:

- If you declare a variable in a stored procedure or trigger, its value is undefined and its state is NULL from the moment of creation until some value is assigned to it. The same is true for output parameters in stored procedures.
- If you insert a record into a table and you only provide values for part of the fields, the remaining fields will be initialised to NULL except where a default value is in effect or a value is assigned by a “before insert” trigger.
- If you add a column to a table that already has records, the fields added to the existing records will be NULL, except if you declare the column as NOT NULL and specify a default value for it. Note

that *both* conditions must be satisfied for the fields to become anything other than NULL.

Chapter 2. NULL support in Firebird SQL

Only a few language elements are purposely designed to give an unambiguous result with NULL (unambiguous in the sense that some specific action is taken and/or a non-NULL result is returned). They are discussed in the following paragraphs.

2.1. Disallowing NULL

In a column or domain definition, you can specify that only non-NULL values may be entered by adding NOT NULL to the definition:

```
create table MyTable ( i int not null )
```

```
create domain DTown as varchar( 32 ) not null
```

```
alter table Sales add TransTime timestamp not null
```

Adding a NOT NULL column to an existing table that already contains records requires special care. This operation will be discussed in detail in the section [Altering populated tables](#).

2.2. Testing for NULL

If you want to know whether a variable, field or other expression is NULL, use the following syntax:

```
<expression> IS [NOT] NULL
```

Examples:

```
if ( MyField is null ) then YourString = 'Dunno'
```

```
select * from Pupils where PhoneNumber is not null
```

```
select * from Pupils where not ( PhoneNumber is null )  
/* does the same as the previous example */
```

```
update Numbers set Total = A + B + C where A + B + C is not null
```

```
delete from Phonebook where PhoneNum is null
```

Do **not** use “... = NULL” to test for nullness. This syntax is illegal in Firebird versions up to 1.5.n, and gives the wrong result in Firebird 2 and up: it returns NULL no matter what you compare. This is by design, incidentally, and in that sense it’s not *really* wrong — it just doesn’t give you what you want. The same goes for “... <> NULL”, so don’t use that either; use IS NOT NULL instead.

IS NULL and IS NOT NULL always return true or false; they never return NULL.

2.3. Assigning NULL

Setting a field or variable to NULL is done with the ‘=’ operator, just like assigning values. You can also include NULL in an insert list or use it as input parameter to a stored procedure (both are special types of assignments).

```
if ( YourString = 'Dunno' ) then MyField = null
```

```
update Potatoes set Amount = null where Amount < 0
```

```
insert into MyTable values ( 3, '8-May-2004', NULL, 'What?' )
```

```
select * from ProcessThis(88, 'Apes', Null)
```

Remember:

- You cannot — and should not — use the *comparison operator* ‘=’ to *test* if something is NULL...
- ...but you can — and often must — use the *assignment operator* ‘=’ to *set* something to NULL.

2.4. Testing DISTINCTness (Firebird 2+)

In Firebird 2 and higher only, you can test for the null-encompassing equality of two expressions with “IS [NOT] DISTINCT FROM”:

```
if ( A is distinct from B ) then...
```



```
if ( Buyer1 is not distinct from Buyer2 ) then...
```

Fields, variables and other expressions are considered:

- DISTINCT if they have different values or if one of them is NULL and the other isn't;
- NOT DISTINCT if they have the same value or if both of them are NULL.

[NOT] DISTINCT always returns true or false, never NULL or something else.

With earlier Firebird versions, you have to write special code to obtain the same information. This will be discussed later.

2.5. The NULL literal

The ability to use NULL literals depends on your Firebird version.

2.5.1. Firebird 1.5 and below

In Firebird 1.5 and below you can only use the literal word “NULL” in a few situations, namely the ones described in the previous paragraphs plus a few others such as “cast(NULL as <datatype>)” and “select NULL from MyTable”.

In all other circumstances, Firebird will complain that NULL is an unknown token. If you really *must* use NULL in such a context, you have to resort to tricks like “cast(NULL as int)”, or using a field or variable that you know is NULL, etc.

2.5.2. Firebird 2.0 and up

Firebird 2 allows the use of NULL literals in every context where a normal value can also be entered. You can e.g. include NULL in an IN() list, write expressions like “if (MyField = NULL) then...”, and so on. However, as a general rule you should **not** make use of these new possibilities! In almost every thinkable situation, such use of NULL literals is a sign of poor SQL design and will lead to NULL results where you meant to get true or false. In that sense the earlier, more restrictive policy was safer, although you could always bypass it with casts etc. — but at least you had to take deliberate steps to bypass it.

Chapter 3. NULL in operations

As many of us have found out to our chagrin, NULL is contagious: use it in a numerical, string or date/time operation, and the result will invariably be NULL. With boolean operators, the outcome depends on the type of operation and the value of the other operand.

Please remember that in Firebird versions prior to 2.0 it is mostly illegal to use the constant NULL directly in operations or comparisons. Wherever you see NULL in the expressions below, read it as “a field, variable or other expression that resolves to NULL”. In Firebird 2 and above this expression may also be a NULL literal.

3.1. Mathematical and string operations

The operations in this list *always* return NULL:

- $1 + 2 + 3 + \text{NULL}$
- $5 * \text{NULL} - 7$
- `'Home ' || 'sweet ' || NULL`
- `MyField = NULL`
- `MyField <> NULL`
- `NULL = NULL`

If you have difficulty understanding why, remember that NULL means “unknown”. You can also look at the following table where per-case explanations are provided. In the table we don’t write NULL in the expressions (as said, this is often illegal); instead, we use two entities A and B that are both NULL. A and B may be fields, variables, or even composite subexpressions — as long as they’re NULL, they’ll all behave the same in the enclosing expressions.

Table 1. Operations on null entities A and B

If A and B are NULL, then:	Is:	Because:
$1 + 2 + 3 + A$	NULL	If A is unknown, then $6 + A$ is also unknown.
$5 * A - 7$	NULL	If A is unknown, then $5 * A$ is also unknown. Subtract 7 and you end up with another unknown.
<code>'Home ' 'sweet ' A</code>	NULL	If A is unknown, <code>'Home sweet ' A</code> is unknown.
<code>MyField = A</code>	NULL	If A is unknown, you can’t tell if MyField has the same value...
<code>MyField <> A</code>	NULL	...but you also can’t tell if MyField has a <i>different</i> value!
<code>A = B</code>	NULL	With A and B unknown, it’s impossible to know if they are equal.

Here is the complete list of math and string operators that return NULL if at least one operand is NULL:

- +, -, *, and /
- !=, ~=, and ^= (synonyms of <>)
- <, <=, >, and >=
- !<, ~<, and ^< (low-precedence synonyms of >=)
- !>, ~>, and ^> (low-precedence synonyms of <=)
- ||
- [NOT] BETWEEN
- [NOT] STARTING WITH
- [NOT] LIKE
- [NOT] CONTAINING

The explanations all follow the same pattern: if A is unknown, you can't tell if it's greater than B; if string S1 is unknown, you can't tell if it contains S2; etcetera.

Using LIKE with a NULL escape character would crash the server in Firebird versions up to and including 1.5. This bug was fixed in v.1.5.1. From that version onward, such a statement will yield an empty result set.

3.2. Boolean operations

All the operators examined so far return NULL if any operand is NULL. With boolean operators, things are a bit more complex:

- not NULL = NULL
- NULL or false = NULL
- NULL or true = true
- NULL or NULL = NULL
- NULL and false = false
- NULL and true = NULL
- NULL and NULL = NULL

In version 2.5 and earlier, Firebird SQL doesn't have a boolean data type; nor are true and false existing constants. In the leftmost column of the explanatory table below, "true" and "false" represent expressions (fields, variables, composites...) that evaluate to true/false.

Table 2. Boolean operations on null entity A

If A is NULL, then:	Is:	Because:
not A	NULL	If A is unknown, its inverse is also unknown.
A or false	NULL	“A or false” always has the same value as A — which is unknown.
A or true	true	“A or true” is always true — A's value doesn't matter.
A or A	NULL	“A or A” always equals A — which is NULL.
A and false	false	“A and false” is always false — A's value doesn't matter.
A and true	NULL	“A and true” always has the same value as A — which is unknown.
A and A	NULL	“A and A” always equals A — which is NULL.

All these results are in accordance with boolean logic. The fact that you don't need to know *X*'s value to compute “*X* or true” and “*X* and false” is also the basis of a feature found in various programming languages: short-circuit boolean evaluation.

The above results can be generalised as follows for expressions with one type of binary boolean operator (and | or) and any number of operands:

Disjunctions (“A or B or C or D or …”)

1. If at least one operand is true, the result is true.
2. Else, if at least one operand is NULL, the result is NULL.
3. Else (i.e. if all operands are false) the result is false.

Conjunctions (“A and B and C and D and …”)

1. If at least one operand is false, the result is false.
2. Else, if at least one operand is NULL, the result is NULL.
3. Else (i.e. if all operands are true) the result is true.

Or, shorter:

- TRUE beats NULL in a disjunction (OR-operation);
- FALSE beats NULL in a conjunction (AND-operation);
- In all other cases, NULL wins.

If you have trouble remembering which constant rules which operation, look at the second letter: tRue prevails with oR — fAlse with And.

3.3. More logic (or not)

The short-circuit results obtained above may lead you to the following ideas:

- 0 times x equals 0 for every x. Hence, even if x's value is unknown, $0 * x$ is 0. (Note: this only holds if x's datatype only contains numbers, not NaN or infinities.)
- The empty string is ordered lexicographically before every other string. Therefore, $S >= ''$ is true whatever the value of S.
- Every value equals itself, whether it's unknown or not. So, although $A = B$ justifiably returns NULL if A and B are different NULL entities, $A = A$ should always return true, even if A is NULL. The same goes for $A \leq A$ and $A >= A$.

By analogous logic, $A <> A$ should always be false, as well as $A < A$ and $A > A$.

- Every string *contains* itself, *starts with* itself and is *like* itself. So, "S CONTAINING S", "S STARTING WITH S" and "S LIKE S" should always return true.

How is this reflected in Firebird SQL? Well, I'm sorry I have to inform you that despite this compelling logic—and the analogy with the boolean results discussed above—the following expressions all resolve to NULL:

- $0 * \text{NULL}$
- $\text{NULL} >= ''$ and $'' \leq \text{NULL}$
- $A = A$, $A \leq A$ and $A >= A$
- $A <> A$, $A < A$ and $A > A$
- S CONTAINING S, S STARTING WITH S and S LIKE S

So much for consistency.

Chapter 4. Internal functions and directives

4.1. Internal functions

The following built-in functions return NULL if at least one argument is NULL:

- CAST()
- EXTRACT()
- GEN_ID()
- SUBSTRING()
- UPPER()
- LOWER()
- BIT_LENGTH()
- CHAR[ACTER]_LENGTH()
- OCTET_LENGTH()
- TRIM()

Notes



- In 1.0.0, EXTRACT from a NULL date would crash the server. Fixed in 1.0.2.
- If the first argument to GEN_ID is a valid generator name and the second argument is NULL, the named generator keeps its current value.
- In versions up to and including 2.0, SUBSTRING results are sometimes returned as “false emptystrings”. These strings are in fact NULL, but are described by the server as non-nullable. Therefore, most clients show them as empty strings. See the [bugs list](#) for a detailed description.

4.2. FIRST, SKIP and ROWS

The following two directives **crash** a Firebird 1.5.n or lower server if given a NULL argument. In Firebird 2, they treat NULL as the value 0:

- FIRST
- SKIP

This new Firebird 2 directive returns an empty set if any argument is NULL:

- ROWS

In new code, use ROWS, not FIRST and SKIP.

Chapter 5. Predicates

Predicates are statements about objects that return a boolean result: true, false or unknown (= NULL). In computer code you typically find predicates in places where a yes/no type of decision has to be taken. For Firebird SQL, that means in WHERE, HAVING, CHECK, CASE WHEN, IF and WHILE clauses.

Comparisons such as “ $x > y$ ” also return boolean results, but they are generally not called predicates, although this is mainly a matter of form. An expression like `Greater(x, y)` that does exactly the same would immediately qualify as a predicate. (Mathematicians like predicates to have a *name* — such as “Greater” or just plain “G” — and a pair of *parentheses* to hold the arguments.)

Firebird supports the following SQL predicates: IN, ANY, SOME, ALL, EXISTS and SINGULAR.



It is also perfectly defensible to call “IS [NOT] NULL” and “IS [NOT] DISTINCT FROM” predicates, despite the absence of parentheses. But, predicates or not, they have already been introduced and won’t be discussed in this section.

5.1. The IN predicate

The IN predicate compares the expression on its left-hand side to a number of expressions passed in the argument list and returns true if a match is found. NOT IN always returns the opposite of IN. Some examples of its use are:

```
select RoomNo, Floor from Classrooms where Floor in (3, 4, 5)
```

```
delete from Customers where upper(Name) in ('UNKNOWN', 'NN', '')
```

```
if ( A not in (MyVar, MyVar + 1, YourVar, HisVar) ) then ...
```

The list can also be generated by a one-column subquery:

```
select ID, Name, Class from Students
  where ID in (select distinct LentTo from LibraryBooks)
```

5.1.1. With an empty list

If the list is empty (this is only possible with a subquery), IN always returns false and NOT IN always returns true, even if the test expression is NULL. This makes sense: even if a value is unknown, it is certain not to occur in an empty list.

5.1.2. With a NULL test expression

If the list is not empty and the test expression — called “A” in the examples below — is NULL, the following predicates will always return NULL, regardless of the expressions in the list:

- A IN (Expr1, Expr2, ..., ExprN)
- A NOT IN (Expr1, Expr2, ..., ExprN)

The first result can be understood by writing out the entire expression as a disjunction (OR-chain) of equality tests:

```
A=Expr1 or A=Expr2 or ... or A=ExprN
```

which, if A is NULL, boils down to

```
NULL or NULL or ... or NULL
```

which is NULL.

The nullness of the second predicate follows from the fact that “not (NULL)” equals NULL.

5.1.3. With NULLs in the list

If A has a proper value, but the list contains one or more NULL expressions, things become a little more complicated:

- If at least one of the expressions in the list has the same value as A:
 - “A IN(Expr1, Expr2, ..., ExprN)” returns true
 - “A NOT IN(Expr1, Expr2, ..., ExprN)” returns false

This is due to the fact that “true or NULL” returns true (see above). Or, more general: a disjunction where at least one of the elements is true, returns true even if some other elements are NULL. (Any falses, if present, are not in the way. In a disjunction, true rules.)

- If none of the expressions in the list have the same value as A:
 - “A IN(Expr1, Expr2, ..., ExprN)” returns NULL
 - “A NOT IN(Expr1, Expr2, ..., ExprN)” returns NULL

This is because “false or NULL” returns NULL. In generalised form: a disjunction that has only false and NULL elements, returns NULL.

Needless to say, if neither A nor any list expression is NULL, the result is always as expected and can only be true or false.

5.1.4. IN() results

The table below shows all the possible results for IN and NOT IN. To use it properly, start with the first question in the left column. If the answer is No, move on to the next line. As soon as an answer is Yes, read the results from the second and third columns and you're done.

Table 3. Results for “A [NOT] IN (<list>)”

Conditions	Results	
	IN()	NOT IN()
Is the list empty?	false	true
Else, is A NULL?	NULL	NULL
Else, is at least one list element equal to A?	true	false
Else, is at least one list element NULL?	NULL	NULL
Else (i.e. all list elements are non-NULL and unequal to A)	false	true

In many contexts (e.g. within IF and WHERE clauses), a NULL result behaves like false in that the condition is not satisfied when the test expression is NULL. On the one hand this is convenient for cases where you might expect false but NULL is returned: you simply won't notice the difference. On the other hand, this may also lead you to expect true when the expression is inverted (using NOT) and this is where you'll run into trouble. In that sense, the most “dangerous” case in the above table is when you use an expression of the type “A NOT IN (<list>)”, with A indeed not present in the list (so you'd expect a clear true result), but the list happens to contain one or more NULLs.

Be especially careful if you use NOT IN with a subselect instead of an explicit list, e.g.

```
A not in ( select Number from MyTable )
```



If A is not present in the Number column, the result is true if no Number is NULL, but NULL if the column does contain a NULL entry. Please be aware that even in a situation where A is constant and its value is never contained in the Number column, the result of the expression (and therefore your program flow) may still vary over time according to the absence or presence of NULLs in the column. Hours of debugging fun! Of course you can avoid this particular problem simply by adding “where Number is not NULL” to the subselect.

Bug alert

All Firebird versions before 2.0 contain a bug that causes [NOT] IN to return the wrong result if an index is active on the subselect and one of the following conditions is true:



- A is NULL and the subselect doesn't return any NULLs, or
- A is not NULL and the subselect result set doesn't contain A but does contain NULL(s).

Please realise that an index may be active even if it has not been created explicitly, namely if a key is defined on A.

Example: Table TA has a column A with values { 3, 8 }. Table TB has a column B containing { 2, 8, 1, NULL }. The expressions:

```
A [not] in ( select B from TB )
```

should both return NULL for A = 3, because of the NULL in B. But if B is indexed, IN returns false and NOT IN returns true. As a result, the query

```
select A from TA where A not in ( select B from TB )
```

returns a dataset with one record — containing the field with value 3 — while it should have returned an empty set. Other errors may also occur, e.g. if you use “NOT IN” in an IF, CASE or WHILE statement.

As an alternative to NOT IN, you can use “<> ALL”. The ALL predicate will be introduced shortly.

5.1.5. IN() in CHECK constraints

The IN() predicate is often used in CHECK constraints. In that context, NULL expressions have a surprisingly different effect in Firebird versions 2.0 and up. This will be discussed in the section [CHECK constraints](#).

5.2. The ANY, SOME and ALL quantifiers

Firebird has two quantifiers that allow you to compare a value to the results of a subselect:

- ALL returns true if the comparison is true for *every* element in the subselect.
- ANY and SOME (full synonyms) return true if the comparison is true for *at least one* element in the subselect.

With ANY, SOME and ALL you provide the comparison operator yourself. This makes it more flexible than IN, which only supports the (implicit) ‘=’ operator. On the other hand, ANY, SOME and ALL only accept a subselect as an argument; you can’t provide an explicit list, as with IN.

Valid operators are =, !=, <, >, =<, => and all their synonyms. You can’t use LIKE, CONTAINING, IS DISTINCT FROM, or any other operators.

Some usage examples:

- ```
select name, income from blacksmiths
```

```
where income > any(select income from goldsmiths)
```

(returns blacksmiths who earn more than at least one goldsmith)

- ```
select name, town from blacksmiths
where town != all( select distinct town from goldsmiths )
```

(returns blacksmiths who live in a goldsmithless town)

- ```
if (GSIncome != some(select income from blacksmiths))
then PoorGoldsmith = 1;
else PoorGoldsmith = 0;
```

(sets PoorGoldsmith to 1 if at least one blacksmith's income is not less than the value of GSIncome)

### 5.2.1. Result values

If the subselect returns an empty set, ALL returns true and ANY|SOME return false, even if the left-hand side expression is NULL. This follows from the definitions and the rules of formal logic. (Math-heads will already have noticed that ALL is equivalent to the universal (“A”) quantifier and ANY|SOME to the existential (“E”) quantifier.)

For non-empty sets, you can write out “A <op> {ANY|SOME} (<subselect>)” as

```
A <op> E1 or A <op> E2 or ... or A <op> En
```

with <op> the operator used and E1, E2 etc. the items returned by the subquery.

Likewise, “A <op> ALL (<subselect>)” is the same as

```
A <op> E1 and A <op> E2 and ... and A <op> En
```

This should look familiar. The first writeout is equal to that of the IN predicate, except that the operator may now be something other than ‘=’. The second is different but has the same general form. We can now work out how nullness of A and/or nullness of subselect results affect the outcome of ANY|SOME and ALL. This is done in the same way as earlier with IN, so instead of including all the steps here we will just present the result tables. Again, read the questions in the left column from top to bottom. As soon as you answer a question with “Yes”, read the result from the second column and you’re done.

Table 4. Results for “A &lt;op&gt; ANY|SOME (&lt;subselect&gt;)”

| Conditions                                      | Result   |
|-------------------------------------------------|----------|
|                                                 | ANY SOME |
| Does the subselect return an empty set?         | false    |
| Else, is A NULL?                                | NULL     |
| Else, does at least one comparison return true? | true     |
| Else, does at least one comparison return NULL? | NULL     |
| Else (i.e. all comparisons return false)        | false    |

If you think these results look a lot like what we saw with IN(), you’re right: with the ‘=’ operator, ANY is the same as IN. In the same way, “<> ALL” is equivalent to NOT IN.



#### Bug alert (revisited)

In versions before 2.0, “= ANY” suffers from the same bug as IN. Under the “right” circumstances, this can lead to wrong results with expressions of the type “NOT A = ANY( ... )”.

On the bright side, “<> ALL” is not affected and will always return the right result.

Table 5. Results for “A &lt;op&gt; ALL (&lt;subselect&gt;)”

| Conditions                                       | Result |
|--------------------------------------------------|--------|
|                                                  | ALL    |
| Does the subselect return an empty set?          | true   |
| Else, is A NULL?                                 | NULL   |
| Else, does at least one comparison return false? | false  |
| Else, does at least one comparison return NULL?  | NULL   |
| Else (i.e. all comparisons return true)          | true   |



#### ALL bug

Although “<> ALL” always works as it should, ALL should nevertheless be considered broken in all pre-2.0 versions of Firebird: with every operator other than “<>”, wrong results may be returned if an index is active on the subselect — with or without NULLs around.



Strictly speaking, the second question in both tables (“is A NULL?”) is redundant and can be dropped. If A is NULL, all the comparisons return NULL, so that situation will be caught a little later. And while we’re at it, we could drop the first question too: the “empty set” situation is just a special case of the final “else”. The whole thing then once again boils down to “true beats NULL beats false” in disjunctions (ANY | SOME) and “false beats NULL beats true” in conjunctions (ALL).

The reason we included those questions is convenience: you can see if a set is empty at a glance, and it's also easier to check if the left-hand side expression is NULL than to evaluate each and every comparison result. But do feel free to skip them, or to skip just the second. Do *not*, however, skip the first question and start with the second: this will lead to a wrong conclusion if the set is empty!

## 5.3. EXISTS and SINGULAR

The EXISTS and SINGULAR predicates return information about a subquery, usually a correlated subquery. You can use them in WHERE, HAVING, CHECK, CASE, IF and WHILE clauses (the latter two are only available in PSQL, Firebird's stored procedure and trigger language).

### 5.3.1. EXISTS

EXISTS tells you whether a subquery returns at least one row of data. Suppose you want a list of farmers who are also landowners. You could get one like this:

```
SELECT Farmer FROM Farms WHERE EXISTS
 (SELECT * FROM Landowners
 WHERE Landowners.Name = Farms.Farmer)
```

This query returns the names of all farmers who also figure in the Landowners table. The EXISTS predicate returns true if the result set of the subselect contains at least one row. If it is empty, EXISTS returns false. EXISTS never returns NULL, because a result set always either has rows, or hasn't. Of course the subselect's search condition may evolve to NULL for certain rows, but that doesn't cause any uncertainty: such a row won't be included in the subresult set.



In reality, the subselect doesn't return a result set at all. The engine simply steps through the Landowners records one by one and applies the search condition. If it evaluates to true, EXISTS returns true immediately and the remaining records aren't checked. If it evaluates to false or NULL, the search continues. If all the records have been searched and there hasn't been a single true result, EXISTS returns false.

NOT EXISTS always returns the opposite of EXISTS: false or true, never NULL. NOT EXISTS returns false immediately if it gets a true result on the subquery's search condition. Before returning true it must step through the entire set.

### 5.3.2. SINGULAR

SINGULAR is an InterBase/Firebird extension to the SQL standard. It is often described as returning true if exactly one row in the subquery meets the search condition. By analogy with EXISTS this would make you expect that SINGULAR too will only ever return true or false. After all, a result set

has either exactly 1 row or a different number of rows. Unfortunately, all versions of Firebird up to and including 2.0 have a bug that causes NULL results in a number of cases. The behaviour is pretty inconsistent, but at the same time fully reproducible. For instance, on a column A containing (1, NULL, 1), a SINGULAR test with subselect "A=1" returns NULL, but the same test on a column with (1, 1, NULL) returns false. Notice that only the insertion order is different here!

To make matters worse, all versions prior to 2.0 sometimes return NULL for NOT SINGULAR where false or true is returned for SINGULAR. In 2.0, this at least doesn't happen anymore: it's either false vs. true or twice NULL.

The code has been fixed for Firebird 2.1; from that version onward SINGULAR will return:

- false if the search condition is never true (this includes the empty-set case);
- true if the search condition is true for exactly 1 row;
- false if the search condition is true for more than 1 row.

Whether the other rows yield false, NULL or a combination thereof, is irrelevant.

NOT SINGULAR will always return the opposite of SINGULAR (as is already the case in 2.0).

In the meantime, if there's *any* chance that the search condition may evolve to NULL for one or more rows, you should always add an IS NOT NULL condition to your [NOT] SINGULAR clauses, e.g. like this:

```
... SINGULAR(SELECT * from MyTable
 WHERE MyField > 38
 AND MyField IS NOT NULL)
```

## Chapter 6. Searches

If the search condition of a SELECT, UPDATE or DELETE statement resolves to NULL for a certain row, the effect is the same as if it had been false. Put another way: if the search expression is NULL, the condition is not met, and consequently the row is not included in the output set (or is not updated/deleted).



The *search condition* or *search expression* is the WHERE clause minus the WHERE keyword itself.

Some examples (with the search condition in boldface):

```
SELECT Farmer, Cows FROM Farms WHERE Cows > 0 ORDER BY Cows
```

The above statement will return the rows for farmers that are known to possess at least one cow. Farmers with an unknown (NULL) number of cows will not be included, because the expression “NULL > 0” returns NULL.

```
SELECT Farmer, Cows FROM Farms WHERE NOT (Cows > 0) ORDER BY Cows
```

Now, it’s tempting to think that this will return “all the other records” from the Farms table, right? But it won’t — not if the Cows column contains any NULLs. Remember that not(NULL) is itself NULL. So for any row where Cows is NULL, “Cows > 0” will be NULL, and “NOT (Cows > 0)” will be NULL as well.

```
SELECT Farmer, Cows, Sheep FROM Farms WHERE Cows + Sheep > 0
```

On the surface, this looks like a query returning all the farms that have at least one cow and/or sheep (assuming that neither Cows nor Sheep can be a negative number). However, if farmer Fred has 30 cows and an unknown number of sheep, the sum Cows + Sheep becomes NULL, and the entire search expression boils down to “NULL > 0”, which is... you got it. So despite his 30 cows, our friend Fred won’t make it into the result set.

As a last example, we shall rewrite the previous statement so that it *will* return any farm which has at least one animal of a known kind, even if the other number is NULL. To do that, we exploit the fact that “NULL or true” returns true — one of the rare occasions where a NULL operand doesn’t render the entire expression NULL:

```
SELECT Farmer, Cows, Sheep FROM Farms WHERE Cows > 0 OR Sheep > 0
```

This time, Fred’s thirty cows will make the first comparison true, while the sheep bit is still NULL. So we have “true or NULL”, which is true, and the row will be included in the output set.



If your search condition contains one or more IN predicates, there is the additional complication that some of the list elements (or subselect results) may be NULL. The implications of this are discussed in [The IN predicate](#).



# Chapter 7. Sorts

In Firebird 2, NULLs are considered “smaller” than anything else when it comes to sorting. Consequently, they come first in ascending sorts and last in descending sorts. You can override this default placement by adding a `NULLS FIRST` or `NULLS LAST` directive to the `ORDER BY` clause.

In earlier versions, NULLs were always placed at the end of a sorted set, no matter whether the order was ascending or descending. For Firebird 1.0, that was the end of the story: NULLs would always come last in any sorted set, period. Firebird 1.5 introduced the `NULLS FIRST/LAST` syntax, so you could force them to the top or bottom.

To sum it all up:

Table 6. NULLs placement in ordered columns

| Ordering                                | NULLs placement |              |            |
|-----------------------------------------|-----------------|--------------|------------|
|                                         | Firebird 1      | Firebird 1.5 | Firebird 2 |
| order by Field [asc]                    | bottom          | bottom       | top        |
| order by Field desc                     | bottom          | bottom       | bottom     |
| order by Field [asc   desc] nulls first | —               | top          | top        |
| order by Field [asc   desc] nulls last  | —               | bottom       | bottom     |

Specifying `NULLS FIRST` on an ascending or `NULLS LAST` on a descending sort in Firebird 2 is of course rather pointless, but perfectly legal. The same is true for `NULLS LAST` on any sort in Firebird 1.5.



- If you override the default NULLs placement, no index will be used for sorting. In Firebird 1.5, that is the case with `NULLS FIRST`. In 2.0 and higher, with `NULLS LAST` on ascending and `NULLS FIRST` on descending sorts.
- If you open a pre-2.0 database with Firebird 2, it will show the *old* NULL ordering behaviour (that is: at the bottom, unless overridden by `NULLS FIRST`). A backup-restore cycle will fix this, provided that at least the restore is executed with Firebird 2’s `gbak`!
- Firebird 2.0 has a bug that causes the `NULLS FIRST|LAST` directive to fail under certain circumstances with `SELECT DISTINCT`. See the [bugs list](#) for more details.



Don’t be tempted into thinking that, because NULL is now the “smallest thing” in sorts, an expression like `NULL < 3` will return `true` in Firebird 2 and up. It won’t. Using NULL in this kind of expression will always give a NULL outcome.

## Chapter 8. Aggregate functions

The aggregate functions — COUNT, SUM, AVG, MAX, MIN and LIST — don't handle NULL in the same way as ordinary functions and operators. Instead of returning NULL as soon as a NULL operand is encountered, they only take non-NULL fields into consideration while computing the outcome. That is, if you have this table:

| MyTable |      |        |
|---------|------|--------|
| ID      | Name | Amount |
| 1       | John | 37     |
| 2       | Jack | NULL   |
| 3       | Jim  | 5      |
| 4       | Joe  | 12     |
| 5       | Josh | NULL   |

...the statement `select sum(Amount) from MyTable` returns 54, which is  $37 + 5 + 12$ . Had all five fields been summed, the result would have been NULL. For AVG, the non-NULL fields are summed and the sum divided by the number of non-NULL fields.

There is one exception to this rule: `COUNT(*)` returns the count of all rows, even rows whose fields are all NULL. But `COUNT(FieldName)` behaves like the other aggregate functions in that it only counts rows where the specified field is not NULL.

Another thing worth knowing is that `COUNT(*)` and `COUNT(FieldName)` never return NULL: if there are no rows in the set, both functions return 0. `COUNT(FieldName)` also returns 0 if all `FieldName` fields in the set are NULL. The other aggregate functions return NULL in such cases. Be warned that SUM even returns NULL if used on an empty set, which is contrary to common logic (if there are no rows, the average, maximum and minimum are undefined, but the sum is *known* to be zero).

Now let's put all that knowledge in a table for your easy reference:

Table 7. Aggregate function results with different column states

| Function     | Results   |                        |                                        |
|--------------|-----------|------------------------|----------------------------------------|
|              | Empty set | All-NULL set or column | Other sets or columns                  |
| COUNT(*)     | 0         | Total number of rows   | Total number of rows                   |
| COUNT(Field) | 0         | 0                      | Number of rows where Field is not NULL |
| MAX, MIN     | NULL      | NULL                   | Max or min value found in the column   |
| SUM          | NULL      | NULL                   | Sum of non-NULL values in the column   |

|                     |      |      |                                                                                                    |
|---------------------|------|------|----------------------------------------------------------------------------------------------------|
| AVG                 | NULL | NULL | Average of non-NULL values in the column. This equals $SUM(Field) / COUNT(Field)$ . <sup>[1]</sup> |
| LIST <sup>[2]</sup> | NULL | NULL | Comma-separated string concatenation of non-NULL values in the column                              |

## 8.1. The GROUP BY clause

A GROUP BY clause doesn't change the aggregate function logic described above, except that it is now applied to each group individually rather than to the result set as a whole. Suppose you have a table `Employee`, with fields `Dept` and `Salary` which both allow NULLs, and you run this query:

```
SELECT Dept, SUM(Salary) FROM Employee GROUP BY Dept
```

The result may look like this (the row where `Dept` is `<null>` may be at the top or bottom, depending on your Firebird version):

```
DEPT SUM
=====
<null> 219465.19
000 266643.00
100 155262.50
110 130442.81
115 13480000.00
120 <null>
121 110000.00
123 390500.00
```

First notice that the people whose department is unknown (NULL) are grouped together, although you can't say that they have the same *value* in the `Dept` field. But the alternative would have been to give each of those records a "group" of their own. Not only would this possibly add a huge number of lines to the output, but it would also defeat the purpose of *grouping*: those lines wouldn't be aggregates, but simple "SELECT Dept, Salary" rows. So it makes sense to group the NULL depts by their state and the rest by their value.

Anyway, the `Dept` field is not what interests us most. What does the aggregate `SUM` column tell us? That all salaries are non-NULL, except in department 120? No. All we can say is that in every department except 120, there is at least one employee with a known salary in the database. Each department *may* contain NULL salaries; in dept. 120 *all* the salaries are NULL.

You can find out more by throwing in one or more `COUNT()` columns. For instance, if you want to know the number of NULL salaries in each group, add a column "`COUNT(*) - COUNT(Salary)`".

### 8.1.1. Counting frequencies

A `GROUP BY` clause can be used to report the frequencies with which values occur in a table. In that case you use the same field name several times in the query statement. Let's say you have a table `TT` with a column `A` whose contents are `{ 3, 8, NULL, 6, 8, -1, NULL, 3, 1 }`. To get a frequencies report, you could use:

```
SELECT A, COUNT(A) FROM TT GROUP BY A
```

which would give you this result:

| A      | COUNT |
|--------|-------|
| =====  | ===== |
| -1     | 1     |
| 1      | 1     |
| 3      | 2     |
| 6      | 1     |
| 8      | 2     |
| <null> | 0     |

Oops—something went wrong with the `NULL` count, but what? Remember that `COUNT(FieldName)` skips all `NULL` fields, so with `COUNT(A)` the count of the `<null>` group can only ever be 0. Reformulate your query like this:

```
SELECT A, COUNT(*) FROM TT GROUP BY A
```

and the correct value will be returned (in casu 2).

## 8.2. The HAVING clause

`HAVING` clauses can place extra restrictions on the output rows of an aggregate query—just like `WHERE` clauses do in record-by-record queries. A `HAVING` clause can impose conditions on any output column or combination of columns, aggregate or not.

As far as `NULL` is concerned, the following two facts are worth knowing (and hardly surprising, I would guess):

- Rows for which the `HAVING` condition evaluates to `NULL` won't be included in the result set. ("Only true is good enough.")
- "`HAVING <col> IS [NOT] NULL`" is a legal and often useful condition, whether `<col>` is aggregate or not. (But if `<col>` is non-aggregate, you may save the engine some work by changing `HAVING` to `WHERE` and placing the condition before the "`GROUP BY`" clause. This goes for any condition on non-aggregate columns.)

For instance, adding the following clause to the [example query](#) from the “GROUP BY” paragraph:

```
...HAVING Dept IS NOT NULL
```

will prevent the first row from being output, whereas this one:

```
...HAVING SUM(Salary) IS NOT NULL
```

suppresses the sixth row (the one with Dept = 120).

[1] If Field is of an integer type, AVG is always rounded towards 0. For instance, 6 non-null INT records with a sum of -11 yield an average of -1, not -2.

[2] LIST was added in Firebird 2.1

# Chapter 9. Conditional statements and loops

## 9.1. IF statements

If the test expression of an IF statement resolves to NULL, the THEN clause is skipped and the ELSE clause — if present — executed. In other words, NULL and false have the same effect in this context. So in situations where you would logically expect false but NULL is returned, no harm will be done. However, we’ve already seen examples of NULL being returned where you would expect true, and that *does* affect the flow of the code!

Below are some examples of the seemingly paradoxical (but perfectly correct) results you can get if NULLs creep into your IF statements.



If you use Firebird 2 or higher, you can avoid all the pitfalls discussed here, simply by using [NOT] DISTINCT instead of the ‘=’ and ‘<>’ operators!

- Equals (‘=’)

```
if (a = b) then
 MyVariable = 'Equal';
else
 MyVariable = 'Not equal';
```

If a and b are both NULL, MyVariable will yet be “Not equal” after executing this code. The reason is that the expression “a = b” yields NULL if at least one of them is NULL. With a NULL test expression, the THEN block is skipped and the ELSE block executed.

- Not equals (‘<>’)

```
if (a <> b) then
 MyVariable = 'Not equal';
else
 MyVariable = 'Equal';
```

Here, MyVariable will be “Equal” if a is NULL and b isn’t, or vice versa. The explanation is analogous to that of the previous example.

So how should you set up equality tests that *do* give the logical result under all circumstances, even with NULL operands? In Firebird 2 you can use DISTINCT, as already shown (see [Testing DISTINCTness](#)). With earlier versions, you’ll have to write some more code. This is discussed in the section [Equality tests](#), later on in this guide. For now, just remember that you have to be very careful with IF conditions that may resolve to NULL.

Another aspect you shouldn’t forget is the following: a NULL test expression may *behave* like false in

an IF condition, but it doesn't have the *value* false. It's still NULL, and that means that its inverse will also be NULL — not “true”. As a consequence, inverting the test expression and swapping the THEN and ELSE blocks may change the behaviour of the IF statement. In binary logic, where only true and false can occur, such a thing could never happen.

To illustrate this, let's refactor the last example:

- Not not equals (“not (.. <> ..)”)

```
if (not (a <> b)) then
 MyVariable = 'Equal';
else
 MyVariable = 'Not equal';
```

In the original version, if one operand was NULL and the other wasn't (so they were intuitively unequal), the result was “Equal”. Here, it's “Not equal”. The explanation: one operand is NULL, therefore “a <> b” is NULL, therefore “not(a <> b)” is NULL, therefore ELSE is executed. While this result is correct where the original had it wrong, there's no reason to rejoice: in the refactored version, the result is also “Not equal” if both operands are NULL — something that the original version “got right”.

Of course, as long as no operand in the test expression can ever be NULL, you can happily formulate your IF statements like above. Also, refactoring by inverting the test expression and swapping the THEN and ELSE blocks will always preserve the functionality, regardless of the complexity of the expressions — as long as they aren't NULL. What's especially treacherous is when the operands are *almost always* non-NULL, so in the vast majority of cases the results will be correct. In such a situation those rare NULL cases may go unnoticed for a long time, silently corrupting your data.

## 9.2. CASE expression

Firebird introduced the CASE construct in version 1.5, with two syntactic variants. The first one is called the *simple syntax*:

```
case <expression>
 when <exp1> then <result1>
 when <exp2> then <result2>
 ...
 [else <defaultresult>]
end
```

This one works more or less like a Pascal case or a C switch construct: <expression> is compared to <exp1>, <exp2> etc., until a match is found, in which case the corresponding result is returned. If there is no match and there is an ELSE clause, <defaultresult> is returned. If there is no match and no ELSE clause, NULL is returned.

It is important to know that the comparisons are done with the ‘=’ operator, so a null <expression> will *not* match a null <expN>. If <expression> is NULL, the only way to get a non-NULL result is via the ELSE clause.

It is OK to specify NULL (or any other valid NULL expression) as a result.

The second, or *searched syntax* is:

```
case
 when <condition1> then <result1>
 when <condition2> then <result2>
 ...
 [else <defaultresult>]
end
```

Here, the <conditionN>s are tests that give a ternary boolean result: true, false, or NULL. Once again, only true is good enough, so a condition like “A = 3” — or even “A = null” — is not satisfied when A is NULL. Remember though that “IS [NOT] NULL” never returns NULL: if A is NULL, the condition “A is null” returns true and the corresponding <resultN> will be returned. In Firebird 2+ you can also use “IS [NOT] DISTINCT FROM” in your conditions — this operator too will never return NULL.

## 9.3. WHILE loops

When evaluating the condition of a WHILE loop, NULL has the same effect as in an IF statement: if the condition resolves to NULL, the loop is not (re)entered — just as if it were false. Again, watch out with inversion using NOT: a condition like

```
while (Counter > 12) do
```

will skip the loop block if Counter is NULL, which is probably what you want, but:

```
while (not Counter > 12) do
```

will also skip if Counter is NULL. Maybe this is also exactly what you want — just be aware that these seemingly complementary tests both exclude NULL counters.

## 9.4. FOR loops

To avoid any possible confusion, let us emphasise here that FOR loops in Firebird PSQL have a totally different function than WHILE loops, or for loops in general programming languages. Firebird FOR loops have the form:



```
for <select-statement> into <var-list> do <code-block>
```

and they will keep executing the code block until all the rows from the result set have been retrieved, unless an exception occurs or a `BREAK`, `LEAVE` or `EXIT` statement is encountered. Fetching a `NULL`, or even row after row filled with `NULL`s, does *not* terminate the loop!

# Chapter 10. Keys and unique indices

## 10.1. Primary keys

NULLs are never allowed in primary keys. A column can only be (part of) a PK if it has been defined as NOT NULL, either in the column definition or in a domain definition. Note that a “CHECK (XXX IS NOT NULL)” constraint won’t do: you need a NOT NULL specifier right after the data type.



Firebird 1.5 has a bug that allows primary keys to be defined on a NOT NULL column with NULL entries. How these NULLs can exist in such a column will be explained later.

## 10.2. Unique keys and indices

### 10.2.1. Firebird 1.0

In Firebird 1.0, unique *keys* are subject to the same restrictions as primary keys: the column(s) involved must be defined as NOT NULL. For unique *indices*, this is not necessary. However, when a unique index is created the table may not contain any NULLs or duplicate values, or the creation will fail. Once the index is in place, insertion of NULLs or duplicate values is no longer possible.

### 10.2.2. Firebird 1.5 and higher

In Firebird 1.5 and up, unique keys and unique indices allow NULLs, and what’s more: they even allow multiple NULLs. With a single-column key or index, you can insert as many NULLs as you want in that column, but you can insert each non-NULL value only once.

If the key or index is defined on multiple columns in Firebird 1.5 and higher:

- You can insert multiple rows where all the key columns are NULL;
- But as soon as one or more key columns are non-NULL, each combination of non-NULL values must be unique in the table. Of course with the understanding that (1, NULL) is not the same as (NULL, 1).

## 10.3. Foreign keys

Foreign keys as such impose no restrictions with respect to NULLs. Foreign key columns must always reference a column (or set of columns) that is a primary key or a unique key. A unique index on the referenced column(s) is not enough.



In versions up to and including 2.0, if you try to create a foreign key referencing a target that is neither a primary nor a unique key, Firebird complains that no unique *index* can be found on the target — even if such an index does exist. In 2.1, the message correctly states that no unique or primary *key* could be found.

Even if NULLs are absolutely forbidden in the target key (for instance if the target is a PK), the foreign key column may still contain NULLs, unless this is prevented by additional constraints.

## Chapter 11. CHECK constraints

It has been said several times in this guide that if test expressions return NULL, they have the same effect as false: the condition is not satisfied. Starting at Firebird 2, this is **no longer true** for the CHECK constraint. To comply with SQL standards, a CHECK is now **passed** if the condition resolves to NULL. Only an unambiguous false outcome will cause the input to be rejected.

In practice, this means that checks like

```
check (value > 10000)
```

```
check (upper(value) in ('A', 'B', 'X'))
```

```
check (value between 30 and 36)
```

```
check (ColA <> ColB)
```

```
check (Town not like 'Amst%')
```

...will reject NULL input in Firebird 1.5, but let it pass in Firebird 2. Existing database creation scripts will have to be carefully examined before being used under Firebird 2. If a domain or column has no NOT NULL constraint, and a CHECK constraint may resolve to NULL (which usually—but not exclusively—happens because the input is NULL), the script has to be adapted. You can extend your check constraints like this:

```
check (value > 10000 and value is not null)
```

```
check (Town not like 'Amst%' and Town is not null)
```

However, it's easier and clearer to add NOT NULL to the domain or column definition:

```
create domain DCENSUS int not null check (value > 10000)
```

```
create table MyPlaces
(
 Town varchar(24) not null check (Town not like 'Amst%'),
 ...
```

)

If your scripts and/or databases should function consistently under both old and new Firebird versions, make sure that no CHECK constraint can ever resolve to NULL. Add “or ... is null” if you want to allow NULL input in older versions. Add NOT NULL constraints or “and ... is not null” restrictions to disallow it explicitly in newer Firebird versions.

## Chapter 12. SELECT DISTINCT

A `SELECT DISTINCT` statement considers all `NULL`s to be equal (NOT `DISTINCT FROM` each other), so if the select is on a single column it will return at most one `NULL`.

As mentioned earlier, Firebird 2.0 has a bug that causes the `NULLS FIRST|LAST` directive to fail under certain circumstances with `SELECT DISTINCT`. For more details, see the [bugs list](#).

## Chapter 13. User-Defined Functions (UDFs)

*UDFs (User-Defined Functions)* are functions that are not internal to the engine, but defined in separate modules. Firebird ships with two UDF libraries: `ib_udf` (a widely used “InterBase library”) and `fbudf`. You can add more libraries, e.g. by buying or downloading them, or by writing them yourself. UDFs can’t be used out of the box; they have to be “declared” to the database first. This also applies to the UDFs that come with Firebird itself.

### 13.1. NULL $\Leftrightarrow$ non-NULL conversions you didn’t ask for

Teaching you how to declare, use, and write UDFs is outside the scope of this guide. However, we must warn you that UDFs can occasionally perform unexpected NULL conversions. This will sometimes result in NULL input being converted to a regular value, and other times in the nullification of valid input like `''` (an empty string).

The main cause of this problem is that with “old style” UDF calling (inherited from InterBase), it is not possible to pass NULL as input to the function. When a UDF like `LTRIM` (left trim) is called with a NULL argument, the argument is passed to the function as an empty string. (Note: in Firebird 2 and up, it *can* also be passed as a null pointer. We’ll get to that later.) From inside the function there is *no way* of telling if this argument represents a real empty string or a NULL. So what does the function implementor do? He has to make a choice: either take the argument at face value, or assume it was originally a NULL and treat it accordingly.

If the function result type is a pointer, returning NULL is possible even if receiving NULL isn’t. Thus, the following unexpected things can happen:

- You call a UDF with a NULL argument. It is passed as a value, e.g. `0` or `''`. Within the function, this argument is not changed back to NULL; a non-NULL result is returned.
- You call a UDF with a valid argument like `0` or `''`. It is passed as-is (obviously). But the function code supposes that this value really represents a NULL, treats it as a black hole, and returns NULL to the caller.

Both conversions are usually unwanted, but the second probably more so than the first (better validate something NULL than wreck something valid). To get back to our `LTRIM` example: in Firebird 1.0, this function returns NULL if you feed it an empty string. This is wrong. In 1.5 it never returns NULL: even NULL strings (passed by the engine as `''`) are “trimmed” to empty strings. This is also wrong, but it’s considered the lesser of two evils. Firebird 2 has finally got it right: a NULL string gives a NULL result, an empty string is trimmed to an empty string—at least if you declare the function in the right way.

### 13.2. Descriptors

As early as in Firebird 1.0, a new method of passing UDF arguments and results was introduced:

“by descriptor”. Descriptors allow NULL signalling no matter the type of data. The `fbudf` library makes ample use of this technique. Unfortunately, using descriptors is rather cumbersome; it's more work and less play for the UDF implementor. But they do solve all the traditional NULL problems, and for the caller they're just as easy to use as old-style UDFs.

## 13.3. Improvements in Firebird 2

Firebird 2 comes with a somewhat improved calling mechanism for old-style UDFs. The engine will now pass NULL input as a null pointer to the function, **if** the function has been declared to the database with a NULL keyword after the argument(s) in question, e.g. like this:

```
declare external function ltrim
 cstring(255) null
 returns cstring(255) free_it
 entry_point 'IB_UDF_ltrim' module_name 'ib_udf';
```

This requirement ensures that existing databases and their applications can continue to function like before. Leave out the NULL keyword and the function will behave like it did under Firebird 1.5 and earlier.

Please note that you can't just add NULL keywords to your declarations and then expect every function to handle NULL input correctly. Each function has to be (re)written in such a way that NULLs are dealt with correctly. Always look at the declarations provided by the function implementor. For the functions in the `ib_udf` library, consult `ib_udf2.sql` in the Firebird UDF directory. Notice the 2 in the file name; the old-style declarations are in `ib_udf.sql`.

These are the `ib_udf` functions that have been updated to recognise NULL input and handle it properly:

- `ascii_char`
- `lower`
- `lpad` and `rpadd`
- `ltrim` and `rtrim`
- `substr` and `substrlen`

Most `ib_udf` functions remain as they were; in any case, passing NULL to an old-style UDF is never possible if the argument isn't of a referenced type.

On a side note: don't use `lower`, `*trim` and `substr*` in new code; use the internal functions `LOWER`, `TRIM` and `SUBSTRING` instead.

### 13.3.1. “Upgrading” `ib_udf` functions in an existing database

If you are using an existing database with one or more of the functions listed above under Firebird 2, and you want to benefit from the improved NULL handling, run the script `ib_udf_upgrade.sql`



against your database. It is located in the Firebird `misc\upgrade\ib_udf` directory.

## 13.4. Being prepared for undesired conversions

The unsolicited NULL  $\Leftrightarrow$  non-NULL conversions described earlier usually only happen with legacy UDFs, but there are a lot of them around (most notably in `ib_udf`). Also, nothing will stop a careless implementor from doing the same in a descriptor-style function. So the bottom line is: if you use a UDF and you don't know how it behaves with respect to NULL:

1. Look at its declaration to see how values are passed and returned. If it says “by descriptor”, it should be safe (though it never hurts to make sure). Ditto if arguments are followed by a NULL keyword. In all other cases, walk through the rest of the steps.
2. If you have the source and you understand the language it's written in, inspect the function code.
3. Test the function both with NULL input and with input like 0 (for numerical arguments) and/or '' (for string arguments).
4. If the function performs an undesired NULL  $\Leftrightarrow$  non-NULL conversion, you'll have to anticipate it in your code before calling the UDF (see also [Testing for NULL — if it matters](#), elsewhere in this guide).

The declarations for the shipped UDF libraries can be found in the Firebird subdirectory `examples` (v.1.0) or `UDF` (v.1.5 and up). Look at the files with extension `.sql`

## 13.5. More on UDFs

To learn more about UDFs, consult the *InterBase 6.0 Developer's Guide* (free at <https://www.ibphoenix.com/downloads/60DevGuide.zip>), *Using Firebird* and the *Firebird Reference Guide* (both on CD), or the *Firebird Book*. CD and book can be purchased via <https://www.ibphoenix.com>.

# Chapter 14. Converting to and from NULL

## 14.1. Substituting NULL with a value

### 14.1.1. The COALESCE function

The COALESCE function in Firebird 1.5 and higher can convert NULL to most anything else. This enables you to perform an on-the-fly conversion and use the result in your further processing, without the need for “if (MyExpression is null) then” or similar constructions. The function signature is:

```
COALESCE(Expr1, Expr2, Expr3, ...)
```

COALESCE returns the value of the first non-NULL expression in the argument list. If all the expressions are NULL, it returns NULL.

This is how you would use COALESCE to construct a person’s full name from the first, middle and last names, assuming that some middle name fields may be NULL:

```
select FirstName
 || coalesce(' ' || MiddleName, '')
 || ' ' || LastName
from Persons
```

Or, to create an as-informal-as-possible name from a table that also includes nicknames, and assuming that both nickname and first name may be NULL:

```
select coalesce (Nickname, FirstName, 'Mr./Mrs.')
 || ' ' || LastName
from OtherPersons
```

COALESCE will only help you out in situations where NULL can be treated in the same way as some allowed value for the datatype. If NULL needs special handling, different from any other value, your only option is to use an IF or CASE construct after all.

### 14.1.2. Firebird 1.0: the \*NVL functions

Firebird 1.0 doesn't have COALESCE. However, you can use four UDFs that provide a good part of its functionality. These UDFs reside in the fbudf lib and they are:

- iNVL, for integer arguments
- i64NVL, for bigint arguments
- dNVL, for double precision arguments
- sNVL, for strings

The \*NVL functions take exactly two arguments. Like COALESCE, they return the first argument if it's not NULL; otherwise, they return the second. Please note that the Firebird 1.0 fbudf lib—and therefore, the \*NVL function set—is only available for Windows.

## 14.2. Converting values to NULL

Sometimes you want certain values to show up as NULL in the output (or intermediate output). This doesn't happen often, but it may for instance be useful if you want to exclude certain values from summing or averaging. The NULLIF functions can do this for you, though only for one value at the time.

### 14.2.1. Firebird 1.5 and up: the NULLIF function

The NULLIF internal function takes two arguments. If their values are equal, the function returns NULL. Otherwise, it returns the value of the first argument.

A typical use is e.g.

```
select avg(nullif(Weight, -1)) from FatPeople
```

which will give you the average weight of the FatPeople population, without counting those with weight -1. (Remember that aggregate functions like AVG exclude all NULL fields from the computation.)

Elaborating on this example, suppose that until now you have used the value -1 to indicate “weight unknown” because you weren't comfortable with NULLs. After reading this guide, you may feel brave enough to give the command:

```
update FatPeople set Weight = nullif(Weight, -1)
```

Now unknown weights will *really* be unknown.

## 14.2.2. Firebird 1.0: the \*nullif UDFs

Firebird 1.0.x doesn't have the NULLIF internal function. Instead, it has four user-defined functions in the fbudf lib that serve the same purpose:

- inullif, for integer arguments
- i64nullif, for bigint arguments
- dnullif, for double precision arguments
- snullif, for strings

Please note that the Firebird 1.0 fbudf lib—and therefore, the \*nullif function set—is only available for Windows.



The Firebird 1 Release Notes state that, because of an engine limitation, these UDFs return a zero-equivalent if the arguments are equal. This is incorrect: if the arguments have the same value, the functions all return a true NULL.

However—they also return NULL if the first argument is a real value and the second argument is NULL. This is a wrong result. The Firebird 1.5 internal NULLIF function correctly returns the first argument in such a case.

# Chapter 15. Altering populated tables

If your table already contains data, and you want to add a non-nullable column or change the nullability of an existing column, there are some consequences that you should know about. We'll discuss the various possibilities in the sections below.

## 15.1. Adding a non-nullable field to a populated table

Suppose you have this table:

*Table 8. Adventures table*

| Name           | Bought      | Price    |
|----------------|-------------|----------|
| Maniac Mansion | 12-Jun-1995 | \$ 49,-- |
| Zak McKracken  | 9-Oct-1995  | \$ 54,95 |

You have already entered some adventure games in this table when you decide to add a non-nullable ID field. There are two ways to go about this, both with their own specific problems.

### 15.1.1. Adding a NOT NULL field

This is by far the preferred method in general, but it causes some special problems if used on a populated table, as you will see in a moment. First, add the field with the following statement:

```
alter table Adventures add id int not null
```

Or, if you want to name the constraint explicitly (this makes it easier if you ever want to drop it later):

```
alter table Adventures add id int constraint IdNotNull not null
```

Despite the NOT NULL constraint, the new ID fields that have been added to the existing rows will all be NULL. In this special case, Firebird allows invalid data to be present in a column. It will even write the NULLs to a backup without complaining, but it will refuse to restore them, precisely because of the constraint violation.



Firebird 1.5 (but not 1.0 or 2.0) even allows you to make such a column the primary key!

## False reporting of NULLs as zeroes

To make matters worse, Firebird lies to you when you retrieve data from the table. With `isql` and many other clients, “`SELECT * FROM ADVENTURES`” will return this dataset:

Table 9. Result set after adding a NOT NULL column

| Name           | Bought      | Price    | ID |
|----------------|-------------|----------|----|
| Maniac Mansion | 12-Jun-1995 | \$ 49,-- | 0  |
| Zak McKracken  | 9-Oct-1995  | \$ 54,95 | 0  |

Of course this will make most people think “OK, cool: Firebird used a default value of 0 for the new fields—nothing to worry about”. But you can verify that the ID fields are really NULL with these queries:

- `SELECT * FROM ADVENTURES WHERE ID = 0` (returns empty set)
- `SELECT * FROM ADVENTURES WHERE ID IS NULL` (returns set shown above, with false 0's)
- `SELECT * FROM ADVENTURES WHERE ID IS NOT NULL` (returns empty set)

Another type of query hinting that something fishy is going on is the following:

- `SELECT NAME, ID, ID+3 FROM ADVENTURES`

Such a query will return 0 in the “ID+3” column. With a true 0 ID it should have been 3. The *correct* result would be NULL, of course!

If the added NOT NULL column is of type (VAR)CHAR instead of INT, you will see phoney emptystrings (' '). With a DATE column, phoney “zero dates” of 17 November 1858 (epoch of the Modified Julian Day). In all cases, the true state of the data is NULL.

### What the...

...is going on here?

When a client application like `isql` queries the server, the conversation passes through several stages. During one of them—the “describe” phase—the engine reports type and nullability for each column that will appear in the result set. It does this in a data structure which is later also used to retrieve the actual row data. For columns flagged as NOT NULL by the server, there is no way to return NULLs to the client—unless the client flips back the flag before entering the data retrieval stage. Most client applications don't do this. After all, if the server assures you that a column can't contain NULLs, why would you think you know better, override the server's decision and check for NULLs anyway? And yet that's exactly what you should do if you want to avoid the risk of reporting false values to your users.

## Ensuring the validity of your data

Here's what you should do to make sure that your data are valid when adding a NOT NULL column to a populated table:

- To prevent the nulls-in-not-null-columns problem from occurring at all, provide a default value when you add the new column:

```
alter table Adventures add id int default -1 not null
```

Default values are normally not applied when adding fields to existing rows, but with NOT NULL fields they are.

- Else, explicitly set the new fields to the value(s) they should have, right after adding the column. Verify that they are all valid with a “SELECT ... WHERE ... IS NULL” query, which should return an empty set.
- If the damage has already been done and you find yourself with an unrestoreable backup, use gbak's -n switch to ignore validity constraints when restoring. Then fix the data and reinstate the constraints manually. Again, verify with a “WHERE ... IS NULL” query.



Firebird versions up to and including 1.5.0 have an additional bug that causes gbak to restore NOT NULL constraints even if you specify -n. With those versions, if you have backed up a database with NULL data in NOT NULL fields, you're completely stuck. Solution: install 1.5.1 or higher, restore with gbak -n and fix your data.

### 15.1.2. Adding a CHECKed column

Using a CHECK constraint is another way to disallow NULL entries in a column:

```
alter table Adventures add id int check (id is not null)
```

If you do it this way, a subsequent SELECT will return:

Table 10. Result set after adding a CHECKed field

| Name           | Bought      | Price    | ID     |
|----------------|-------------|----------|--------|
| Maniac Mansion | 12-Jun-1995 | \$ 49,-- | <null> |
| Zak McKracken  | 9-Oct-1995  | \$ 54,95 | <null> |

Well, at least now you can *see* that the fields are NULL! Firebird does not enforce CHECK constraints on existing rows when you add new fields. The same is true if you add checks to existing fields with ADD CONSTRAINT or ADD CHECK.

This time, Firebird not only tolerates the presence and the backing up of the NULL entries, but it will also restore them. Firebird's gbak tool does restore CHECK constraints, but doesn't apply them to the existing data in the backup.



Even with the -n switch, gbak restores CHECK constraints. But since they are not

used to validate backed-up data, this will never lead to a failed restore.

This restorability of your NULL data despite the presence of the CHECK constraint is consistent with the fact that Firebird allows them to be present in the first place, and to be backed up as well. But from a pragmatical point of view, there's a downside: you can now go through cycle after cycle of backup and restore, and your “illegal” data will survive without you even receiving a warning. So again: make sure that your existing rows obey the new rule immediately after adding the constrained column. The “default” trick won't work here; you'll just have to remember to set the right value(s) yourself. If you forget it now, chances are that your outlawed NULLs will survive for a long time, as there won't be any wake-up calls later on.



The `isql` command `SHOW TABLE` lists “CHECK ... IS NOT NULL” columns as nullable, because the column type is not intrinsically NOT NULL. But it also shows the CHECKs, so you know how things stand.

Likewise, the engine describes these columns as nullable when a query is executed. This accounts for the fact that NULLs are truthfully reported in this case, as you've seen in the table above.

### 15.1.3. Using domains to add a non-nullable field

Instead of specifying data types and constraints directly, you can also use domains, e.g. like this:

```
create domain inn as int not null;
alter table Adventures add id inn;
```

Or like this:

```
create domain icnn as int check (value is not null);
alter table Adventures add id icnn;
```

For the presence of NULLs in the added columns, returning of false 0's, effects of default values etc., it makes *no difference at all* whether you take the domain route or the direct approach. The only difference is that domain-based constraints can't be removed at the column level. So if you ever want to drop the constraint later, you must either switch the column to another domain or built-in type again, or remove the constraint from the entire domain. The latter operation is described in the section [Changing the nullability of a domain](#).

## 15.2. Making existing columns non-nullable



### 15.2.1. Making an existing column NOT NULL

You cannot add NOT NULL to an existing column, but there's a simple workaround. Suppose the current type is int, then this:

```
create domain intnn as int not null;
alter table MyTable alter MyColumn type intnn;
```

will change the column type to “int not null”.

If the table already had records, any NULLs in the column will remain NULL, and again most Firebird clients will report them as 0 to the user. The situation is almost exactly the same as when you add a NOT NULL column (see [Adding a NOT NULL field](#)). The only difference is that if you give the domain (and therefore the column) a default value, this time you can't be sure that it will be applied to the existing NULL entries. Tests show that sometimes the default is applied to all NULLs, sometimes to none, and in a few cases to *some* of the existing entries but not to others! Bottom line: if you change a column's type and the new type includes a default, double-check the existing entries — especially if they “seem to be” 0 or zero-equivalents.



Some Firebird tools allow you to make an existing column NOT NULL with the click of a button. They do this by poking a value directly into a system table. This technique is neither recommended nor supported by Firebird, and although until now it works in practice, this may not be the case in future versions. It's better to stay safe and use the SQL given above.

### 15.2.2. Adding a CHECK constraint to an existing column

To add a CHECK constraint to a column, use one of the following syntaxes:

```
alter table Stk add check (Amt is not null)
```

```
alter table Stk add constraint AmtNotNull check (Amt is not null)
```

The second form is preferred because it gives you an easy handle to drop the check, but the constraints themselves function exactly the same. As you may have expected, existing NULLs in the column will remain, can be backed up and restored, etc. etc. — see [Adding a CHECKed column](#).

## 15.3. Making non-nullable columns nullable again

### 15.3.1. Removing a NOT NULL constraint

If you gave the NOT NULL constraint a name when you created it, you can simply drop it:

```
alter table Adventures drop constraint IdNotNull
```

If you forgot the name, you can retrieve it with isql's `SHOW TABLE` command (i.e. `SHOW TABLE ADVENTURES`); other clients may have their own provisions to let you find or browse constraint names.

If you didn't name the constraint explicitly, Firebird has created a name for it, but `SHOW TABLE` won't display it. You have to use this piece of SQL to dig it up:

```
select rc.rdb$constraint_name
from rdb$relation_constraints rc
 join rdb$check_constraints cc
 on rc.rdb$constraint_name = cc.rdb$constraint_name
where rc.rdb$constraint_type = 'NOT NULL'
 and rc.rdb$relation_name = '<TableName>'
 and cc.rdb$trigger_name = '<FieldName>'
```

Don't break your head over some of the table and field names in this statement; they are illogical but correct. Make sure to uppercase the names of your table and field if they were defined case-insensitively. Otherwise, match the case exactly but don't enclose the names in double-quotes like you would do in a regular query. Also don't include the angle brackets (<>). Once you have the constraint name, you can drop it just like in the previous example.

If the above statement returns an empty set and you are sure that you've correctly filled in the table and field names (including case!), and the constraint did not come from a domain either (this is discussed in the next sections), it may be that a third-party tool has made the column NOT NULL by setting a flag in a system table. In that case it's probably best to remove it again with the same tool. If that is not an option, check the field's NULL flag with:



```
select rdb$null_flag from rdb$relation_fields
where rdb$relation_name = '<TableName>'
 and rdb$field_name = '<FieldName>'
```

If the flag is NULL or 0, the field is nullable (at least as far as this flag is concerned). If it's 1, clear it with:

```
update rdb$relation_fields set rdb$null_flag = null /* or 0 */
where rdb$relation_name = '<TableName>'
```

```
and rdb$field_name = '<FieldName>'
```

followed by a commit.



As soon as you've dropped the NOT NULL constraint — by whichever method — SHOW TABLE will report the column as nullable. Any existing NULLs that were previously illegal and therefore hidden by most clients (see [False reporting of NULLs as zeroes](#)) will become visible again.

However, before you can *insert* NULLs into the column, you must commit your work, *close all connections to the database*, and reconnect.

### Removing a domain-based NOT NULL constraint

If the NOT NULL constraint came with a domain, it is not registered directly with the column. This means you can't DROP it from the column either. Instead, change the column's type to a nullable domain or built-in data type:

```
alter table MyTable alter MyColumn type int
```

Even though this time the constraint was not tied directly to the column, you must again close all connections and reconnect before NULL input is accepted.

### 15.3.2. Removing a CHECK constraint

If you used a CHECK constraint to make the column non-nullable, you can simply drop it again:

```
alter table Stk drop constraint AmtNotNull
```

If you haven't named the constraint yourself but added the CHECK directly to the column or table, you must first find out its name before you can drop it. This can be done with the `isql` "SHOW TABLE" command (in this case: SHOW TABLE STK). Unlike NOT NULL constraints, CHECKs will also be shown if they were created without a user-defined name.



Dropping a column-based CHECK constraint takes effect immediately. You don't have to disconnect and reconnect to be able to insert values that would have violated the check.

### Removing a domain-based CHECK constraint

You can't disable a domain-based CHECK constraint on the column level (you can add an extra CHECK, but the one from the domain will stay in effect as well). So unless you want to remove the CHECK from the entire domain, you'll have to change the column's data type to a domain or built-in type that allows NULLs, e.g.:

```
alter table Stk alter Amt type bigint
```

# Chapter 16. Changing the nullability of a domain

When you create a domain, you can optionally specify `NOT NULL` and/or a `CHECK` constraint:

```
create domain posint as int not null check (value > 0)
```

Domain constraints cannot be overridden or switched off at the column level, but they can be added to. For instance, you can create a nullable domain but specify `NOT NULL` for certain columns based on that domain. Or you can define an additional `CHECK` on the column level. But sometimes you may want to change the constraints for the entire domain after it has been used for a while. The following paragraphs show you how.

## 16.1. Adding and removing domain-level `CHECK` constraints

If the domain doesn't have a `CHECK` constraint yet, you can add one like this:

```
alter domain MyDomain add constraint check (value is not null)
```

You may leave out the `constraint` keyword if you wish. The added `CHECK` takes effect immediately for all the columns that are based on the domain. However, the check is only applied to new updates and inserts; existing `NULL` data will remain in place and will continue to be shown as `<null>` in result sets.

A domain can have at most one `CHECK` constraint. There is no `ALTER CHECK` statement; if you want to change the `CHECK`, you must drop it and create a new one.

This is how you drop a `CHECK` constraint from a domain:

```
alter domain MyDomain drop constraint
```

You must close all connections and reconnect before you can insert values that would have violated the dropped `CHECK` in `MyDomain`-based columns.

## 16.2. Altering a domain's `NOT NULL` setting

Once a domain is created, Firebird doesn't allow you to add or remove a `NOT NULL` constraint (`DROP CONSTRAINT` will only drop a `CHECK`). If you want to change a domain-wide `NOT NULL` setting, the official procedure is:

1. Create a new domain with the desired characteristics.
2. Switch all the concerned columns over to the new domain.

### 3. Drop the old domain.

This is fine when it only concerns a few columns, but what if there are dozens or even hundreds? It is possible to change the setting by going directly to the system table. Be aware however that Firebird does *not* recommend or support this type of operation, nor is it guaranteed to keep working in future versions. That being said, it's a relatively simple operation and if properly executed it shouldn't cause you any problems.

So here's the SQL, but remember: at your own risk!

```
update rdb$fields
 set rdb$null_flag = <value> where rdb$field_name = '<DomainName>'
```

To make a domain NOT NULL, <value> should be 1. To remove a NOT NULL constraint, use 0 or NULL.

Write the domain name in all-caps if it was created case-insensitively; otherwise, match the case exactly. Don't use double-quotes and don't include the '<>'. Also note that, even when DDL autocommit is on (which is the default in isql and many other clients), this statement won't be autocommitted because technically it's not DDL. So don't forget to commit!

If you have set the flag to 1, a subsequent SHOW DOMAIN will immediately report the domain as being NOT NULL. Likewise, SHOW TABLE will list all columns based on the domain as NOT NULL. But if those columns already contained NULLs, a SELECT still truthfully reports them as such (the result set column is still “described” as nullable)—for now. You won't be able to get any new NULLs in the column though. Close all connections and reconnect, and any illegal NULLs will appear as zeroes (at least in most clients; if this surprises you, read [False reporting of NULLs as zeroes](#), earlier in this guide).

If you have changed the flag from 1 to 0 or NULL—making the domain nullable—SHOW DOMAIN and SHOW TABLE will immediately report the domain and “its” columns as nullable. But you still can't insert NULLs in the columns, and any present NULLs are still shown as zeroes (in most clients). Close all connections and reconnect to straighten everything out.

Lastly, please be warned again that this type of fiddling with the system tables is not recommended or supported by Firebird, and not guaranteed to keep working in future versions. If the number of columns based on the domain is limited, it's better to switch them over to another domain or built-in type and then drop the old domain.

# Chapter 17. Testing for NULL and equality in practice

This section contains some practical tips and examples that may be of use to you in your everyday dealings with NULLs. It concentrates on testing for NULL itself and testing the (in)equality of two things when NULLs may be involved.

## 17.1. Testing for NULL — if it matters

Quite often, you don't need to take special measures for fields or variables that may be NULL. For instance, if you do this:

```
select * from Customers where Town = 'Ralston'
```

you probably don't want to see the customers whose town is unspecified. Likewise:

```
if (Age >= 18) then CanVote = 'Yes'
```

doesn't include people of unknown age, which is also defensible. But:

```
if (Age >= 18) then CanVote = 'Yes';
else CanVote = 'No';
```

seems less justified: if you don't know a person's age, you shouldn't explicitly deny her the right to vote. Worse, this:

```
if (Age < 18) then CanVote = 'No';
else CanVote = 'Yes';
```

won't have the same effect as the previous. If some of the NULL ages are in reality under 18, you're now letting minors vote!

The right approach here is to test for NULL explicitly:

```
if (Age is null) then CanVote = 'Unsure';
else if (Age >= 18) then CanVote = 'Yes';
else CanVote = 'No';
```

Since this code handles more than two possibilities, using the CASE syntax (supported by Firebird 1.5 and up) is more elegant:

```
CanVote = case
 when Age is null then 'Unsure'
 when Age >= 18 then 'Yes'
 else 'No'
end;
```

Or, prettier:

```
CanVote = case
 when Age >= 18 then 'Yes'
 when Age < 18 then 'No'
 else 'Unsure'
end;
```

## 17.2. Equality tests

Sometimes you want to find out if two fields or variables are the same and you want to consider them equal if they are both NULL. The way to do this depends on your Firebird version.

### 17.2.1. Firebird 2.0 and up

In Firebird 2 and higher, you test for null-encompassing equality with DISTINCT. This has already been discussed, but here's a quick recap. Two expressions are considered:

- DISTINCT if they have different values or if one of them is NULL and the other isn't;
- NOT DISTINCT if they have the same value or if both of them are NULL.

[NOT] DISTINCT always returns true or false, never NULL or something else. Examples:

```
if (A is distinct from B) then...
```

```
if (Buyer1 is not distinct from Buyer2) then...
```

[Skip the next section](#) if you're not interested in the pre-Firebird-2 stuff.

### 17.2.2. Earlier Firebird versions

Pre-2.0 versions of Firebird don't support this use of DISTINCT. Consequently, the tests are a little more complicated and there are some pitfalls to avoid.



The correct equality test for pre-2.0 Firebird versions is:

```
if (A = B or A is null and B is null) then...
```

or, if you want to make the precedence of the operations explicit:

```
if ((A = B) or (A is null and B is null)) then...
```

A word of warning though: if exactly one of A and B is NULL, the test expression becomes NULL, not false! This is OK in an if statement, and we can even add an else clause which will be executed if A and B are not equal (including when one is NULL and the other isn't):

```
if (A = B or A is null and B is null)
 then ...stuff to be done if A equals B...
 else ...stuff to be done if A and B are different...
```

But don't get the bright idea of inverting the expression and using it as an inequality test:

```
/* Don't do this! */
if (not(A = B or A is null and B is null))
 then ...stuff to be done if A differs from B...
```

The above code will work correctly if A and B are both NULL or both non-NULL. But it will fail to execute the then clause if exactly one of them is NULL.

If you only want something to be done if A and B are different, either use one of the correct expressions shown above and put a dummy statement in the then clause (starting at 1.5, an empty begin ... end block is also allowed), or use this longer test expression:

```
/* This is a correct inequality test for pre-2 Firebird: */
if (A <> B
 or A is null and B is not null
 or A is not null and B is null) then...
```

Remember, all this is only necessary in pre-2.0 Firebird versions. From version 2 onward, the inequality test is simply “if (A is distinct from B)”.

### 17.2.3. Summary of (in)equality tests

Table 11. Testing (in)equality of A and B in different Firebird versions

| Test type | Firebird version                 |                          |
|-----------|----------------------------------|--------------------------|
|           | <= 1.5.x                         | >= 2.0                   |
| Equality  | A = B or A is null and B is null | A is not distinct from B |

|                   |                                                                            |                      |
|-------------------|----------------------------------------------------------------------------|----------------------|
| <i>Inequality</i> | A <> B<br>or A is null and B is not null<br>or A is not null and B is null | A is distinct from B |
|-------------------|----------------------------------------------------------------------------|----------------------|

Please keep in mind that with Firebird 1.5.x and earlier:

- the equality test returns NULL if exactly one operand is NULL;
- the inequality test returns NULL if both operands are NULL.

In an IF or WHERE context, these NULL results act as false—which is fine for our purposes. But remember that an inversion with NOT() will also return NULL—not “true”. Also, if you use the 1.5-and-earlier tests within CHECK constraints in Firebird 2 or higher, be sure to read the section [CHECK constraints](#), if you haven’t done so already.



Most JOINS are made on equality of fields in different tables, and use the ‘=’ operator. This will leave out all NULL-NULL pairs. If you want NULL to match NULL, pick the equality test for your Firebird version from the table above.

### 17.3. Finding out if a field has changed

In triggers you often want to test if a certain field has changed (including: gone from NULL to non-NULL or vice versa) or stayed the same (including: kept its NULL state). This is nothing but a special case of testing the (in)equality of two fields, so here again our approach depends on the Firebird version.

In Firebird 2 and higher we use this code:

```
if (New.Job is not distinct from Old.Job)
 then ...Job field has stayed the same...
 else ...Job field has changed...
```

And in older versions:

```
if (New.Job = Old.Job or New.Job is null and Old.Job is null)
 then ...Job field has stayed the same...
 else ...Job field has changed...
```

# Chapter 18. Summary

NULL in a nutshell:

- NULL means *unknown*.
- Every field or variable that has been created but not initialised is in a NULL state.
- To exclude NULLs from a domain or column, add “NOT NULL” after the type name.
- To find out if A is NULL, use “A IS [NOT] NULL”.
- Assigning NULL is done like assigning values: with “A = NULL” or an insert list.
- To find out if A and B are the same, with the understanding that all NULLs are the same and different from anything else, use “A IS [NOT] DISTINCT FROM B” in Firebird 2 and up. In earlier versions the tests are:

*equality*

```
A = B or A is null and B is null
```

*inequality*

```
A <> B
or A is null and B is not null
or A is not null and B is null
```

- In Firebird 2 and up you can use NULL literals in just about every situation where a regular value is also allowed. In practice this mainly gives you a lot more rope to hang yourself.
- Most of the time, NULL operands make the entire operation return NULL. Noteworthy exceptions are:
  - “NULL or true” evaluates to true;
  - “NULL and false” evaluates to false.
- The IN, ANY|SOME and ALL predicates may (but do not always) return NULL if either the left-hand side expression or a list/subresult element is NULL.
- The [NOT] EXISTS predicate never returns NULL. The [NOT] SINGULAR predicate never returns NULL in Firebird 2.1 and up. It is broken in all previous versions.
- In aggregate functions only non-NULL fields are involved in the computation. Exception: COUNT(\*).
- In ordered sets, NULLs are placed...
  - 1.0: At the bottom;
  - 1.5: At the bottom, unless NULLS FIRST specified;
  - 2.0: At the “small end” (top if ascending, bottom if descending), unless overridden by NULLS FIRST/LAST.

- If a WHERE or HAVING clause evaluates to NULL, the row is not included in the result set.
- If the test expression of an IF statement is NULL, the THEN block is skipped and the ELSE block executed.
- A CASE statement returns NULL:
  - If the selected result is NULL.
  - If no matches are found (simple CASE) or no conditions are true (searched CASE) and there is no ELSE clause.
- In a simple CASE statement, “CASE <null\_expr>” does *not* match “WHEN <null\_expr>”.
- If the test expression of a WHILE statement evaluates to NULL, the loop is not (re)entered.
- A FOR statement is not exited when NULLs are received. It continues to loop until either all the rows have been processed or it is interrupted by an exception or a loop-breaking PSQL statement.
- In Primary Keys, NULLs are never allowed.
- In Unique Keys and Unique Indices, NULLs are
  - *not allowed* in Firebird 1.0;
  - *allowed* (even multiple) in Firebird 1.5 and higher.
- In Foreign Key columns, multiple NULLs are allowed.
- If a CHECK constraint evaluates to NULL, the input is
  - *rejected* under Firebird 1.5 and earlier;
  - *accepted* under Firebird 2.0 and higher.
- SELECT DISTINCT considers all NULLs equal: in a single-column select, at most one is returned.
- UDFs sometimes convert NULL <=> non-NULL in a seemingly random manner.
- The COALESCE and \*NVL functions can convert NULL to a value.
- The NULLIF family of functions can convert values to NULL.
- If you add a NOT NULL column without a default value to a populated table, all the entries in that column will be NULL upon creation. Most clients however — including Firebird’s isql tool — will falsely report them as zeroes (0 for numerical fields, ' ' for string fields, etc.)
- If you change a column’s datatype to a NOT NULL domain, any existing NULLs in the column will remain NULL. Again most clients — including isql — will show them as zeroes.

Remember, this is how NULL works *in Firebird SQL*. There may be (at times subtle) differences with other RDBMSes.

# Appendix A: NULL-related bugs in Firebird

Attention: both historic and current bugs are listed in the sections below. Always look if and when a bug has been fixed before assuming that it exists in your version of Firebird.

## Bugs that crash the server

### EXECUTE STATEMENT with NULL argument

EXECUTE STATEMENT with a NULL argument crashed Firebird 1.5 and 1.5.1 servers. Fixed in 1.5.2.

### EXTRACT from NULL date

In 1.0.0, EXTRACT from a NULL date would crash the server. Fixed in 1.0.2.

### FIRST and SKIP with NULL argument

FIRST and SKIP crash a Firebird 1.5.n or lower server if given a NULL argument. Fixed in 2.0.

### LIKE with NULL escape

Using LIKE with a NULL escape character would crash the server. Fixed in 1.5.1.

## Other bugs

### NULLs in NOT NULL columns

NULLs can exist in NOT NULL columns in the following situations:

- If you add a NOT NULL column to a populated table, the fields in the newly added column will all be NULL.
- If you make an existing column NOT NULL, any NULLs already present in the column will remain in that state.

Firebird allows these NULLs to stay, also backs them up, but refuses to restore them with gbak. See [Adding a NOT NULL field](#) and [Making an existing column NOT NULL](#).

### Illegal NULLs returned as 0, '', etc.

If a NOT NULL column contains NULLs (see previous bug), the server will still describe it as non-nullable to the client. Since most clients don't question this assurance from the server, they will

present these NULLs as 0 (or equivalent) to the user. See [False reporting of NULLs as zeroes](#).

## Primary key with NULL entries

The following bug appeared in Firebird 1.5: if you had a table with some rows and you added a NOT NULL column (which automatically creates NULL entries in the existing rows — see above), you could make that column the primary key even though it had NULL entries. In 1.0 this didn't work because of the stricter rules for UNIQUE indices. Fixed in 2.0.

## SUBSTRING results described as non-nullable

The engine describes SUBSTRING result columns as non-nullable in the following two cases:

- If the first argument is a string literal, as in “SUBSTRING( 'Ootchie-coo' FROM 5 FOR 2 )”.
- If the first argument is a NOT NULL column.

This is incorrect because even with a known string, substrings may be NULL, namely if the one of the other arguments is NULL. In versions 1.\* this bug didn't bite: the FROM and FOR args had to be literal values, so they could never be NULL. But as from Firebird 2, any expression that resolves to the required data type is allowed. And although the engine correctly returns NULL whenever any argument is NULL, it *describes* the result column as non-nullable, so most clients show the result as an empty string.

This bug seems to be fixed in 2.1.

## Gbak -n restoring NOT NULL

Gbak -n[o\_validity] restored NOT NULL constraints in early Firebird versions. Fixed in 1.5.1.

## IN, = ANY and = SOME with indexed subselect

Let A be the expression on the left-hand side and S the result set of the subselect. In versions prior to 2.0, “IN”, “= ANY” and “= SOME” return false instead of NULL if an index is active on the subselect column and:

- either A is NULL and S doesn't contain any NULLs;
- or A is not NULL, A is not found in S, and S contains at least one NULL.

See the warnings in the [IN](#) and [ANY](#) sections. Workaround: use “<> ALL” instead. Fixed in 2.0.

## ALL with indexed subselect

With every operator except '<>', ALL may return wrong results if an index is active on the subselect column. This can happen with or without NULLs involved. See the [ALL bug warning](#). Fixed in 2.0.

## SELECT DISTINCT with wrong NULLS FIRST|LAST ordering

Firebird 2.0 has the following bug: if a SELECT DISTINCT is combined with an [ASC] NULLS LAST or DESC NULLS FIRST ordering, and the ordering field(s) form(s) the beginning (but not the whole) of the select list, every field in the ORDER BY clause that is followed by a field with a different (or no) ordering gets the NULLs placed at the default relative location, ignoring the NULLS XXX directive. Fixed in 2.0.1 and 2.1.

## UDFs returning values when they should return NULL

This should definitely be considered a bug. If an angle is unknown, *don't* tell me that its cosine is 1! Although the history of these functions is known and we can understand why they behave like they do (see [User-Defined Functions \(UDFs\)](#)), it's still wrong. Incorrect results are returned and this should not happen. Most of the math functions in `ib_udf`, as well as some others, have this bug.

## UDFs returning NULL when they should return a value

This is the complement of the previous bug. LPAD for instance returns NULL if you want to pad an empty string with 10 dots. This function and others are fixed in 2.0, with the annotation that you must explicitly declare them with the NULL keyword or they'll show the old —buggy— behaviour. LTRIM and RTRIM trim empty strings to NULL in Firebird 1.0.n. This is fixed in 1.5 at the expense of returning ' ' when trimming a NULL string, and only fully fixed in 2.0 (if declared with the NULL keyword).

## SINGULAR inconsistent with NULL results

NOT SINGULAR sometimes returns NULL where SINGULAR returns true or false. Fixed in 2.0.

SINGULAR may wrongly return NULL, in an inconsistent but reproducible manner. Fixed in 2.1.

See the section on [SINGULAR](#).

## Appendix B: Document history

The exact file history is recorded in the firebird-documentation git repository; see <https://github.com/FirebirdSQL/firebird-documentation>

### Revision History

---

- |       |                |    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------|----------------|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 0.1   | 8 Apr<br>2005  | PV | First edition.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| 0.2   | 15 Apr<br>2005 | PV | <p>Mentioned that Fb 2.0 legalises “A = NULL” comparisons.</p> <p>Changed text in “Testing if something is NULL”.</p> <p>Slightly altered “Dealing with NULLs” section.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| 1.0   | 24 Jan<br>2007 | PV | <p>This is a major update, with so much new material added that the document has grown to around 4 times its former size. In addition, much of the existing text has been reorganised and thoroughly reworked. It’s not feasible to give a summary of all the changes here. Consider this a new guide with 15–25% old material. The most important additions are:</p> <p style="padding-left: 2em;">* NULL literals * IS [NOT] DISTINCT FROM * Internal functions and directives * Predicates: IN, ANY, SOME, ALL, EXISTS, SINGULAR * Searches (WHERE) * Sorts (ORDER BY) * GROUP BY and HAVING * CASE, WHILE and FOR * Keys and indices * CHECK constraints * SELECT DISTINCT * Converting values to NULL with NULLIF * Altering populated tables * Bugs list * Alphabetical index</p> |
| 1.0.1 | 26 Jan<br>2007 | PV | <p><i>Making non-nullable columns nullable again</i>: Provisory fix of error regarding removal of NOT NULL constraints.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |



---

**Revision History**


---

- 1.1 13 Oct 2011 PV *What is NULL?: Added subsection NULL as a default state.*
- NULL support in Firebird SQL :: Assigning NULL: Added 4th example.*
- Predicates :: EXISTS and SINGULAR: “evolves” → “evaluates” (2x) in Note.*
- Altering populated tables :: Adding a non-nullable field to a populated table :: Adding a NOT NULL field: Added para + additional programlisting after first programlisting.*
- Altering populated tables :: Adding a non-nullable field to a populated table :: Adding a CHECKed column: Added second Note.*
- Altering populated tables :: Adding a non-nullable field to a populated table :: Adding a non-nullable field using domains: Renamed section to Using domains to add a non-nullable field.*
- Altering populated tables :: Adding a non-nullable field to a populated table :: Using domains to add a non-nullable field: Two programlistings instead of one. Text heavily edited and extended.*
- Altering populated tables :: Making existing columns non-nullable :: Making an existing column NOT NULL: Added Warning.*
- Altering populated tables :: Making non-nullable columns nullable again: Largely rewritten, greatly extended and divided into subsections.*
- Changing the nullability of a domain :: New top-level section. For free!*
- Summary: Added “Every field or variable that has been created but not initialised is in a NULL state” as second listitem.*
- 1.2 30 Jun 2020 MR Conversion to AsciiDoc, minor copy-editing
- Removed section *FSQL* as linked page no longer exists and no alternative location found.

## Appendix C: License notice

The contents of this Documentation are subject to the Public Documentation License Version 1.0 (the “License”); you may only use this Documentation if you comply with the terms of this License. Copies of the License are available at <https://www.firebirdsql.org/pdfmanual/pdl.pdf> (PDF) and <https://www.firebirdsql.org/manual/pdl.html> (HTML).

The Original Documentation is titled *Firebird Null Guide*.

The Initial Writer of the Original Documentation is: Paul Vinkenoog.

Copyright © 2005–2020. All Rights Reserved. Initial Writer contact: paulvink at users dot sourceforge dot net.

# Alphabetical index

## A

Adding CHECKed columns, 46  
 Adding non-nullable columns, 44  
 Adding NOT NULL columns, 44  
   using domains, 47  
 Aggregate functions, 25  
   GROUP BY, 26  
   HAVING, 27  
 ALL, 17  
   bug with indexed subselect, 61  
   results, 19  
 Altering tables, 44  
 AND operator, 10  
 ANY, 17  
   bug with indexed subselect, 61  
   results, 18  
 Assigning NULL, 7  
 AVG, 25

## B

Backup, 44  
 BETWEEN, 10  
 Boolean operations, 10  
 Bugs list, 60  
   other bugs, 60  
   server-crashers, 60

## C

CASE, 30  
 CHECK  
   remove, 50  
   via domain  
     remove, 50  
 CHECK constraints, 17, 35  
 COALESCE, 41  
 Comparison operations, 9  
 Conjunctions, 11  
 CONTAINING, 10  
 Conversions, 41  
   from a value to NULL, 42  
     NULLIF internal function, 42  
     NULLIF UDFs, 43  
   from NULL to a value, 41  
     COALESCE, 41  
     NVL functions, 41

unwanted, 38  
   prepare for, 40

COUNT, 25

## D

Descriptors, 38  
 Directives, 13  
 Disjunctions, 11  
 DISTINCT  
   SELECT DISTINCT, 24, 37, 62  
   testing distinctness, 7, 55

## E

Equality tests, 55  
   in Firebird 1.\*, 55  
   in Firebird 2+, 55  
   summary, 56  
 EXISTS, 20

## F

False, 10  
   beating NULL, 11  
 FIRST, 13  
 FOR loops, 31  
 Foreign keys, 33  
 Functions  
   aggregate, 25  
     GROUP BY, 26  
   internal, 13

## G

gbak, 44  
   -n switch, 46  
 GROUP BY, 26

## H

HAVING, 27

## I

IF statements, 29  
 IN  
   bug with indexed subselect, 61  
 IN predicate, 14  
   in CHECK constraints, 17  
   results, 16

- Indices, 33
  - unique, 33
- Internal functions, 13
- IS [NOT] DISTINCT FROM, 7, 55
- IS [NOT] NULL, 6
- J**
- JOIN, 57
- K**
- Keys, 33, 33
  - foreign, 33
  - primary, 33
  - unique, 33
- L**
- LIKE, 10
- LIST, 25
- M**
- Mathematical operations, 9
- MAX, 25
- MIN, 25
- N**
- NOT NULL, 6
  - direct, 44
  - remove, 49
  - via domain, 47
    - add, 48
    - remove, 50
- NOT operator, 10
- NULL, 4
  - and GROUP BY, 26
  - as a default, 4
  - assign, 7
  - bugs, 60
  - conversions from, 41
  - conversions to, 42
  - conversions to/from, 41
  - disallow, 6
  - falsely reported as 0, 45
  - in a nutshell, 58
  - in aggregate functions, 25
  - in boolean operations, 10
  - in CHECK constraints, 35
  - in conjunctions, 11
  - in disjunctions, 11
  - in foreign keys, 33
  - in IF statements, 29
  - in indices, 33
  - in internal functions, 13
  - in JOINS, 57
  - in keys, 33
  - in NOT NULL columns, 44
  - in operations, 9
  - in primary keys, 33
  - in searches, 22
  - in sorts, 24
  - in UDFs, 38
  - in unique keys and indices, 33
  - literal, 8
  - NULL keyword in UDFs, 39
  - test for, 6
    - in practice, 54
  - What is it?, 4
  - with IN(), 14
- NULL keyword in UDFs, 39
- NULLIF internal function, 42
- NULLIF UDFs, 43
- NULLS FIRST, 24
- NULLS LAST, 24
- NVL functions, 41
- O**
- OR operator, 10
- ORDER BY, 24
- Ordering, 24
- P**
- Predicates, 14
  - ANY, SOME and ALL, 17
    - results, 18
  - EXISTS, 20
  - IN, 14
    - results, 16
  - SINGULAR, 20
- Primary keys, 33
- R**
- Restoring
  - problem with NULLs, 44
    - solution, 46
- ROWS, 13

**S**

Searches, [22](#)  
SELECT DISTINCT, [24](#), [37](#), [62](#)  
SINGULAR, [20](#)  
SKIP, [13](#)  
SOME, [17](#)  
    bug with indexed subselect, [61](#)  
    results, [18](#)  
Sorting, [24](#)  
STARTING WITH, [10](#)  
String operations, [9](#)  
SUM, [25](#)  
Summary, [58](#)

**T**

## Tables

    add CHECK to columns, [48](#)  
    add CHECKed columns, [46](#)  
    add non-nullable columns, [44](#)  
    add NOT NULL columns, [44](#)  
        using domains, [47](#)  
    altering, [44](#)  
    make columns non-nullable, [47](#)  
    make columns NOT NULL, [48](#)  
    make columns nullable, [48](#)  
Testing for NULL, [6](#)  
    in practice, [54](#)  
True, [10](#)  
    beating NULL, [11](#)

**U**UDFs, [38](#)

    by descriptor, [38](#)  
    links, [40](#)  
    NULLIF functions, [43](#)  
    NVL functions, [41](#)  
    unwanted conversions, [38](#)  
        prepare for, [40](#)  
    with NULL keyword, [39](#)  
Unique indices, [33](#)  
Unique keys, [33](#)

**W**

WHERE, [22](#)  
WHILE loops, [31](#)