Information technology — Database languages — SQL —

Part 2:
Foundation (SQL/Foundation)

Technologies de l'information — Langages de base de données —
SQL —

Partie 2: Fondations (SQL/Fondations)
# Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>xxii</td>
</tr>
<tr>
<td>Introduction</td>
<td>xxiii</td>
</tr>
<tr>
<td>1 Scope</td>
<td>1</td>
</tr>
<tr>
<td>2 Normative References</td>
<td>3</td>
</tr>
<tr>
<td>2.1 ISO and IEC standards</td>
<td>3</td>
</tr>
<tr>
<td>2.2 Other International Standards</td>
<td>4</td>
</tr>
<tr>
<td>3 Definitions, Notations, and Conventions</td>
<td>5</td>
</tr>
<tr>
<td>3.1 Definitions</td>
<td>5</td>
</tr>
<tr>
<td>3.1.1 Definitions taken from [ISO10646]</td>
<td>5</td>
</tr>
<tr>
<td>3.1.2 Definitions taken from [ISO14651]</td>
<td>5</td>
</tr>
<tr>
<td>3.1.3 Definitions taken from [Unicode]</td>
<td>5</td>
</tr>
<tr>
<td>3.1.4 Definitions taken from [ISO8601]</td>
<td>6</td>
</tr>
<tr>
<td>3.1.5 Definitions taken from [ISO9075-1]</td>
<td>6</td>
</tr>
<tr>
<td>3.1.6 Definitions provided in Part 2</td>
<td>7</td>
</tr>
<tr>
<td>3.2 Notation</td>
<td>13</td>
</tr>
<tr>
<td>3.3 Conventions</td>
<td>13</td>
</tr>
<tr>
<td>3.3.1 Use of terms</td>
<td>13</td>
</tr>
<tr>
<td>3.3.1.1 Other terms</td>
<td>14</td>
</tr>
<tr>
<td>4 Concepts</td>
<td>15</td>
</tr>
<tr>
<td>4.1 Data types</td>
<td>15</td>
</tr>
<tr>
<td>4.1.1 General introduction to data types</td>
<td>15</td>
</tr>
<tr>
<td>4.1.2 Naming of predefined types</td>
<td>16</td>
</tr>
<tr>
<td>4.1.3 Host language data types</td>
<td>17</td>
</tr>
<tr>
<td>4.1.4 Data type terminology</td>
<td>17</td>
</tr>
<tr>
<td>4.1.5 Properties of distinct</td>
<td>19</td>
</tr>
<tr>
<td>4.2 Character strings</td>
<td>20</td>
</tr>
<tr>
<td>4.2.1 Introduction to character strings</td>
<td>20</td>
</tr>
<tr>
<td>4.2.2 Comparison of character strings</td>
<td>21</td>
</tr>
<tr>
<td>4.2.3 Operations involving character strings</td>
<td>22</td>
</tr>
<tr>
<td>4.2.3.1 Regular expression syntaxes</td>
<td>22</td>
</tr>
<tr>
<td>4.2.3.2 Operators that operate on character strings and return character strings</td>
<td>22</td>
</tr>
<tr>
<td>4.2.3.3 Other operators involving character strings</td>
<td>24</td>
</tr>
<tr>
<td>4.2.3.4 Operations involving large object character strings</td>
<td>25</td>
</tr>
<tr>
<td>4.2.4 Character repertoires</td>
<td>26</td>
</tr>
<tr>
<td>4.2.5 Character encoding forms</td>
<td>27</td>
</tr>
</tbody>
</table>
## ISO/IEC 9075-2:2016(E)

4.2.6 Collations ................................................................. 28
4.2.7 Character sets ............................................................ 29
4.2.8 Universal character sets ............................................... 31
4.3 Binary strings .............................................................. 31
4.3.1 Introduction to binary strings ......................................... 31
4.3.2 Binary string comparison ............................................. 31
4.3.3 Operations involving binary strings .................................. 32
4.3.3.1 Operators that operate on binary strings and return binary strings ...................................................... 32
4.3.3.2 Other operators involving binary strings ......................... 32
4.4 Numbers .................................................................. 33
4.4.1 Introduction to numbers ............................................... 33
4.4.2 Characteristics of numbers ............................................. 33
4.4.3 Operations involving numbers ....................................... 35
4.5 Boolean types ............................................................... 36
4.5.1 Introduction to Boolean types ......................................... 36
4.5.2 Comparison and assignment of booleans ......................... 36
4.5.3 Operations involving booleans ....................................... 37
4.5.3.1 Operations on booleans that return booleans .................... 37
4.5.3.2 Other operators involving booleans ............................... 37
4.6 Datetimes and intervals .................................................. 37
4.6.1 Introduction to datetimes and intervals ............................. 37
4.6.2 Datetimes ................................................................. 38
4.6.3 Intervals ................................................................ 40
4.6.4 Operations involving datetimes and intervals .................... 42
4.7 User-defined types .......................................................... 43
4.7.1 Introduction to user-defined types ................................. 43
4.7.2 Distinct types ........................................................... 43
4.7.3 Structured types ........................................................ 44
4.7.3.1 Introduction to structured types ................................. 44
4.7.3.2 Observer functions and mutator functions .................... 44
4.7.3.3 Constructors ........................................................ 44
4.7.3.4 Subtypes and supertypes ........................................... 45
4.7.4 Methods ................................................................. 46
4.7.5 User-defined type comparison and assignment .................. 47
4.7.6 Transforms for user-defined types ................................... 48
4.7.7 User-defined type descriptor .......................................... 48
4.8 Row types ................................................................ 50
4.9 Reference types ............................................................ 50
4.9.1 Introduction to reference types ....................................... 50
4.9.2 Operations involving references ..................................... 51
4.10 Collection types .......................................................... 52
4.10.1 Introduction to collection types ..................................... 52
4.10.2 Arrays .................................................................. 52
4.10.3 Multisets ................................................................. 53
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.10.4 Collection comparison and assignment</td>
<td>53</td>
</tr>
<tr>
<td>4.10.5 Operations involving arrays</td>
<td>53</td>
</tr>
<tr>
<td>4.10.5.1 Operators that operate on array values and return array elements</td>
<td>53</td>
</tr>
<tr>
<td>4.10.5.2 Operators that operate on array values and return array values</td>
<td>54</td>
</tr>
<tr>
<td>4.10.5.3 Operators that operate on array values and return numbers</td>
<td>54</td>
</tr>
<tr>
<td>4.10.6 Operations involving multisets</td>
<td>54</td>
</tr>
<tr>
<td>4.10.6.1 Operators that operate on multisets and return multiset elements</td>
<td>54</td>
</tr>
<tr>
<td>4.10.6.2 Operators that operate on multisets and return multisets</td>
<td>54</td>
</tr>
<tr>
<td>4.10.6.3 Operators that operate on multiset values and return numbers</td>
<td>54</td>
</tr>
<tr>
<td>4.11 Data conversions</td>
<td>55</td>
</tr>
<tr>
<td>4.12 Domains</td>
<td>56</td>
</tr>
<tr>
<td>4.13 Columns, fields, and attributes</td>
<td>56</td>
</tr>
<tr>
<td>4.14 Periods</td>
<td>58</td>
</tr>
<tr>
<td>4.14.1 Introduction to periods</td>
<td>58</td>
</tr>
<tr>
<td>4.14.2 Operations involving periods</td>
<td>59</td>
</tr>
<tr>
<td>4.15 Tables</td>
<td>59</td>
</tr>
<tr>
<td>4.15.1 Introduction to tables</td>
<td>59</td>
</tr>
<tr>
<td>4.15.2 Base tables</td>
<td>60</td>
</tr>
<tr>
<td>4.15.2.1 Regular persistent base tables</td>
<td>60</td>
</tr>
<tr>
<td>4.15.2.2 System-versioned tables</td>
<td>60</td>
</tr>
<tr>
<td>4.15.2.3 Temporary tables</td>
<td>60</td>
</tr>
<tr>
<td>4.15.3 Derived tables</td>
<td>61</td>
</tr>
<tr>
<td>4.15.4 Transient tables</td>
<td>62</td>
</tr>
<tr>
<td>4.15.5 Unique identification of tables</td>
<td>62</td>
</tr>
<tr>
<td>4.15.6 Table updatability</td>
<td>62</td>
</tr>
<tr>
<td>4.15.7 Table descriptors</td>
<td>63</td>
</tr>
<tr>
<td>4.15.8 Syntactic analysis of derived tables and cursors</td>
<td>65</td>
</tr>
<tr>
<td>4.15.9 Referenceable tables, subtables, and supertables</td>
<td>67</td>
</tr>
<tr>
<td>4.15.10 Operations involving tables</td>
<td>68</td>
</tr>
<tr>
<td>4.15.11 Range variables</td>
<td>70</td>
</tr>
<tr>
<td>4.15.12 Identity columns</td>
<td>71</td>
</tr>
<tr>
<td>4.15.13 Base columns and generated columns</td>
<td>72</td>
</tr>
<tr>
<td>4.15.14 Grouped tables</td>
<td>72</td>
</tr>
<tr>
<td>4.15.15 Windowed tables</td>
<td>72</td>
</tr>
<tr>
<td>4.16 Data analysis operations (involving tables)</td>
<td>74</td>
</tr>
<tr>
<td>4.16.1 Introduction to data analysis operations</td>
<td>74</td>
</tr>
<tr>
<td>4.16.2 Group functions</td>
<td>74</td>
</tr>
<tr>
<td>4.16.3 Window functions</td>
<td>74</td>
</tr>
<tr>
<td>4.16.4 Aggregate functions</td>
<td>77</td>
</tr>
<tr>
<td>4.16.5 Row pattern measures</td>
<td>79</td>
</tr>
<tr>
<td>4.17 Row pattern matching</td>
<td>80</td>
</tr>
<tr>
<td>4.17.1 Matching rows with a pattern</td>
<td>80</td>
</tr>
<tr>
<td>4.17.2 Row pattern matching illustrated</td>
<td>82</td>
</tr>
<tr>
<td>4.17.3 Row pattern partitioning</td>
<td>85</td>
</tr>
</tbody>
</table>
ISO/IEC 9075-2:2016(E)

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.17.4</td>
<td>Row ordering</td>
<td>85</td>
</tr>
<tr>
<td>4.17.5</td>
<td>Row pattern measure columns</td>
<td>85</td>
</tr>
<tr>
<td>4.17.6</td>
<td>Number of rows per match</td>
<td>85</td>
</tr>
<tr>
<td>4.17.7</td>
<td>Skipping rows after matching</td>
<td>86</td>
</tr>
<tr>
<td>4.18</td>
<td>Row patterns</td>
<td>86</td>
</tr>
<tr>
<td>4.19</td>
<td>Unions of row pattern variables</td>
<td>88</td>
</tr>
<tr>
<td>4.20</td>
<td>Defining Boolean conditions</td>
<td>88</td>
</tr>
<tr>
<td>4.21</td>
<td>Scalar expressions in row pattern matching</td>
<td>89</td>
</tr>
<tr>
<td>4.21.1</td>
<td>Running vs. final semantics</td>
<td>89</td>
</tr>
<tr>
<td>4.21.2</td>
<td>Row pattern navigation operations</td>
<td>89</td>
</tr>
<tr>
<td>4.21.3</td>
<td>Row pattern classifier function</td>
<td>90</td>
</tr>
<tr>
<td>4.21.4</td>
<td>Row pattern match number function</td>
<td>90</td>
</tr>
<tr>
<td>4.22</td>
<td>Determinism</td>
<td>90</td>
</tr>
<tr>
<td>4.23</td>
<td>Integrity constraints</td>
<td>91</td>
</tr>
<tr>
<td>4.23.1</td>
<td>Overview of integrity constraints</td>
<td>91</td>
</tr>
<tr>
<td>4.23.2</td>
<td>Checking of constraints</td>
<td>92</td>
</tr>
<tr>
<td>4.23.3</td>
<td>Table constraints</td>
<td>92</td>
</tr>
<tr>
<td>4.23.3.1</td>
<td>Introduction to table constraints</td>
<td>92</td>
</tr>
<tr>
<td>4.23.3.2</td>
<td>Unique constraints</td>
<td>93</td>
</tr>
<tr>
<td>4.23.3.3</td>
<td>Referential constraints</td>
<td>93</td>
</tr>
<tr>
<td>4.23.3.4</td>
<td>Table check constraints</td>
<td>96</td>
</tr>
<tr>
<td>4.23.4</td>
<td>Domain constraints</td>
<td>96</td>
</tr>
<tr>
<td>4.23.5</td>
<td>Assertions</td>
<td>97</td>
</tr>
<tr>
<td>4.24</td>
<td>Functional dependencies</td>
<td>97</td>
</tr>
<tr>
<td>4.24.1</td>
<td>Overview of functional dependency rules and notations</td>
<td>98</td>
</tr>
<tr>
<td>4.24.2</td>
<td>General rules and definitions</td>
<td>98</td>
</tr>
<tr>
<td>4.24.3</td>
<td>Known functional dependencies in a base table</td>
<td>99</td>
</tr>
<tr>
<td>4.24.4</td>
<td>Known functional dependencies in a viewed table</td>
<td>99</td>
</tr>
<tr>
<td>4.24.5</td>
<td>Known functional dependencies in a transition table</td>
<td>100</td>
</tr>
<tr>
<td>4.24.6</td>
<td>Known functional dependencies in a table value constructor</td>
<td>100</td>
</tr>
<tr>
<td>4.24.7</td>
<td>Known functional dependencies in a joined table</td>
<td>100</td>
</tr>
<tr>
<td>4.24.8</td>
<td>Known functional dependencies in a table primary</td>
<td>102</td>
</tr>
<tr>
<td>4.24.9</td>
<td>Known functional dependencies in a table factor</td>
<td>103</td>
</tr>
<tr>
<td>4.24.10</td>
<td>Known functional dependencies in a table reference</td>
<td>103</td>
</tr>
<tr>
<td>4.24.11</td>
<td>Known functional dependencies in the result of a from clause</td>
<td>103</td>
</tr>
<tr>
<td>4.24.12</td>
<td>Known functional dependencies in the result of a where clause</td>
<td>104</td>
</tr>
<tr>
<td>4.24.13</td>
<td>Known functional dependencies in the result of a group by clause</td>
<td>104</td>
</tr>
<tr>
<td>4.24.14</td>
<td>Known functional dependencies in the result of a having clause</td>
<td>105</td>
</tr>
<tr>
<td>4.24.15</td>
<td>Known functional dependencies in a query specification</td>
<td>105</td>
</tr>
<tr>
<td>4.24.16</td>
<td>Known functional dependencies in a query expression</td>
<td>106</td>
</tr>
<tr>
<td>4.25</td>
<td>Candidate keys</td>
<td>106</td>
</tr>
<tr>
<td>4.26</td>
<td>SQL-schemas</td>
<td>107</td>
</tr>
<tr>
<td>4.27</td>
<td>Sequence generators</td>
<td>108</td>
</tr>
<tr>
<td>4.27.1</td>
<td>General description of sequence generators</td>
<td>108</td>
</tr>
</tbody>
</table>
### 4.39 SQL-statement atomicity and statement execution contexts
- 4.39.5 SQL-statement atomicity and statement execution contexts .................................................. 148
- 4.39.6 Embeddable SQL-statements .................................................................................................... 149
- 4.39.7 Preparable and immediately executable SQL-statements ............................................................ 151
- 4.39.8 Directly executable SQL-statements ............................................................................................ 153

### 4.40 Basic security model
- 4.40.1 Authorization identifiers ............................................................................................................ 154
  - 4.40.1.1 SQL-session authorization identifiers ................................................................................. 154
  - 4.40.1.2 SQL-client module authorization identifiers ................................................................. 155
  - 4.40.1.3 SQL-schema authorization identifiers ............................................................................. 155
- 4.40.2 Privileges .................................................................................................................................. 158
- 4.40.3 Roles ........................................................................................................................................ 158
- 4.40.4 Security model definitions ........................................................................................................ 158

### 4.41 SQL-transactions
- 4.41.1 General description of SQL-transactions .................................................................................. 159
- 4.41.2 Savepoints .................................................................................................................................. 160
- 4.41.3 Properties of SQL-transactions .................................................................................................. 160
- 4.41.4 Isolation levels of SQL-transactions ............................................................................................ 161
- 4.41.5 Implicit rollbacks ....................................................................................................................... 162
- 4.41.6 Effects of SQL-statements in an SQL-transaction ........................................................................ 163
- 4.41.7 Encompassing transactions ........................................................................................................ 163
  - 4.41.7.1 Encompassing transaction belonging to an external agent ............................................... 163
  - 4.41.7.2 Encompassing transaction belonging to the SQL-agent ..................................................... 164
- 4.42 SQL-connections .......................................................................................................................... 164
- 4.43 SQL-sessions ................................................................................................................................... 165
  - 4.43.1 General description of SQL-sessions ....................................................................................... 165
  - 4.43.2 SQL-session identification ........................................................................................................ 166
  - 4.43.3 SQL-session properties ............................................................................................................. 167
  - 4.43.4 SQL-session context management ............................................................................................ 169
  - 4.43.5 Execution contexts ................................................................................................................ 169
- 4.43.6 Routine execution context .......................................................................................................... 170
- 4.44 Triggers ........................................................................................................................................ 170
  - 4.44.1 General description of triggers ................................................................................................. 170
  - 4.44.2 Trigger execution .................................................................................................................... 172
- 4.45 Client-server operation ............................................................................................................... 174
- 4.46 JSON data handling in SQL
  - 4.46.1 Introduction ............................................................................................................................ 174
  - 4.46.2 Implied JSON data model ......................................................................................................... 175
  - 4.46.3 SQL/JSON data model .............................................................................................................. 176
  - 4.46.4 SQL/JSON functions ................................................................................................................ 177
- 4.46.5 Overview of SQL/JSON path language .................................................................................... 178

### 5 Lexical elements
- 5.1 <SQL terminal character> .............................................................................................................. 181
- 5.2 <token> and <separator> ................................................................................................................ 185
### 6 Scalar expressions

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>data type</td>
</tr>
<tr>
<td>6.2</td>
<td>field definition</td>
</tr>
<tr>
<td>6.3</td>
<td>value expression primary</td>
</tr>
<tr>
<td>6.4</td>
<td>value specification and target specification</td>
</tr>
<tr>
<td>6.5</td>
<td>contextually typed value specification</td>
</tr>
<tr>
<td>6.6</td>
<td>identifier chain</td>
</tr>
<tr>
<td>6.7</td>
<td>column reference</td>
</tr>
<tr>
<td>6.8</td>
<td>SQL parameter reference</td>
</tr>
<tr>
<td>6.9</td>
<td>set function specification</td>
</tr>
<tr>
<td>6.10</td>
<td>window function</td>
</tr>
<tr>
<td>6.11</td>
<td>nested window function</td>
</tr>
<tr>
<td>6.12</td>
<td>case expression</td>
</tr>
<tr>
<td>6.13</td>
<td>cast specification</td>
</tr>
<tr>
<td>6.14</td>
<td>next value expression</td>
</tr>
<tr>
<td>6.15</td>
<td>field reference</td>
</tr>
<tr>
<td>6.16</td>
<td>subtype treatment</td>
</tr>
<tr>
<td>6.17</td>
<td>method invocation</td>
</tr>
<tr>
<td>6.18</td>
<td>static method invocation</td>
</tr>
<tr>
<td>6.19</td>
<td>new specification</td>
</tr>
<tr>
<td>6.20</td>
<td>attribute or method reference</td>
</tr>
<tr>
<td>6.21</td>
<td>dereference operation</td>
</tr>
<tr>
<td>6.22</td>
<td>method reference</td>
</tr>
<tr>
<td>6.23</td>
<td>reference resolution</td>
</tr>
<tr>
<td>6.24</td>
<td>array element reference</td>
</tr>
<tr>
<td>6.25</td>
<td>multiset element reference</td>
</tr>
<tr>
<td>6.26</td>
<td>row pattern navigation operation</td>
</tr>
<tr>
<td>6.27</td>
<td>JSON value function</td>
</tr>
<tr>
<td>6.28</td>
<td>value expression</td>
</tr>
<tr>
<td>6.29</td>
<td>numeric value expression</td>
</tr>
<tr>
<td>6.30</td>
<td>numeric value function</td>
</tr>
<tr>
<td>6.31</td>
<td>string value expression</td>
</tr>
<tr>
<td>6.32</td>
<td>string value function</td>
</tr>
<tr>
<td>6.33</td>
<td>JSON value constructor</td>
</tr>
<tr>
<td>6.34</td>
<td>JSON query</td>
</tr>
<tr>
<td>6.35</td>
<td>datetime value expression</td>
</tr>
<tr>
<td>6.36</td>
<td>datetime value function</td>
</tr>
<tr>
<td>6.37</td>
<td>interval value expression</td>
</tr>
<tr>
<td>6.38</td>
<td>interval value function</td>
</tr>
<tr>
<td>6.39</td>
<td>boolean value expression</td>
</tr>
<tr>
<td>6.40</td>
<td>array value expression</td>
</tr>
</tbody>
</table>
### QUERY EXPRESSIONS

- **7.1** `<row value constructor>` .......................... 395
- **7.2** `<row value expression>` .......................... 398
- **7.3** `<table value constructor>` ......................... 400
- **7.4** `<table expression>` ................................. 402
- **7.5** `<from clause>` ..................................... 403
- **7.6** `<table reference>` .................................. 406
- **7.7** `<row pattern recognition clause>` ............... 425
- **7.8** `<row pattern measures>` ............................ 431
- **7.9** `<row pattern common syntax>` ................. 433
- **7.10** `<joined table>` .................................. 438
- **7.11** `<JSON table>` ..................................... 449
- **7.12** `<where clause>` .................................. 464
- **7.13** `<group by clause>` ................................. 465
- **7.14** `<having clause>` .................................. 474
- **7.15** `<window clause>` ................................ 476
- **7.16** `<query specification>` ............................. 491
- **7.17** `<query expression>` .............................. 502
- **7.18** `<search or cycle clause>` ......................... 520
- **7.19** `<subquery>` ....................................... 525

### PREDICATES

- **8.1** `<predicate>` ......................................... 527
- **8.2** `<comparison predicate>` ........................... 529
- **8.3** `<between predicate>` ............................... 537
- **8.4** `<in predicate>` ..................................... 538
- **8.5** `<like predicate>` .................................... 540
- **8.6** `<similar predicate>` ................................ 546
- **8.7** `<regex like predicate>` .............................. 552
- **8.8** `<null predicate>` .................................... 554
- **8.9** `<quantified comparison predicate>` ............. 556
- **8.10** `<exists predicate>` ................................ 558
- **8.11** `<unique predicate>` ............................... 559
- **8.12** `<normalized predicate>` ......................... 560
- **8.13** `<match predicate>` ............................... 562
- **8.14** `<overlaps predicate>` ............................ 565
- **8.15** `<distinct predicate>` ............................. 567
- **8.16** `<member predicate>` ............................. 570
- **8.17** `<submultiset predicate>` ......................... 572
ISO/IEC 9075-2:2016(E)

10. Additional common elements. ................................................................. 745
10.1 <interval qualifier>. ............................................................................. 745
10.2 <language clause>. ............................................................................. 749
10.3 <path specification>. .......................................................................... 751
10.4 <routine invocation>. ......................................................................... 752
10.5 <character set specification>. ............................................................... 784
10.6 <specific routine designator>. ............................................................... 786
10.7 <collate clause>. ................................................................................ 789
10.8 <constraint name definition> and <constraint characteristics>. .......... 790
10.9 <aggregate function>. ........................................................................ 792
10.10 <sort specification list>. ..................................................................... 809
10.11 <JSON aggregate function>. ................................................................. 812
10.12 <JSON value expression>. .................................................................. 817
10.13 <JSON output clause>. ....................................................................... 819
10.14 <JSON API common syntax>. ............................................................... 821

11. Schema definition and manipulation. ..................................................... 823
11.1 <schema definition>. .......................................................................... 823
11.2 <drop schema statement>. ................................................................ 826
11.3 <table definition>. ............................................................................. 829
11.4 <column definition>. .......................................................................... 842
11.5 <default clause>. ................................................................................. 848
11.6 <table constraint definition>. ................................................................. 852
11.7 <unique constraint definition>. ............................................................ 854
11.8 <referential constraint definition>. ....................................................... 857
11.9 <check constraint definition>. ............................................................... 863
11.10 <alter table statement>. ..................................................................... 865
11.11 <add column statement>. .................................................................. 867
11.12 <alter column definition>. ................................................................. 869
11.13 <set column default clause>. ............................................................... 871
11.14 <drop column default clause>. ........................................................... 872
11.15 <set column not null clause>. ............................................................... 873
11.16 <drop column not null clause>. ........................................................... 874
11.17 <add column scope clause>. ............................................................... 876
11.18 <drop column scope clause>. ............................................................... 877
11.19 <alter column data type clause>. ....................................................... 879
<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.20</td>
<td>alter identity column specification</td>
</tr>
<tr>
<td>11.21</td>
<td>drop identity property clause</td>
</tr>
<tr>
<td>11.22</td>
<td>drop column generation expression clause</td>
</tr>
<tr>
<td>11.23</td>
<td>drop column definition</td>
</tr>
<tr>
<td>11.24</td>
<td>add table constraint definition</td>
</tr>
<tr>
<td>11.25</td>
<td>alter table constraint definition</td>
</tr>
<tr>
<td>11.26</td>
<td>drop table constraint definition</td>
</tr>
<tr>
<td>11.27</td>
<td>add table period definition</td>
</tr>
<tr>
<td>11.28</td>
<td>drop table period definition</td>
</tr>
<tr>
<td>11.29</td>
<td>add system versioning clause</td>
</tr>
<tr>
<td>11.30</td>
<td>drop system versioning clause</td>
</tr>
<tr>
<td>11.31</td>
<td>drop table statement</td>
</tr>
<tr>
<td>11.32</td>
<td>view definition</td>
</tr>
<tr>
<td>11.33</td>
<td>drop view statement</td>
</tr>
<tr>
<td>11.34</td>
<td>domain definition</td>
</tr>
<tr>
<td>11.35</td>
<td>alter domain statement</td>
</tr>
<tr>
<td>11.36</td>
<td>set domain default clause</td>
</tr>
<tr>
<td>11.37</td>
<td>drop domain default clause</td>
</tr>
<tr>
<td>11.38</td>
<td>add domain constraint definition</td>
</tr>
<tr>
<td>11.39</td>
<td>drop domain constraint definition</td>
</tr>
<tr>
<td>11.40</td>
<td>drop domain statement</td>
</tr>
<tr>
<td>11.41</td>
<td>character set definition</td>
</tr>
<tr>
<td>11.42</td>
<td>drop character set statement</td>
</tr>
<tr>
<td>11.43</td>
<td>collation definition</td>
</tr>
<tr>
<td>11.44</td>
<td>drop collation statement</td>
</tr>
<tr>
<td>11.45</td>
<td>transliteration definition</td>
</tr>
<tr>
<td>11.46</td>
<td>drop transliteration statement</td>
</tr>
<tr>
<td>11.47</td>
<td>assertion definition</td>
</tr>
<tr>
<td>11.48</td>
<td>drop assertion statement</td>
</tr>
<tr>
<td>11.49</td>
<td>trigger definition</td>
</tr>
<tr>
<td>11.50</td>
<td>drop trigger statement</td>
</tr>
<tr>
<td>11.51</td>
<td>user-defined type definition</td>
</tr>
<tr>
<td>11.52</td>
<td>attribute definition</td>
</tr>
<tr>
<td>11.53</td>
<td>alter type statement</td>
</tr>
<tr>
<td>11.54</td>
<td>add attribute definition</td>
</tr>
<tr>
<td>11.55</td>
<td>drop attribute definition</td>
</tr>
<tr>
<td>11.56</td>
<td>add original method specification</td>
</tr>
<tr>
<td>11.57</td>
<td>add overriding method specification</td>
</tr>
<tr>
<td>11.58</td>
<td>drop method specification</td>
</tr>
<tr>
<td>11.59</td>
<td>drop data type statement</td>
</tr>
<tr>
<td>11.60</td>
<td>SQL-invoked routine</td>
</tr>
<tr>
<td>11.61</td>
<td>alter routine statement</td>
</tr>
<tr>
<td>11.62</td>
<td>drop routine statement</td>
</tr>
<tr>
<td>11.63</td>
<td>user-defined cast definition</td>
</tr>
</tbody>
</table>
15 Additional data manipulation rules. .................................................. 1201
15.1 Effect of opening a cursor. ....................................................... 1201
15.2 Effect of receiving a result set. ............................................... 1204
15.3 Determination of the current row of a cursor. ................................ 1205
15.4 Effect of closing a cursor. ...................................................... 1208
15.5 Effect of a positioned delete. ............................................... 1209
15.6 Effect of a positioned update. .............................................. 1211
15.7 Effect of deleting rows from base tables. ................................ 1214
15.8 Effect of deleting some rows from a derived table. ....................... 1217
15.9 Effect of deleting some rows from a viewed table. ........................ 1219
15.10 Effect of inserting tables into base tables. ................................ 1221
15.11 Effect of inserting a table into a derived table. ........................ 1224
15.12 Effect of inserting a table into a viewed table. ........................ 1226
15.13 Effect of replacing rows in base tables. ................................ 1228
15.14 Effect of replacing some rows in a derived table. ....................... 1232
15.15 Effect of replacing some rows in a viewed table. ...................... 1235
15.16 Execution of BEFORE triggers. ........................................... 1237
15.17 Execution of referential actions. ........................................... 1238
15.18 Execution of AFTER triggers. ............................................. 1244
15.19 Execution of triggers. ....................................................... 1245
16 Control statements. ............................................................. 1249
16.1 <call statement> ............................................................. 1249
16.2 <return statement> .......................................................... 1250
17 Transaction management. ......................................................... 1251
17.1 <start transaction statement> .............................................. 1251
17.2 <set transaction statement> ................................................. 1253
17.3 <transaction characteristics> .............................................. 1255
17.4 <set constraints mode statement> ....................................... 1257
17.5 <savepoint statement> ..................................................... 1259
17.6 <release savepoint statement> ............................................ 1260
17.7 <commit statement> ....................................................... 1261
17.8 <rollback statement> ...................................................... 1263
18 Connection management. ......................................................... 1267
18.1 <connect statement> ....................................................... 1267
18.2 <set connection statement> .............................................. 1270
18.3 <disconnect statement> .................................................. 1272
19 Session management. .......................................................... 1275
19.1 <set session characteristics statement> ................................ 1275
19.2 <set session user identifier statement> ................................ 1277
19.3 <set role statement> ...................................................... 1278
## Dynamic SQL

20.1 Description of SQL descriptor areas ................................................................. 1289
20.2 <allocate descriptor statement> ................................................................. 1300
20.3 <deallocate descriptor statement> ............................................................... 1302
20.4 <get descriptor statement> ........................................................................... 1303
20.5 <set descriptor statement> ........................................................................... 1307
20.6 <copy descriptor statement> ......................................................................... 1312
20.7 <prepare statement> ................................................................................... 1315
20.8 <cursor attributes> ..................................................................................... 1327
20.9 <deallocate prepared statement> ................................................................. 1328
20.10 <describe statement> ................................................................................. 1330
20.11 <input using clause> .................................................................................. 1337
20.12 <output using clause> ................................................................................ 1341
20.13 <execute statement> .................................................................................. 1346
20.14 <execute immediate statement> ................................................................. 1348
20.15 <dynamic declare cursor> .......................................................................... 1349
20.16 <descriptor value constructor> ................................................................. 1351
20.17 <allocate extended dynamic cursor statement> ........................................... 1353
20.18 <allocate received cursor statement> .......................................................... 1355
20.19 <dynamic open statement> ...................................................................... 1357
20.20 <dynamic fetch statement> ...................................................................... 1359
20.21 <dynamic single row select statement> ....................................................... 1360
20.22 <dynamic close statement> ...................................................................... 1361
20.23 <dynamic delete statement: positioned> .................................................... 1362
20.24 <dynamic update statement: positioned> .................................................... 1364
20.25 <preparable dynamic delete statement: positioned> ..................................... 1366
20.26 <preparable dynamic cursor name> ............................................................ 1368
20.27 <preparable dynamic update statement: positioned> .................................... 1370
20.28 <pipe row statement> .............................................................................. 1372

## Embedded SQL

21.1 <embedded SQL host program> ................................................................. 1375
21.2 <embedded exception declaration> ............................................................... 1386
21.3 <embedded SQL Ada program> ................................................................. 1390
21.4 <embedded SQL C program> ................................................................. 1398
21.5 <embedded SQL COBOL program> ............................................................ 1407
21.6 <embedded SQL Fortran program> ............................................................. 1414
Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Overview of character sets.</td>
</tr>
<tr>
<td>2</td>
<td>Fields in datetime values.</td>
</tr>
<tr>
<td>3</td>
<td>Datetime data type conversions.</td>
</tr>
<tr>
<td>4</td>
<td>Fields in year-month INTERVAL values.</td>
</tr>
<tr>
<td>5</td>
<td>Fields in day-time INTERVAL values.</td>
</tr>
<tr>
<td>6</td>
<td>Valid values for fields in INTERVAL values.</td>
</tr>
<tr>
<td>7</td>
<td>Valid operators involving datetimes and intervals.</td>
</tr>
<tr>
<td>8</td>
<td>Schematic diagram of effective parameter lists of PTF component procedures.</td>
</tr>
<tr>
<td>9</td>
<td>SQL-transaction isolation levels and the three phenomena.</td>
</tr>
<tr>
<td>10</td>
<td>Interpretation of datetime components.</td>
</tr>
<tr>
<td>11</td>
<td>Valid values for datetime fields.</td>
</tr>
<tr>
<td>12</td>
<td>Valid absolute values for interval fields.</td>
</tr>
<tr>
<td>13</td>
<td>Truth table for the AND boolean operator.</td>
</tr>
<tr>
<td>14</td>
<td>Truth table for the OR boolean operator.</td>
</tr>
<tr>
<td>15</td>
<td>Truth table for the IS boolean operator.</td>
</tr>
<tr>
<td>16</td>
<td>&lt;null predicate&gt; semantics.</td>
</tr>
<tr>
<td>17</td>
<td>SQL/JSON and ECMAScript correspondences.</td>
</tr>
<tr>
<td>18</td>
<td>Standard programming languages.</td>
</tr>
<tr>
<td>19</td>
<td>Data type correspondences for Ada.</td>
</tr>
<tr>
<td>20</td>
<td>Data type correspondences for C.</td>
</tr>
<tr>
<td>21</td>
<td>Data type correspondences for COBOL.</td>
</tr>
<tr>
<td>22</td>
<td>Data type correspondences for Fortran.</td>
</tr>
<tr>
<td>23</td>
<td>Data type correspondences for M.</td>
</tr>
<tr>
<td>24</td>
<td>Data type correspondences for Pascal.</td>
</tr>
<tr>
<td>25</td>
<td>Data type correspondences for PL/I.</td>
</tr>
<tr>
<td>26</td>
<td>Data types of &lt;key word&gt;s used in the header of SQL descriptor areas.</td>
</tr>
<tr>
<td>27</td>
<td>Data types of &lt;key word&gt;s used in SQL item descriptor areas.</td>
</tr>
<tr>
<td>28</td>
<td>Codes used for SQL data types in Dynamic SQL.</td>
</tr>
<tr>
<td>29</td>
<td>Codes associated with datetime data types in Dynamic SQL.</td>
</tr>
<tr>
<td>30</td>
<td>Codes used for &lt;interval qualifier&gt;s in Dynamic SQL.</td>
</tr>
<tr>
<td>31</td>
<td>Codes used for input/output SQL parameter modes in Dynamic SQL.</td>
</tr>
<tr>
<td>32</td>
<td>Codes associated with user-defined types in Dynamic SQL.</td>
</tr>
<tr>
<td>33</td>
<td>Codes associated with sort direction.</td>
</tr>
<tr>
<td>34</td>
<td>Codes associated with null ordering.</td>
</tr>
<tr>
<td>35</td>
<td>&lt;statement information item name&gt;s for use with &lt;get diagnostics statement&gt;.</td>
</tr>
<tr>
<td>36</td>
<td>&lt;condition information item name&gt;s for use with &lt;get diagnostics statement&gt;.</td>
</tr>
<tr>
<td>37</td>
<td>SQL-statement codes.</td>
</tr>
<tr>
<td>38</td>
<td>SQLSTATE class and subclass codes.</td>
</tr>
<tr>
<td>39</td>
<td>SQLSTATE class codes for RDA.</td>
</tr>
<tr>
<td>40</td>
<td>Implied feature relationships of SQL/Foundation.</td>
</tr>
<tr>
<td>41</td>
<td>Syntactic transformations applied before Conformance Rules.</td>
</tr>
<tr>
<td>42</td>
<td>Feature definitions outside of Conformance Rules.</td>
</tr>
<tr>
<td>43</td>
<td>Feature taxonomy and definition for mandatory features.</td>
</tr>
</tbody>
</table>
Feature taxonomy for optional features. ................................................................. 1628
Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Operation of &lt;regular expression substring function&gt;</td>
<td>23</td>
</tr>
<tr>
<td>2</td>
<td>Illustration of WIDTH_BUCKET Semantics</td>
<td>36</td>
</tr>
<tr>
<td>3</td>
<td>Illustration of important concepts in example query</td>
<td>83</td>
</tr>
<tr>
<td>4</td>
<td>Taxonomy of SQL-invoked routines</td>
<td>116</td>
</tr>
<tr>
<td>5</td>
<td>Flow of information during the invocation of a polymorphic table function</td>
<td>124</td>
</tr>
<tr>
<td>6</td>
<td>Architecture of SQL/JSON path language usage</td>
<td>178</td>
</tr>
<tr>
<td>7</td>
<td>Diagram of COLTREE</td>
<td>456</td>
</tr>
<tr>
<td>8</td>
<td>Diagram of a plan tree</td>
<td>457</td>
</tr>
</tbody>
</table>
Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/IEC JTC 1, Information technology, SC 32, Data management and interchange.


A list of all parts in the ISO/IEC 9075 series, published under the general title Information technology — Database languages — SQL, can be found on the ISO website.

NOTE The individual parts of multi-part standards are not necessarily published together. New editions of one or more parts can be published without publication of new editions of other parts.

©ISO/IEC 2016 – All rights reserved

Foreword xxi
Introduction

The organization of this part of ISO/IEC 9075 is as follows:

1) Clause 1, “Scope”, specifies the scope of this part of ISO/IEC 9075.
2) Clause 2, “Normative references”, identifies additional standards that, through reference in this part of ISO/IEC 9075, constitute provisions of this part of ISO/IEC 9075.
3) Clause 3, “Definitions, notations, and conventions”, defines the notations and conventions used in this part of ISO/IEC 9075.
4) Clause 4, “Concepts”, presents concepts used in the definition of SQL.
5) Clause 5, “Lexical elements”, defines the lexical elements of the language.
6) Clause 6, “Scalar expressions”, defines the elements of the language that produce scalar values.
7) Clause 7, “Query expressions”, defines the elements of the language that produce rows and tables of data.
8) Clause 8, “Predicates”, defines the predicates of the language.
9) Clause 9, “Additional common rules”, specifies the rules for assignments that retrieve data from or store data into SQL-data, and formation rules for set operations.
10) Clause 10, “Additional common elements”, defines additional language elements that are used in various parts of the language.
12) Clause 12, “Access control”, defines facilities for controlling access to SQL-data.
14) Clause 14, “Data manipulation”, defines the data manipulation statements.
16) Clause 16, “Control statements”, defines the SQL-control statements.
17) Clause 17, “Transaction management”, defines the SQL-transaction management statements.
18) Clause 18, “Connection management” defines the SQL-connection management statements.
19) Clause 19, “Session management”, defines the SQL-session management statements.
20) Clause 20, “Dynamic SQL”, defines the SQL dynamic statements.
21) Clause 21, “Embedded SQL”, defines the host language embeddings.
22) Clause 22, “Direct invocation of SQL”, defines direct invocation of SQL language.
24) Clause 24, “Status codes”, defines values that identify the status of the execution of SQL-statements and the mechanisms by which those values are returned.
25) **Clause 25, “Conformance”,** defines the criteria for conformance to this part of ISO/IEC 9075.

26) **Annex A, “SQL Conformance Summary”,** is an informative Annex. It summarizes the conformance requirements of the SQL language.

27) **Annex B, “Implementation-defined elements”,** is an informative Annex. It lists those features for which the body of this part of ISO/IEC 9075 states that the syntax, the meaning, the returned results, the effect on SQL-data and/or schemas, or any other behavior is partly or wholly implementation-defined.

28) **Annex C, “Implementation-dependent elements”,** is an informative Annex. It lists those features for which the body of this part of ISO/IEC 9075 states that the syntax, the meaning, the returned results, the effect on SQL-data and/or schemas, or any other behavior is partly or wholly implementation-dependent.

29) **Annex D, “Deprecated features”,** is an informative Annex. It lists features that the responsible Technical Committee intend will not appear in a future revised version of this part of ISO/IEC 9075.

30) **Annex E, “Incompatibilities with ISO/IEC 9075:2011”,** is an informative Annex. It lists incompatibilities with the previous version of this part of ISO/IEC 9075.

31) **Annex F, “SQL feature taxonomy”,** is an informative Annex. It identifies features of the SQL language specified in this part of ISO/IEC 9075 by an identifier and a short descriptive name. This taxonomy is used to specify conformance.

32) **Annex G, “Defect Reports not addressed in this edition of this part of ISO/IEC 9075”,** is an informative Annex. It describes the Defect Reports that were known at the time of publication of this part of this International Standard. Each of these problems is a problem carried forward from the previous edition of ISO/IEC 9075. No new problems have been created in the drafting of this edition of this International Standard.

In the text of this part of ISO/IEC 9075, Clauses and Annexes begin new odd-numbered pages, and in **Clause 5, “Lexical elements”,** through **Clause 24, “Status codes”,** Subclauses begin new pages. Any resulting blank space is not significant.
ISO/IEC 9075-2:2016(E)

(Blank page)