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[ISO/CEI CD 14651 - Classement international de chaînes de caractères - Méthode de comparaison de chaînes de caractères et description du modèle commun d'ordre de classement]

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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 known as ISO/IEC JTC1. Draft International Standards adopted by the joint technical committee are circulated to the national bodies for voting. Publication as an international standard requires approval by at least 75% of the national bodies that cast a vote.

The ISO/IEC 14651 International Standard has been prepared by the Joint Technical Committee ISO/IEC JTC1, Information Technology.

INTRODUCTION

This International Standard provides a method for ordering text data worldwide, and provides a Common Template Table whose tailoring eases adaptation of a specific script while retaining universal properties for other scripts. The purpose of such a mechanism is to correct errors of the past regarding collation done only on binary coded character values. Past approaches have often not respected cultural preferences for collation. English is one exception, although a poor one, when only upper case alphabetic data was used instead of other characters including punctuation and spacing.

This is one of the major flaws that affect portability between countries and between applications. (Traditionally, different programs use different ordering specifications.) Therefore, it has been considered feasible to design a Common Template Table for ordering and a comparison method that can be used as a reference for the results to be achieved by implementations. This Standard is the achievement of this challenge.

The Common Template Table requires some tailoring in different local environments. However conformance to this International Standard requires that the deviations to the Template, called "deltas", be declared to document result discrepancies.

This Standard describes a method to order text data independently of context. It has provisions to allow a lot of flexibility in implementations, while remaining an excellent international reference for ordering to which all technical and cultural environments can commonly refer to.

1 Scope

This International Standard defines:

- A simple method of reference for comparing two characters strings in order to determine their respective order in a sorted list. The method is applicable on strings that exploit the full repertoire of ISO/IEC 10646 (independently of coding). These comparisons are also applicable for subrepertoires, such as those of ISO 8859 parts or any other character set, standard or private, to produce ordering results valid (after tailoring) in a given set of languages for each script. This method uses transformation tables derived from either the Common Template Table defined in this International Standard or from one of its tailorings.
- A reference format using a variant of the Backus-Naur Form (BNF) to describe the Common Template Table used normatively in this International Standard.
- A specific Common Template Table used by the comparison method. This table describes a basic order for all characters specified in ISO/IEC 10646-1 up to amendment 7 in this edition of this International Standard. This table is a starting point in enabling the specification of culturally acceptable orders adapted to different cultures, without requiring a knowledge of all the different scripts already taken care of by this International Standard.

Note: It is to be considered normal practice that this Common Template Table be modified with a minimum of efforts to suit the needs of a local environment. The main benefit, worldwide, is that for other scripts, no modification is required and that the order will remain as consistent as possible and predictable from an international point of view.

- A reference name representing this particular version of the Common Template Table for use by various applications as a starting base for tailoring. In particular this name implies that the table is linked to a particular stage of development of the ISO/IEC 10646 Universal multiple-octet coded character set.

This International Standard does *not* mandate:

- A specific comparison method; any equivalent method giving the same results is acceptable.
- A specific format for describing or tailoring tables in a given implementation.
- Specific symbols to be used by implementations except the name of the Common Template Table.
- A specific user interface for choosing options.
- A specific internal format for intermediate keys used in comparisons nor for the table used. The use of numeric keys is not mandated either.
- A context-dependent ordering which would require complex transformation of data to order.

Note: Although no user interface is prescribed to choose options or to specify tailoring of the Common Template Table, conformance requires always declaring the applicable delta, a declaration of differences with this table. It is highly recommended that these fundamental choices be presented by the application interfacing with the users of the results produced.

2 Conformance

An application is conformant to this International Standard if it meets the requirements prescribed in section 6.

Any declaration of conformity to this International Standard shall be accompanied by a declaration of the tailoring *delta* described in clause 6.4 in case tailoring is not provided by the concerned application. In case tailoring is provided, the declaration shall indicate which elements of clause 6.3 it is possible to tailor in the concerned application and which ones have no tailoring provisions. More specifically, it is the responsibility of implementers to show how their delta declaration is related to the table syntax described in clause 6.3, and how the comparison method they use. If different from the one mentioned in clause 6.1, can be considered as giving the same results as those prescribed by the method specified in clause 6.1.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

Members of IEC and ISO maintain registers of currently valid International Standards.

- ISO/IEC 10646-1:1993 Information technology -- Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane
- ISO/IEC 10646-1:1993/Amd.1:1996 Information technology – Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane Amendment 1: Transformation Format for 16 planes of group 00 (UTF-16).
- ISO/IEC 10646-1:1993/Amd.2:1996 Information technology – Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane Amendment 2: UCS Transformation Format 8 (UTF-8).
- ISO/IEC 10646-1:1993/Amd.3:1996 Information technology – Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane Amendment 3.
- ISO/IEC 10646-1:1993/Amd.4:1996 Information technology – Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane Amendment 4.
- ISO/IEC 10646-1:1993/Amd.5:1998 Information technology – Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane Amendment 5: Hangul syllables.
- ISO/IEC 10646-1:1993/Amd.6:1997 Information technology – Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane Amendment 6: Tibetan.
- ISO/IEC 10646-1:1993/Amd.7:1997 Information technology – Universal Multiple-Octet Coded Character Set (UCS) -- Part 1: Architecture and Basic Multilingual Plane Amendment 7: 33 additional characters.

4 Definitions

For the purposes of this International Standard, the following definitions apply:

- 4.1 canonical form** the coding of a UCS character in 4 octet binary form according to ISO/IEC 10646-1
- 4.2 character string** a sequence of characters considered as a single object
- 4.3 collation** ordering of elements
- 4.4 collating symbol** a symbol used to specify weights assigned to a character
- 4.5 collating element** a single weight or a sequence of weights attributed to a character at a specific level of ordering
- 4.6 delta** list of differences of a specific ordering table relatively to the Common Template Table defined in this International Standard
- 4.7 glyph** a recognizable abstract graphic symbol which is independent of any specific design
- 4.8 graphic character** a character, other than a control function, that has a visual representation normally handwritten, printed, or displayed. To a graphic character normally corresponds a glyph
- 4.9 level** whenever used without qualification in this International Standard, *level* stands for the depth at which a comparison is made on two character strings.
- 4.10 token** a number used as an actual comparison element by the reference comparison method
- 4.11 ordering** a process in which a set of strings are assigned a given order relative to any other set of strings
- 4.12 ordering key** a series of numerical values used to determine an order
- 4.13 preparation** a process in which character strings are modified internally to lead to straightforward comparisons according to this standard

5 Symbols and abbreviations

Identification of characters of the ISO/IEC 10646-1 (Universal multiple-octet-coded Character Set or UCS) repertoire is made in this edition of this International Standard by means of symbols of the form <UXXXX>. The occurrences of XXXX which follow the letter "U" represent the hexadecimal value (using upper case letters when applicable) of a coded character as defined in ISO/IEC 10646 but no specific coded value is intended. What is being referenced is a graphic character, independently of its coding, and any character set whose subrepertoire is taken into account in ISO/IEC 10646-1 is covered in this way.

This use of symbols is a means to be code-independent (the same value being possibly used even if the coded character set in use in a given implementation is not ISO/IEC 10646). At the same time, this is a means to keep a straightforward link with the Universal multiple-octet Coded Character Set (UCS), which contains all the coded graphic characters ever defined by ISO/IEC JTC1 standards. Addenda to ISO/IEC

10646 will be published from time to time; these addenda may then also result in addenda to this International Standard if necessary.

By convention, if a character outside of the standard repertoire of ISO/IEC 10646 is to be used in tailored ordering tables, it is recommended that the code-independent symbol identifying this character use the form <Pyyyyyyy> for documentary purposes indicating its nonstandard nature. The binding to actual coding of these symbols for nonstandard characters is left to implementation and to tailoring. If, for example, actual UCS coding is used, then private zones of this character set will normally be used for meeting such special requirements, and binding could then be specified so that the sequence yyyyyyy used in the symbol represents private-zone UCS coding.

In the Common Template Table arbitrary symbols representing weights are used according to the BNF notation description in 6.3.1.

6 Requirements

6.1 Reference method for establishing an order between two character strings

6.1.1 Preparation of character strings prior to comparison

It may be necessary to transform character strings before these character strings are fed into the comparison method (see annex C for an example of such preparation). Although not part of the scope of this International Standard, context-sensitive preparation may be an important part of the ordering process, as for example in telephone-book ordering, a complex case in point.

An application conformant to this international standard shall at the minimum prepare the string so that sequences using either combining sequences or using precomposed characters be presented to the comparison method described in 6.1, if they are meant to be equivalent. An application is also conformant if it uses a comparison method for forming ordering keys which, without making any such preparation, is demonstrated to produce results identical to the ones resulting from the use of such a preparation.

Note 1: In this International Standard, the Common Template Table is built so that, with minimum effort, precomposed characters will be ordered in the same way as when equivalent sequences of combining characters are used, provided that the preparation prescribed in the previous paragraph is made. It is demonstrated that by tailoring the Common Template Table to add extra token values at level 2 for all precomposed characters affected by a diacritics, it is possible to accomplish identical results for combining sequences without requiring that preparation. However as it is not typically the case that such double-coding will be used, it is not considered required to add extra tokens for keeping a reasonable economy of means in the general case.

Note 2: Escape sequences constitute very sensitive data to interpret, and it is highly recommended that preparation should filter out or transform these sequences. Ideally, all control characters should be filtered out before comparison and reintroduced afterward in case of absolute homography to distinguish two character strings being compared.

6.1.2 Comparison method of reference resulting in ordering two character strings

The following describes the comparison method used as a reference to determine conformance to this International Standard:

1. In considering a table describing weights at m levels for each of n characters in the implementation character set, build a numeric key for both of two arbitrary character strings being compared, according to the algorithm of key formation described in clause 6.2 of this International Standard.

2. Compare the numeric keys produced for the two character strings. The character string whose numeric key is smaller shall be ordered before the other one. If the two numeric keys are identical in value then the two character strings compared shall be considered as equal according to this International Standard.

The table used in this reference method for comparison is the result of the numeric interpretation of the symbols in the Common Template Table, or in a tailored table into a table of n by m elements (n characters by m levels described per character). In the Common Template Table, the number of levels m described per character is equal to 4.

6.2 Building the Ordering key used in the reference comparison method

6.2.1 Preliminary considerations

6.2.1.1 Assumptions

The ordering table is a transformation table that can be considered as a matrix of n lines. n is the number of characters in the repertoire used. In each line 4 levels are described in the Common Template Table. This number of levels can be extended in the tailoring phase by the end-user. The user shall take care that, in case of tailoring, levels be adjusted so that the last level may processed in a special way according to what is described in what follows. Normally the last level is intended to specify "special" characters, i.e., characters normally not part of the orthography of any script, sometimes called "ignorable" characters in the context of computerized ordering.

6.2.1.2 Blocks and processing properties

A tailored table may be separated into blocks. Each block has specific scanning and ordering properties.

One of the tailoring possibilities is to assign a given order to each block and to change the relative order of a whole block relatively to other blocks.

The scanning direction (forward or backward) used to process the string at each level is a property of each block. These properties can be changed.

A specific property of the last level of comparison is that before comparing weights of each "ignorable" character, a comparison on the numeric position of each such character of two strings is effected (in other words, for two strings equivalent at all levels except the last one, the string having an ignorable in the lowest position comes before the other one. In case ignorables share the same positions, then weights are considered, and this until a difference is found).

Note: The scanning direction (forward or backward) is not normally related to the natural writing direction of a script or of scripts described by one block. The scanning direction applies to the logical sequence of the coded character string.

According to ISO/IEC 10646, for scripts written right to left, such as Arabic, the lowest positions in the logical sequence of characters correspond to the rightmost characters of a string (from the point of view of their natural sequence). Conversely, for the Latin script, written left to right, the lowest positions in the logical sequence of characters correspond to the leftmost characters of the string (from the point of view of their natural presentation sequence).

Scanning forward starts with the lowest positions in the logical sequence, while scanning backward starts from the highest positions, and this independently of the presentation sequence. The scanning direction for ordering purposes is a property of a block.

In ISO/IEC 10646-1, Arabic is artificially separated in two scripts: the logical, intrinsic Arabic, coded independently of shapes, and the presentation forms. Both allow to code Arabic completely, but intrinsic Arabic is normally preferred for better processing, while the second is preferred by some presentation-oriented

applications. ISO/IEC 10646-1 does not prescribe that the logical order of the presentation forms be coded in presentation order or logical order. Therefore tables can be tailored to specify a specific block for these characters and the scanning properties can then be specified according to the application.

6.2.2 Key composition

A series of m intermediary subkeys is formed out of a character string composing a comparison field; m is the maximum number of levels described in either the Common Template Table or the in the tailored ordering table. The following paragraphs describe the formation of each of these subkeys whose successive sequence form a complete ordering key. In the Common Template table, m is equal to 4.

6.2.2.1 Formation of subkey level 1 through $(m - 1)$ (level i ; $m=4$ in the Common Template)

For i varying from 1 to $(m - 1)$ (from 1 to 3 if the Common Template Table is used), form subkey level i in the following way:

During forward scanning of each character of the input character string, one or more tokens are obtained. These tokens correspond to the transformation value of that character at level i .

The scanning properties for the level i being processed needs to be carefully monitored. When there is a change in scanning direction at level i (this implies that the character being processed comes from a block that is different from the preceding character processed and which has different scanning properties) and the new direction is backward, stacking of the token will be done at the position where the change of direction has occurred. Therefore when such a condition occurs, the application shall retain the current position in the output subkey i as **position p** (*push position*).

According to scanning direction assigned to the level i of the block in which the character being processed belongs, the obtained token is either added in sequence (concatenated) at the end of subkey i (which behaves like a list), or pushed at **position p** of subkey i (which then behaves like a stack). Subkey i is initially empty.

Note: This is the equivalent of backward or forward scanning of the input string for that level. This property of scanning direction is given for each level of each block and is a block property. The Common Template Table has only one block until it is tailored.

6.2.2.2 Formation of subkey level m ($m=4$ in the Common Template table)

If the `order_start_entry` does not uses the `position` value at level m of a block (the `position` value is explicitly used in the template for the only block defined) then the formation of subkey level m is done in exactly the same way as the above-defined formation. Otherwise the formation of subkey level m is as follows, in accordance with frequent market practice:

During forward scanning of each character of the input character string, a pair of tokens is concatenated to subkey level m . The first token of the pair corresponds to the logical position in the original character string of the character being processed. The second token in the pair corresponds to the weight assigned to that character at level m of the table. When the character is not assigned at level m in the table, it is ignored for the formation of subkey level m and no pair is concatenated. The pair of tokens is concatenated immediately after subkey level m . Subkey level m is initially empty.

Generally, and in the Common Template Table, levels represent the following decomposition for basic characters:

Level 1: Base level of each script. This level corresponds to the basic letters of the alphabet for that script, if the script is alphabetic, and to the set of basic characters of the script if the script is ideographic or syllabic.

Level 2: The level corresponding to diacritical marks affecting each basic character of the script. For some scripts, diacritics are always considered an integral part of the basic letters of the alphabet, and are not considered at this second level, but rather at the first. For example, N TILDE in Spanish is considered a basic letter of the Latin script. Therefore, tailoring for Spanish will change the definition of N TILDE from "the weight of an N in the first level and a tilde weight in the second level" to "the weight of an N TILDE (placed after N and before O) in the first level, and indication of the absence of extra diacritics in the second level".

Level 3: The level corresponding to case or to variant character shape that affects each basic character of the script.

Level 4: This level represents the level common to all scripts or the level not specifically belonging to any script. The property of this level is that it is ordered positionally according to this International Standard. This means that the numerical value of the position in the original string has precedence over the weight assigned to the special character which occupies this position. This means that subkey level m is composed of a pair of values for each such character (the character string being **always** scanned forward in the logical string sequence). The first value of the pair corresponds to the sequential position of the character in the input string in logical sequence. The second value of the pair corresponds to the weight assigned to the character according to level m in script <SPECIAL>.

In the table, this behavior is described using the parameter couple "forward, position". To be conformant to this, the parameter couple "backward, position" shall never be specified for level m (see clause 5.4). These two parameters shall be considered mutually exclusive.

In the Common Template table, definitions of these characters for levels 1 to 3 are such that they are ignored at these levels and values are exclusively assigned to level m (m being equal to 4 in the Common Template).

6.3 Common Template Table: formation and interpretation

This section specifies:

- the syntax used to form the Common Template Table in Annex A of this International Standard or a table tailored starting from the Common Template Table
- conditions of well-formedness of a table using this syntax
- interpretation of tables formed using this syntax
- conditions for considering two tables equivalent
- conditions for considering comparison results as equivalent

6.3.1 BNF Syntax Rules

Definitions between curly brackets make use of terms not defined in this BNF syntax, and assume general English usage.

Other conventions:

* means 0 or more repetitions of a token,
 parentheses indicate optional occurrence of a token.

1. character ::= {any member of the repertoire of the encoded character set in use}
2. line_delimiter ::= {end-of-line in the text conventions in use}
3. digit ::= '0'|'1'|'2'|'3'|'4'|'5'|'6'|'7'|'8'|'9'
4. hexdigit ::= 'A'|'B'|'C'|'D'|'E'|'F'|digit
5. id_start ::=
 'a'|'b'|'c'|'d'|'e'|'f'|'g'|'h'|'i'|'j'|'k'|'l'|'m'|'n'|'o'|'p'|'q'|'r'|'s'|'t'|'u'|'v'|'w'|'x'|'y'|'z'|'A'|'B'|'C'|'D'|
 'E'|'F'|'G'|'H'|'I'|'J'|'K'|'L'|'M'|'N'|'O'|'P'|'Q'|'R'|'S'|'T'|'U'|'V'|'W'|'X'|'Y'|'Z'
6. id_part ::= id_start|digit|'-'|'_'|'+'
7. comment_char ::= '%'
8. space ::= ' '
9. four_digit_hex_string ::= hexdigit hexdigit hexdigit hexdigit
10. comment ::= comment_char character*
11. identifier ::= id_start id_part*
12. simple_symbol ::= '<' identifier '>'
13. ucs_symbol ::= '<U' four_digit_hex_string '>'
14. symbol ::= simple_symbol | ucs_symbol
15. symbol_group ::= symbol |'"' symbol symbol* '"'
16. level_token ::= symbol_group | 'IGNORE'
17. delimited_level_token ::= level_token ';'
18. multiple_level_token ::= delimited_level_token* level_token
19. line_completion ::= ((space)comment) line_delimiter
20. symbol_list_item ::= symbol
21. symbol_list_item_range ::= symbol_list_item '..' symbol_list_item
22. symbol_list_element ::= symbol_list_item_range | symbol_list_item
23. symbol_definition ::= symbol_list_element
24. symbol_weight_entry ::= symbol_list_item space multiple_level_token line_completion
25. delimited_symbol_list_element ::= symbol_list_element ';'
26. symbol_list ::= delimited_symbol_list_element* symbol_list_element
27. section_identifier ::= identifier
28. section_definition_simple_entry ::= 'section' space section_identifier line_completion
29. section_definition_list_entry ::= 'section' space section_identifier space symbol_list
 line_completion
30. section_definition_entry ::= section_definition_simple_entry | section_definition_list_entry
31. target_symbol ::= symbol
32. reorder_after_entry ::= 'reorder-after' space target_symbol line_completion
33. reorder_end_entry ::= 'reorder-end' line_completion
34. reorder_section_after_entry ::= 'reorder-section-after' space section_identifier space target_symbol
 line_completion
35. direction ::= 'forward' | 'backward'
36. delimited_direction ::= direction ';'
37. multiple_level_direction ::= delimited_direction* direction
38. order_start_entry ::= 'order_start' space identifier ';' multiple_level_direction space (' ,position')
 line_completion
39. order_end_entry ::= 'order_end' line_completion
40. simple_line ::= (symbol_definition | symbol_weight_entry) line_completion
41. tailoring_line ::= (section_definition_entry | reorder_after_entry | reorder_end_entry |
 reorder_section_after_entry | order_start_entry | order_end_entry) line_completion
42. table_line ::= simple_line | tailoring_line
43. section ::= {ordered set of simple_line's –See II below.}
44. untailed_template_table ::= simple_line*

45. `tailored_table ::= table_line*`
 46. `weight_table ::= untailed_template_table | tailored_table`

6.3.2 Well-formedness Conditions

WF1. Any *simple_symbol* occurring in a *multiple_level_token* must occur in a *symbol_definition* in the same *symbol_weight_entry* that the *multiple_level_token* occurs in, or in a *symbol_weight_entry* that occurs earlier in the sequence of *table_line*'s that constitute a *tailored_table*. [I.e., all *simple_symbol*'s must be "defined" before they are "used". Note that *hex_symbol*'s are all assumed to be predefined.]

WF2. All *multiple_level_token*'s in a *tailored_table* must contain the same number of *delimited_level_token*'s. [I.e., a tailorable table must be consistent in its use of levels throughout.]

WF3. A *tailored_table* may not contain a *multiple_level_direction* if it does not also contain a *multiple_level_token*. [I.e., no *order_start* statement can be used in a table which defines no multi-level weights.]

WF4. A *multiple_level_direction* in a *tailored_table* must contain the same number of *delimited_direction*'s as the number of *delimited_level_token*'s of any *multiple_level_token* in that *tailored_table*. [I.e., any *order_start* must have the same number of levels as is generally used in the table.]

WF5. If a *level_token* in a *multiple_level_token* consists of a *symbol_group*, all successive *level_token*'s in that *multiple_level_token* must also consist of a *symbol_group*. [I.e., don't use IGNORE at a level after an explicit symbol for a weighting.]

WF6. Any *section_identifier* occurring in a *reorder_section_after_entry* must occur in a *section_definition_entry* that occurs earlier in the sequence of *table_line*'s that constitute a *tailored_table*. [I.e., all *section_identifier*'s must be "defined" before they are "used".]

WF7. No two *section_definition_entry*'s in a *tailored_table* may contain the same values in their *section_identifier*'s. [I.e. multiple definition of *section*'s is prohibited; *section_identifier*'s must be unique.]

WF8. Each *reorder_after_entry* in a *tailored_table* must be followed by a *reorder_end_entry* or another *reorder_after_entry*.

WF9. If a *tailored_table* contains one or more *order_start_entry*'s, it must be terminated with an *order_end_entry*.

WF10. No *reorder_section_after_entry* may contain a *target_symbol* whose value is the same as any *symbol* in the *section_definition_list_entry* whose *section_identifier* is the same as the *section_identifier* in that *reorder_section_after_entry*. [I.e., a *section* cannot be reordered after a line which the *section* itself contains; prohibit attempts at recursive relocation of lines.]

6.3.3 Interpretation of Tailored Tables

I1. A *section* consists of the list of *simple_line*'s which contain a *symbol_definition* whose value is equal to any *symbol* contained in the *symbol_list* in a *section_definition_list_entry* OR consists of the list of *simple_line*'s following a *section_definition_simple_entry* in a *tailored_table*. [I.e., a *section* is defined by a specific *symbol_list*, or just by taking all the lines following the *section_definition_entry* until you hit another tailoring line such as an *order_start_entry*, a *reorder_section_after_entry*, another *section_definition_entry*, or the end of the entire table.]

I2. A *tailored_table* containing a *reorder_after_entry* is equivalent to the same *tailored_table* with the *table_line*'s between that *reorder_after_entry* and the first subsequent *reorder_end_entry* reordered to immediately follow the last *table_line* in the *tailored_table* containing a *symbol_definition* whose *symbol* is the same as the *target_symbol* in the *reorder_after_entry*, and with that *reorder_after_entry* and that *reorder_end_entry* removed. [I.e., move the block of lines between the *reorder_after_entry* and the *reorder_end_entry* to follow the *target_symbol* and remove the *reorder_after_entry* and *reorder_end_entry* themselves.]

I3. A *tailored_table* containing a *section_reorder_after_entry* is equivalent to the same *tailored_table* with the *section* associated with that *section_reorder_after_entry* reordered (in the same relative order as the *table_line*'s have in that section) to immediately follow the last *table_line* in the *tailored_table* containing a *symbol_definition* whose *symbol* is the same as the *target_symbol* in the *section_reorder_after_entry*, and with that *section_reorder_after_entry* removed.

I4. A *weight_table* is said to be in normal form when it contains no *reorder_after_entry*'s or *section_reorder_after_entry*'s. [In general, a *tailored_table* can be put into normal form by the operations implied by I1 and I2.]

I5. A *weight_table* in normal form is said to be evaluated when each *symbol_definition* in the *weight_table* is mapped to a positive integral numeric value such that those values are monotonically increasing by the order that the *symbol_definition*'s occur in the *weight_table*. (The *table_line*'s of the *weight_table* are first mapped to the set of positive integers, by sequential order in the file. This mapping defines an ordered set of line numbers. The *symbol_definition*'s are then mapped to a set of positive integers that varies monotonically with the set of line numbers.) [Note that this does not restrict the starting number for the weight of the first *symbol_definition*, nor does it require that the numbers for these weights be immediately consecutive.]

I6. An evaluated *weight_table* is said to be collation-element-weighted when each *simple_symbol* occurring in each *multiple_level_token* in that evaluated *weight_table* has been mapped to the integral value which corresponds to the *symbol_definition* that contains the same *simple_symbol*. [I.e., each *multiple_level_token* can now be interpreted as containing either *symbol*'s mapped to integral weight values or instances of the string 'IGNORE'. All *hex_symbol*'s are assumed to map to an integral weight value equal to that *hex_symbol* interpreted as a hexadecimal number. At this point the mathematical injection of strings can be defined using the *weight_table*.]

6.3.4 Conditions for considering specific table equivalences

C1 Two collation weighting tables W1 and W2 are said to be equivalent if for all strings S defined on a repertoire R, any comparison of any two of the strings S1 and S2 based on their corresponding numbers from the injection P1 produced on W1 is exactly matched by the comparison of S1 and S2 based on their corresponding numbers from the injection P2 produced on W2. [I.e., if one takes two strings, builds keys for each based on table 1 and compares them, one should always get the same results as when one builds keys for them based on table 2 and compare them.]

6.3.5 Conditions for results to be considered equivalent

C2. An implementation of international string ordering is conformant with this standard if for any set of strings S defined on a repertoire R, the implementation can duplicate the same comparisons as those resulting from comparison of the numbers from an injection constructed according to the rules of Section 6.1.2 of this standard.

C3. An implementation of international string ordering is conformant with this standard if any tailoring it uses can be demonstrated to be equivalent to a *weight_table* constructed according to the rules of clause 6.1.2 of this standard.

6.4 Declaration of a delta

It is recommended that tailoring be done starting with the Common Template table described in annex A. If the format used in the Common Template Table is used then tailoring can be accomplished using, for example, ISO/IEC 14652, which uses a syntax that is compatible with the one described in this International Standard.

Any declaration of conformance to this International Standard shall be accompanied with a declaration of the differences that occur in the comparison table used relatively to the Common Template Table if a fixed table is used by the application. These differences are called a *delta* according to this International Standard. Such a delta shall contain the equivalent of:

1. At least one valid *order_start_entry* described in clause 6.3.1; many blocks containing an *order_start_entry* and an *order_end_entry* may be declared. The direction values may vary between "forward" and "backward" depending on writing systems.
2. The number of levels used for comparison.
3. The list of *symbol_definition* (as defined in 6.2.1) weights added and after which *symbol_definition* entry each insertion is made.
4. The list of *simple_line* (as defined in 6.2.1) entries deleted or inserted, referencing after which *simple_line* entry in the Common Template Table the insertions are made

In cases where the applications has provision to allow the end-user to tailor the table himself, any statement of conformance shall indicate which ones of the 4 elements of the previous list are tailorable and which ones are not tailorable. For those not tailorable, the delta of fixed elements relative to the Common Template Table shall be declared.

Note: The declaration may use a different syntax from the one proposed in 6.3 provided that the relationship with this syntax can be reasonably established. For example, the following declarations are valid:

```
"Collate U+00E5 after U+007A at the primary level.
Collate U+00E4 after U+00E5 at the primary level. "
```

or

```
"The primary alphabet order is modified so that in all cases z < å < ä"
```

These two notations can reasonably be considered to be equivalent to the more precise expressions (which also give weights at level 2 and 3):

```
reorder_after <U007A>
<U00E5> <U00E5>;<BLANK>;<MIN>
reorder_end
```

```
reorder_after <U00E5>
<U00E4> <U00E4>;<BLANK>;<MIN>
reorder_end
```

6.5 Name of the Common Template Table and name declaration

Whenever the Common Template Table is referred externally as a starting point in a given context, either applicative or contractual, it shall be referenced using the name ISO14651_1999_TABLE1. If another name is used due to different practical constraints, any declaration of conformance shall indicate how the correspondence between this other name and the name ISO14651_1999_TABLE1 is taken care of.

The use of a defined name is necessary to manage the different stages of development of this table. This follows from the nature of the reference character repertoire, for which development will be ongoing for a number of years or even decades.

Annex A -- Common Template Table (normative)

In this ordering table constituting a common template, a number of characters and scripts of the world are missing, due to the non-inclusion of those characters or scripts in the current stage of development of the reference character set repertoire, that of ISO/IEC 10646-1 (Universal multiple-octet coded Character Set, or UCS) at time of publishing.

It is the intent of ISO/IEC to complete ordering of those scripts explicitly in the common template whenever data becomes available by way of amendments to this International Standard. If the common template is not tailored for unspecified characters, then an implicit order is assigned in the following table, which might not meet user requirements of a particular community. Any delta with this table shall be declared in any statement of conformance to this International Standard as per the prescriptions of the conformance clause.

Name used for referring to this table in this version of this International standard:
ISO14651_1999_TABLE1

Note: The complete table can be found at URL

<http://www.normos.org/iso-cei/jtc1/sc22/wg20/fcd/iso-14561-1999-table1-en.txt>

for the whole duration of the FCD ballot stage. When the DIS will be produced, the complete table will be inserted in this International Standard. This table is intended to be machine-readable and is normally produced on paper only for checking or for reference purposes or for helping in declaring a delta.

Brief excerpt of the table, which requires 520K of storage in plain text:

```
% escape_char /
% comment_char %

% LC_COLLATE

% Uncomment the lines above to create a 14652-style
% LC_COLLATE definition.

% Autogenerated LC_COLLATE weight symbol table
% created from unidata.txt
% Equivalent to weights of basekeys.txt + compkeys.txt

% Order of internal symbols

<RES-1>
<BLK>
<MIN>
.
.
.
<BODKA>
<CJKVS>
<S0200>..

```

```
% To tailor for French accent handling, or not to make French
% a special case add an order_start statement
% and order_end for Latin in the Latin section, as follows:

% order_start Latin;forward;backward;forward;forward,position

% <Uxxxx> <Base>;<Accent>;<Case>;<Special>

% Note that <Special> must be evaluated as exact hex value
% and not as an autoweighted symbol.

<U0000> IGNORE;IGNORE;IGNORE;<@0000> % NULL
.
.
.
```

Annex B -- Benchmarks (informative)

B.1 Example 1 – Canadian delta and benchmark

The next few pages contain benchmark 1, based on Canadian standard CAN/CSA Z243.4.1-1998 (and -1992). The delta that precedes the benchmark *has been simplified* for the illustration; a bigger delta is required, mainly for special characters, for full conformance to this Canadian standard, referenced here as an example only. The example's specifications are to be performed using the Common Template Table of annex A, with the following delta:

1. Block properties: only one block with the following properties:
 - order_start TABLE;forward;backward;forward;forward,position
2. Number of levels unchanged to 4.
3. No symbol change.
4. No other insertion, deletion or redefinition than:
 - æ sorted as if it were separate letters "æ" at level 1. The letters "ae" are distinguished only at level 2 from the joined digraph "æ" and are then sorted before. Upper case is distinguished at level 3.
 - ð sorted as if it were the letter "d" at level 1. Letter "ð" is distinguished at level 2 from the letter "d". Upper case is distinguished at level 3.
 - þ sorted as if it were separate letters "þ" at level 1. The letters "th" are distinguished only at level 2 from the letter "þ" and are then sorted before. Upper case is distinguished at level 3.

Note: the last two letters are not used in the benchmark but are part of the Canadian delta.

Alternate formal ISO/IEC 14652 tailoring equivalent

```
copy ISO14651_1999_TABLE1
order_start TABLE;forward;backward;forward;forward,position
reorder-after <U00C6>
<U00E6> <S6CD><S72D>;<COMPAT><COMPAT>;<MIN><MIN>;IGNORE % <ae>
<U00C6> <S6CD><S72D>;<COMPAT><COMPAT>;<CAP><CAP>;IGNORE % <AE>
reorder-after <U1E0E>
<U00F0> <S705>;<COMPAT>;<MIN>;IGNORE % <d->
<U00D0> <S705>;<COMPAT>;<CAP>;IGNORE % <D->
reorder-after <U2122>
<U00FE> <S88B><S781>;<COMPAT><COMPAT>;<MIN><MIN>;IGNORE % <th>
<U00DE> <S88B><S781>;<COMPAT><COMPAT>;<CAP><CAP>;IGNORE % <TH>
reorder-end
```

1 Unordered list (required test as per Canadian standard CAN/CSA Z243.4.1-1998)

ou	0000	vice-president
lésé	relève	modélé
péché	gène	MODÈLE
vice-président	casanier	maçon
9999	élevé	MÂCON
OÙ	COTÉ	pèche
haï e	relevé	pêché
coop	Grossist	ovoi de
caennais	vice-presidents' offices	pechère
lèse	Copenhagen	ode
dû	côte	péchère
air@@@	McArthur	oël
côlon	Mc Mahon	
bohème	Aalborg	
géné	Größe	
lamé	vice-president's offices	
pêche	cøibat	
LÈS	PÉCHÉ	
vice versa	COOP	
C.A.F.	@@@air	
caesium	VICE-VERSA	
resumé	gène	
Bohémien	CO-OP	
co-op	révélé	
pêcher	révèle	
les	çà et là	
CÔTÉ	Noël	
résumé	île	
Ålborg	aï eul	
cañon	Île d'Orléans	
du	nôtre	
haie	notre	
pécher	août	
Mc Arthur	NOËL	
cote	@@@@@	
colon	L'Hay-les-Roses	
l'âme	CÔTE	
resume	COTE	
élève	côté	
Canon	coté	
lame	aide	
Bohème	air	

2 List with required results as per Canadian standard CAN/CSA Z243.4.1-1998

@@@@@	gêne	relevé
0000	gêné	resume
9999	Größe	resumé
Aalborg	Grossist	résumé
aide	haie	révèle
aï eul	hai e	révélé
air	île	vice-president
@@@air	Île d'Orléans	vice-président
air@@@	lame	vice-president's offices
Ålborg	l'âme	vice-presidents' offices
août	lamé	vice versa
bohème	les	VICE-VERSA
Bohême	LÈS	
Bohémien	lèse	
caennais	lésé	
caesium	L'Hay-les-Roses	
çà et là	MÂCON	
C.A.F.	maçon	
Canon	McArthur	
cañon	Mc Arthur	
casanier	Mc Mahon	
cøibat	MODÈLE	
colon	modelé	
côlon	Noël	
coop	NOËL	
co-op	notre	
COOP	nôtre	
CO-OP	ode	
Copenhagen	oël	
cote	ou	
COTE	OÙ	
côte	ovoï de	
CÔTE	pèche	
coté	pêche	
COTÉ	péché	
côté	PÉCHÉ	
CÔTÉ	pêché	
du	pécher	
dû	pêcher	
élève	pechère	
élevé	péchère	
gène	relève	

B.2 Example 2 – Danish delta and benchmark

The following is a Danish delta following ISO/IEC 14652 tailoring with the assumption that character mnemonics are resolved into UCS identifiers to fit the *ISO14651_1999_TABLE1* template used in this International Standard (this formal specification corresponds to Danish standard DS 377 and to "Retskrivningsordbogen", the Danish orthography specification):

```
escape_char /
comment_char %

% The ordering algorithm is in accordance
% with Danish Standard DS 377 (1980)
% and the Danish Orthography Dictionary
% (Retskrivningsordbogen, 1986).
% It is also in accordance with
% Greenlandic orthography.

LC_COLLATE
collating-element <A-A> from "<A><A>"
collating-element <A-a> from "<A><a>"
collating-element <a-A> from "<a><A>"
collating-element <a-a> from "<a><a>"
copy ISO14651_1999_TABLE1
reorder-after <CAP>
<CAP>
<CAPITAL-SMALL>
<SMALL-CAPITAL>
<MIN>
reorder-after <SP>
<SP> <SP>;<SP>;IGNORE;IGNORE
<-> <SP>;<->;IGNORE;IGNORE
</> <SP>;</>;IGNORE;IGNORE
reorder-after <U24C6>
<kk> <Q>;<COMPAT>;<MIN>;IGNORE
reorder-after <U2122>
<TH> "<T><H>"; "<TH><TH>"; "<CAP><CAP>"; IGNORE
<th> "<T><H>"; "<TH><TH>"; "<MIN><MIN>"; IGNORE
reorder-after <U1EF4>
% <U:> and <U"> are treated as <Y> in Danish
<U:> <Y>;<U:>;<CAP>;IGNORE
<u:> <Y>;<u:>;<MIN>;IGNORE
<U"> <Y>;<U">;<CAP>;IGNORE
<u"> <Y>;<U">;<MIN>;IGNORE
reorder-after <U1E94>
% <AE> is a separate letter in Danish
<AE> <AE>;<BLK>;<CAP>;IGNORE
<ae> <AE>;<BLK>;<MIN>;IGNORE
<AE'> <AE>;<AIGUT>;<CAP>;IGNORE
<ae'> <AE>;<AIGUT>;<MIN>;IGNORE
<A3> <AE>;<MACRON>;<CAP>;IGNORE
<a3> <AE>;<MACRON>;<MIN>;IGNORE
<A:> <AE>;<COMPAT>;<CAP>;IGNORE
<a:> <AE>;<COMPAT>;<MIN>;IGNORE
% <O//> is a separate letter in Danish
<O//> <O//>;<BLK>;<CAP>;IGNORE
<o//> <O//>;<BLK>;<MIN>;IGNORE
<O//'> <O//>;<AIGUT>;<CAP>;IGNORE
<o//'> <O//>;<AIGUT>;<MIN>;IGNORE
<O:> <O//>;<TREMA>;<CAP>;IGNORE
<o:> <O//>;<TREMA>;<MIN>;IGNORE
```

```

<O"> <O//>;<2AIGU>;<CAP>;IGNORE
<o"> <O//>;<2AIGU>;<MIN>;IGNORE
% <AA> is a separate letter in Danish
<AA> <AA>;<BLK>;<CAP>;IGNORE
<aa> <AA>;<BLK>;<MIN>;IGNORE
<A-A> <AA>;<A-A>;<CAP>;IGNORE
<A-a> <AA>;<A-A>;<CAPITAL-SMALL>;IGNORE
<a-A> <AA>;<A-A>;<SMALL-CAPITAL>;IGNORE
<a-a> <AA>;<A-A>;<MIN>;IGNORE
<AA'> <AA>;<AA'>;<CAP>;IGNORE
<aa'> <AA>;<AA'>;<MIN>;IGNORE
reorder-end
END LC_COLLATE

```

Benchmark 2 for Danish

A/S	ß
ANDRE	SSA
ANDRÉ	STORE VILDMOSE
ANDREAS	STOREKÆR
AS	STORM PETERSEN
CA	STORMLY
ÇA	THORVALD
CB	THORVARDUR
ÇC	ÞORVARÐUR
DA	THYGESEN
ÐA	VESTERGÅRD, A
DB	VESTERGAARD, A
ÐC	VESTERGÅRD, B
DSB	ÆBLE
D.S.B.	ÄBLE
DSC	ØBERG
EKSTRA-ARBEJDE	ÖBERG
EKSTRABUD	
HØST	
HAAG	
HÅNDBOG	
HAANDVÆRKS BANKEN	
Karl	
karl	
NIELS-JØRGEN	
NIELS JØRGEN	
NIELSEN	
RÉE, A	
REE, B	
RÉE, L	
REE, V	
SCHYTT, B	
SCHYTT, H	
SCHÜTT, H	
SCHYTT, L	
SCHÜTT, M	
SS	

Annex C -- Preparation (informative)

C.1 General considerations

Preparation is necessary only for modification and/or duplication of original strings to render them context-independent prior to the comparison phase. Examples are:

- duplicating a string such as "41" for phonetic ordering into 3 strings for trilingual phonetic ordering usage (French, English and German):

QUARANTE-ET-UN

FORTY-ONE

EINUNDVIERZIG

- removing or rotating characters that are a nuisance for special requirements of ordering; for example, in France, removing "de" in "de Gaulle" and not removing "De" in "De Gaulle" according to noble origin or not, to give:

Gaulle (de)

De Gaulle

- transform incomplete data into full form; for example, transform "Mc Arthur" to give "Mac Arthur"
- transform numbers so that the result will be ordered in numerical order and not positionally (see specific section presented hereafter). Numeric ordering is particularly delicate and requires special consideration in many specific cases.

C.2 Handling of numeral substrings in collation

A numeral is a string representing a number. We will here only deal with numerals that represent values in R , the real numbers, or subsets of R , as these have a total order. We will also only be dealing with decimal numerals in the examples given here.

The same principles apply to, for example, hexadecimal numerals, with the caveat that there are some words that look like hexadecimal numerals, and one must be careful to distinguish which are words and which are hexadecimal numerals. In some cases one uses run-together numerals, perhaps mixed with other substrings. This may happen for instance for part numbers, some date formats, and the like, where it is not obvious which substrings are really separate numerals. Run-together numerals will *not* be discussed below.

The presentation below will start with positional system decimal numerals for natural numbers using the digits 0-9. It will progress to numerals for whole numbers, numerals with a fraction part, a fraction part and an exponent. There is also a brief discussion on numerals with digits from other scripts, scripts which sometimes uses another syntax with digits for numerals (like Hà numerals), and Roman numerals.

C.2.1 Handling of 'ordinary' numerals for natural numbers

The Common Template Table has no means of sorting strings with numbers in such a way that the resulting order reflects the number values represented by the numerals. For example, given the following strings:

Release 1
Release 20
Release 12
Release 2
Release 9

the method described in this International Standard gives the following list of "sorted" strings:

Release 1
Release 12
Release 2
Release 20
Release 9

(It is sufficient to positionally look at just the first digit in each numeral to see why one gets this order.) A more acceptable ordering is:

Release 1
Release 2
Release 9
Release 12
Release 20

The Common Template Table defined in this International Standard cannot be tailored to give this result. However, preparation can be done prior to the basic collation step to achieve the desired results when numeric value order is desired. The prepared strings are normally not presented to the user, only the original strings are. The prepared strings are normally only used for the collation key construction. A simple, but not very general, way of preparing numerals for natural numbers is to zero-pad them to a given number of digits. If one zero-pads up to three digits the numerals in our original example strings one gets:

Release 001
Release 020
Release 012
Release 002
Release 009

Using the Common Template Table defined in this International Standard one then gets the strings in better order (here showing the strings as they are after preparation, which are normally not shown in the result):

Release 001
Release 002
Release 009

Release 012
Release 020

However, there are two problems with this approach:

1. One has to determine beforehand a (usually small) number of digits to pad up to. If the number of digits to pad up to is too large, the strings after preparation can become rather long, especially if there are several numerals in each string. If the number of digits to pad up to is too small, however, the risk is larger that there are actually occurring numerals with more digits than one pads up to, which results in partially getting back to the original situation, where the numerals's values are not taken into (full) account.
2. Determinacy is lost, if some of the original numerals were already partially zero-padded. E.g. if the original strings were:

Release 01
Release 1

the strings after preparation are identical, and the end result (as the user would normally see it) could be either

Release 01
Release 1

or

Release 1
Release 01

and the relative order may come out differently for different occurrences of numerals, or different runs of the collation process with the same rules. Indeterminacy in the collation is not desirable.

There are many ways to deal with these problems. The following is one way.

To each maximal digit subsequence prepend a fixed-number-of-digits numeral that represents the original number of digits in the numeral. For most cases a two-digit count would suffice (allowing up to 99 digits in the original integer numerals). E.g., given the original strings:

Release 1
Release 01
Release 20
Release 12
Release 2
Release 09
Release 9

One get after this preparation the following strings:

Release 011
 Release 0201
 Release 0220
 Release 0212
 Release 012
 Release 0209
 Release 019

Which would be collated by the basic mechanism of this standard to:

Release 011
 Release 012
 Release 019
 Release 0201
 Release 0209
 Release 0212
 Release 0220

As normally presented to the user:

Release 1
 Release 2
 Release 9
 Release 01
 Release 09
 Release 12
 Release 20

This particular method puts numerals with like original number of digits close to each-other, even if the actual value represented is smaller due to the original zero-padding. If the represented *values* should be kept close together, instead duplicate the numeral: first a count of digits for the leading-zero-stripped numeral, the leading-zero-stripped numeral itself, followed by the original numeral. The duplication is needed to get determinacy relative to the original strings. E.g., using the same original strings as above:

Release 011 1
 Release 011 01
 Release 0220 20
 Release 0212 12
 Release 012 2
 Release 019 09
 Release 019 9

Which would be collated by the basic mechanism of this standard to:

Release 011 01
 Release 011 1
 Release 012 2
 Release 019 09

Release 019 9
Release 0212 12
Release 0220 20

As normally presented to the user:

Release 01
Release 1
Release 2
Release 09
Release 9
Release 12
Release 20

The originally zero-padded numerals consistently comes before the numeral without (or with less) original zero-padding. The preparation processing could move the original numerals (in order of occurrence) to the very end of each string, if one wants to give the original zero-padding lesser significance than the text after the numerals.

There being several natural numerals in each string causes no additional problem.

Taking care of the natural number numerals is in most cases sufficient, and it is recommended that it be included as part of the usual preparation of strings to be collated. However such preparation is not required by this standard.

C.2.2 Handling of positional numerals in other scripts

ISO/IEC 10646 has decimal digits for a number of scripts. In most cases these are used in a positional system, just like 0-9 usually are. However, one should not regard a sequence of numerals mixed from different scripts as a single numeral, but rather that each maximal substring of digits of the same script are each considered a numeral.

C.2.3 Handling of other non-pure positional system numerals or non-positional system numerals (e.g. Roman numerals)

Chinese and a few other scripts can use decimal digits (in the Hà script for Chinese) interspersed with ideographs for “one thousand”, “ten”, etc. If such numerals are to be collated according to the value they represent, one can proceed as above, adding a step just after the initial copying: convert the copy to the corresponding positional system numeral in the syntax used here for whole numerals.

Roman numerals, if handled, can be handled similar to the above. Duplicate, and replace the first copy with the same natural number expressed in the decimal positional system. E.g. “Lois V”, where the V is determined to be a Roman numeral, can be modified to “Lois 5 V”.

Caveat: In this case human interactive intervention or an expert system may be required, as in the following example involving the French language: CHAPITRE DIX might mean CHAPTER 10 or CHAPTER 509 (“dix” is the French word for 10, it is also the Roman numeral for 509). This generally requires context to be solved with total certainty.

C.2.4 Handling of numerals for whole numbers

If negative whole numbers are also to be sorted according to value, there are a number of issues. Most often, negative whole values are given numerals that begin with a negation sign. The negation sign can be HYPHEN-MINUS (caveat: it may be a hyphen, rather than a negation), or MINUS SIGN. But there are other conventions also, like using a SLASH or a PERCENT SIGN to indicate negativeness; or the negation indication can come *after* the digits rather than before; or negativeness can be indicated by putting the digits between parenthesis, and/or putting the digits in a contrasting color (often red). We will in the examples here only deal with the case that negativeness is indicated by an immediately prepended MINUS SIGN. Positiveness is indicated by either the absence of a MINUS SIGN, or the presence of a PLUS SIGN.

Temperature: -9 °C
 Temperature: 0 °C
 Temperature: -14 °C
 Temperature: 05 °C
 Temperature: +5 °C
 Temperature: -0 °C
 Temperature: -09 °C
 Temperature: 105 °C
 Temperature: +05 °C
 Temperature: 5 °C

One preparation to get an acceptable and determinate order for numerals (in this syntax) for whole numbers is as follows (actual implementations should do something equivalent, but more efficient):

1. Duplicate the numerals in the string (including sign indications), putting the 'original' ones (not to be touched by the following steps) in order of original occurrence at the end of the string, leaving the copies at the original positions. This step is to ensure determinacy.
2. See to that all of the copies have an explicit initial sign indication.
3. Remove leading zeroes in the copies of the numerals (systematically either leaving one zero digit for zero or represent 0 by the empty string of digits), alternatively let all numeral copies have exactly one leading zero.
4. Between the sign indication and the digits in the copies of the numerals, insert a (two-digit) count of how many digits there were (after removing the leading zeroes).
5. Do 9's complement on each digit in each copy of a negated numeral. 9's complement of a digit that individually represents the value x , is $9-x$. I.e. 9's complement of 0 is 9, of 9 is 0, of 5 is 4, etc.
6. Done with this (part of the) preparation.

For the basic collation step, use a tailoring of the template given in this standard. A tailoring where the PLUS SIGN and the MINUS SIGN are significant at the same level as the digits, and where the MINUS SIGN has less weight than the PLUS SIGN. (In the example below, it is assumed that the weight of PLUS SIGN is less than the weight of 0, but that is not a prerequisite for getting an acceptable ordering.)

Our example strings after this prehanding:

Temperature: -980 °C -9
Temperature: +00 °C 0
Temperature: -9785 °C -14
Temperature: +015 °C 05
Temperature: +015 °C +5
Temperature: -99 °C -0
Temperature: -980 °C -09
Temperature: +03105 °C 105
Temperature: +015 °C +05
Temperature: +015 °C 5

Sort these, using the basic mechanism of this standard:

Temperature: -9785 °C -14
Temperature: -980 °C -09
Temperature: -980 °C -9
Temperature: -99 °C -0
Temperature: +00 °C 0
Temperature: +015 °C +05
Temperature: +015 °C +5
Temperature: +015 °C 05
Temperature: +015 °C 5
Temperature: +03105 °C 105

As presented to the user:

Temperature: -14 °C
Temperature: -09 °C
Temperature: -9 °C
Temperature: -0 °C
Temperature: 0 °C
Temperature: +05 °C
Temperature: +5 °C
Temperature: 05 °C
Temperature: 5 °C
Temperature: 105 °C

This preparation results in a determinate ordering of strings that may have numerals for whole numbers in them (also if there are several such numerals in some of the strings), that is such that the numerals are ordered according to the integer value they represent.

The process for other syntaxes for whole numbers can be similar. Just add a step to convert the copies to the syntax used here for whole numbers.

This technique for handling negative numerals can be used also for numerals with fraction part, and so on (see below).

C.2.5 Handling of positive positional numerals with fraction parts

The method presented above can easily be adapted to the case where fraction parts may occur and are to be taken into account. A problem is, however, that the characters often used to delimit the integer part from the fraction part are also used for other purposes. The separator character is often PERIOD, or COMMA. These characters also have other uses, also in conjunction with digits.

For the example, assume that PERIOD is used (only) as a fraction part delimiter.

Do as above, but count only the digits in the integer part of the numeral for the count of digits to be prepended. The fraction part delimiter character can be removed.

For example:

-12.34

12.34

3.1415

3.14

After preparation:

-978765 -12.34

+021234 12.34

+013.1415 3.1415

+01314 3.14

After sorting:

-978765 -12.34

+01314 3.14

+0131415 3.1415

+021234 12.34

As presented to the user:

-12.34

3.14

3.1415

12.34

C.2.6 Handling of positive positional numerals with fraction parts and exponent parts

For very big, or very tiny, values, one often uses formats like $2.5 \cdot 10^7$ (to just pick one possible way of writing these for the purposes of the examples here). Here there is already an exponent, which must be combined with the "number of integer part digits" (here: digits before the decimal point), by adding those two

numbers to get a resulting fixed-number-of-digits exponent to prepend just before the first digit. For this example, with a three-digit exponent: we get +00825. One problem here is that the resulting exponent may be negative. To handle this, use an exponent bias. For a three-digit exponent a bias of 500 may be suitable, which gives us for this example numeral: +50825, and for the numeral 2.5×10^{-7} we get +49425. Negative values are handled as before, with 9's complement. -2.5×10^7 gives -49174, and -2.5×10^{-7} gives -50574.

This method should be familiar to anyone with knowledge about (radix 10) floating point arithmetic.

Thus:

$$\begin{array}{l} 2.5 \times 10^{-7} \\ -2.5 \times 10^7 \\ 2.5 \times 10^7 \\ -2.5 \times 10^{-7} \end{array}$$

After preparation (including a duplicate of the original, for determinacy):

$$\begin{array}{l} +49425 \ 2.5 \times 10^{-7} \\ -49174 \ -2.5 \times 10^7 \\ +50825 \ 2.5 \times 10^7 \\ -50574 \ -2.5 \times 10^{-7} \end{array}$$

After sorting:

$$\begin{array}{l} -49174 \ -2.5 \times 10^7 \\ -50574 \ -2.5 \times 10^{-7} \\ +49425 \ 2.5 \times 10^{-7} \\ +50825 \ 2.5 \times 10^7 \end{array}$$

As presented to the user:

$$\begin{array}{l} -2.5 \times 10^7 \\ -2.5 \times 10^{-7} \\ 2.5 \times 10^{-7} \\ 2.5 \times 10^7 \end{array}$$

C.2.8 Handling of date and time of day indications

Going a bit beyond plain numerals, date and time-of-day indications often employ numerals (as well as names for months, weekdays, etc.) for the parts of the date and time-of-day indication. It is not uncommon to want to sort this kind of information also when it occurs within strings.

The preparation needed to get date and time-of-day indications, of some predetermined syntaxes, sorted according to point in time is similar to what has been described above.

1. Duplicate all date and time-of-day indications to maintain determinacy of collation when the original strings differ, but point in time identical. Leave the originals at the end of the strings, untouched by the following steps.
2. Convert the copies of the date and time indications to the same calendar system, if there are several calendar (sub)systems used and handled. The calendar (sub)system converted to, must be suitable

for being able to get proper time order. We will here use the Gregorian calendar system and the subsystem of year, month, day-of-month.

3. Put the date and time-of-day elements in order of decreasing significance (to the resolution taken into account). Full year, month, day-of-month, hour, minute, second, fraction of second.
4. Use a 24-hour/day clock for the time-of-day indications. Remove A.M. or P.M. indications, if present and handled, in the date-time indication copies.
5. Use the UTC time zone for the date and time-of-day indications. Remove time zone indications, if present, in the date-time indication copies.
6. Use month numbers, rather than month names. Use two digits each for month, day-of-month, hour, minute, second.
7. Use full year number representation, as many digits as needed. Take abbreviations into account so that the full year number is used. E.g. '98' might denote year 98 or year 1998, or 1898, or... No indeterminacy regarding year due to abbreviations like these may be present after the preparation step.
8. For years A.D., use an initial PLUS SIGN. For years B.C., use an initial MINUS SIGN. Remove the original A.D. or B.C. indication from the copies. (To be nitpicking, year n B.C. should be represented by year $(1-n)$, which is less or equal to zero if n is positive.)
9. For the year indications, insert between the sign indication and the first digit for the year indication a digit telling how many digits there are in the full year indication. One digit for this should suffice...
10. For negative years, replace the each digit in the year indication (including the digit telling the number of digits in the original full year indication) with its 9's complement digit.
11. Make sure the textual format for all of the date indication copies is the same (paying attention to hyphens, spaces, ...). (Most easily accomplished by printing them in the same format from an internal, non-string, representation.)
12. Alternatively, use a number indicating the point of time on a linear time scale (e.g., hours, milliseconds, or days from a predetermined point in time), to the resolution desired, and handle this as an ordinary numeral (see above).
13. Done with this (part of the) preparation.
14. For the basic collation step, use a tailoring of the template given in this standard. Use a tailoring where the PLUS SIGN and the MINUS SIGN are significant at the same level as the digits, and where the MINUS SIGN has less weight than the PLUS SIGN.

For example:

Dated: July 19, 1955, at 1 p.m. GMT

Dated: January, 20 B.C.

Dated: Sept. 20, 1995, at 1 p.m. PST

Dated: 11-june/345 A.D.

After preparation:

Dated: +41955-07-19T13:00Z July 19, 1955, at 1 p.m. GMT
 Dated: -780-01 January, 20 B.C.
 Dated: +1995-09-20T10:00Z Sept. 20, 1995, at 1 p.m. PST
 Dated: +3345-06-11 11-june/345 A.D.

After sorting:

Dated: -780-01 January, 20 B.C.
 Dated: +3345-06-11 11-june/345 A.D.
 Dated: +41955-07-19T13:00Z July 19, 1955, at 1 p.m. GMT
 Dated: +41995-09-20T10:00Z Sept. 20, 1995, at 1 p.m. PST

As presented to the user:

Dated: January, 20 B.C.
 Dated: 11-june/345 A.D.
 Dated: July 19, 1955, at 1 p.m. GMT
 Dated: Sept. 20, 1995, at 1 p.m. PST

C.2.9 Making numbers less significant than letters

In many cases numerals preceding letters should be considered as less significant than the following alphabetic part. But the Common Template Table has digits as level 1 significant. To make numerals less significant than letters, either tailor the weight table so that numerals are ignored at level 1 (but significant at level 2 or 3), or alternatively leave them significant at level 1, but prepare the strings so that numerals are moved to the end of the string or moved to a less significant field. When doing such a move, one must pay attention not to map different strings to identical strings (or identical string fields), so that determinacy is maintained (see the section C.2.10).

Some examples where it is appropriate to consider numerals as less significant than letters: Street or block names with one or more numbers to indicate where in the street/block, if that/those number(s) precede the street or block name (common for example in the US and in Japan). Chemical compound names which have prepended numerals, e.g., 1,2-dichlorobenzol.

C.2.10 Maintaining determinacy

As noted above in several cases, we have duplicated part of the string to maintain determinacy in collation, when the original strings are different, but when preparation may otherwise turn different strings into identical strings.

This method of duplicating for determinacy can be used more generally, so if there are several preparations affecting different parts of the strings, one may simply duplicate the original strings to begin with, and only do the preparation (without additional duplication) on the first half of the “doubled” string.

One disadvantage with just concatenating the two copies is that the base letters of the second half of the “doubled” string count as more significant than the accents and case of the resulting first half of the “doubled” string. The present standard has no mechanism for handling this in a better way, where the “original” (the second half of the “doubled” string) would count as less significant than the *entire* first half of the “doubled” string. This may be handled better by having the original and copy in different ‘fields’, and construct the collation key by combining the full keys for each ‘field’. Such processing is beyond the scope of this International Standard, though.

Note that the string after preparation is used only for the collation key construction. The original string is not intended to be retrievable from the modified string, though that is possible with this way of attaining determinacy. The strings presented to the user are the original, by preparation untouched, strings.

To maintain determinacy when some of the original strings to be collated are identical, is out of scope for this standard. A collation processor should, however, document if it is 'stable' (maintain initial relative order of identical strings) or not. This is useful to know when collating on one field of multi-field data.

C.3 Posthandling

In case of equality established according to this International Standard on two character strings, it may be necessary to establish a posteriori an ultimate differentiation based on the original record being processed which may contain additional data. Although this posthandling is not part of the scope of this International Standard, consideration is given here on an informative basis to this ultimate stage of ordering.

Posthandling is necessary for modifying a resulting ordering key, or appending the original character string to an ordering key so that the results of comparisons can determine differences particularly in cases where homography results from the preparation phase. For example, there could be equivalencies if numerical values (for example, "010" and "10") may have been rendered identical in the preparation phase. A strict implementation of this International Standard has no knowledge that the original strings are different in such cases, but the predictability requirement may still exist and posthandling will then be required to achieve this specific requirement.

Another case in point exists, for example, where different coding methods have been used in the original strings to be ordered in the same process. An optional posthandling phase can then determine internal differences even when results would appear exactly the same on paper for end-users (for example, an ISO 2022 input stream intermixing ISO/IEC 6937 and ISO/IEC 8859-2 coded characters). This may be required for internal processing of applications and maintaining integrity of comparison between records and even entire files.

Annex D -- Tutorial on solutions brought by this standard to problems of lexical ordering (informative)

Why aren't existing standard codes, character by character comparisons and commercial sort programs appropriate for sorting and what must be done to solve the problem? For clarity, this discussion will start with the Latin script.

- i. Sorting, in any language using the Latin script, including English, using standard ISO 646 coding, does not follow traditional dictionary sequence, which is the minimum the average user needs.

Ex.: Sorting the list "august", "August", "container", "coop", "co-op", "Vice-president", "Vice versa" gives the following order, if ISO 646 coding is used and a simple sort following binary order is done:

```
August
Vice versa
Vice-president
august
co-op
container
coop
```

which is obviously wrong.

- ii. Translating lower case to upper case and removing special characters gives a sorted list acceptable to users, but also unpredictable results.

Ex.: Sorting the list "August", "august", "coop", "co-op" gives the following order:

```
August
august
coop
co-op
```

Sorting the same list with a different initial order, say, "august", "August", "co-op", "coop" may give a different order with this method:

```
august
August
co-op
coop
```

- iii. If accented characters are introduced using for example ISO 8859-1 code, the problems encountered in steps i and ii above are amplified but they share the same causes.
- iv. If tables are reorganized to make all related characters contiguous, one might think it would permit a simplified single-character sort, but this does not work either. Take upper and lower case unaccented letters as an example. If code point 01 is assigned to "a", code point 02 assigned to

"A", code point 03 to "b", code point 04 to "B" and so on, let's see what happens in a list sorted directly by these rearranged values:

Sorted List	Internal Values
aaaa	01010101
abbb	01030303
Aaaa	02010101
Abbb	02030303

This is predictable also, but obviously wrong in any country from a cultural point of view.

- v. The only path of solution is to decompose the initial data in a way that will respect traditional lexical order, and at the same time ensure absolute predictability. For the Latin script, this necessitates at least four levels:

1. The first decomposition renders information to be sorted case insensitive and diacritical mark insensitive, and removes all special characters which have no pre-established order in any human culture:

An example using English:

"résumé" (an English word derived from French but with a very different meaning in French) becomes "resume", without any accent.

An example using French:

"Vice-légation" becomes "vicelegation", with no accent, no upper case and no dash.

An example using German:

"groß" becomes "gross", with the sharp-s being converted to double-s to render it case insensitive.

In Spanish or Scandinavian languages, some extra letters are added to the 26 fixed letters of the English, French and German alphabet, which are not ordered according to the expectations of this group of languages. This calls for adaptability.

2. The second decomposition breaks ties on quasi-homographs, strings that differ only because they have different diacritical marks. In the English example above, "resumé" and "résumé" are quasi-homographs. Traditional lexical order requires that "resume" always come before "résumé" (which sorting using only the first level would not guarantee). In this case, tradition does not say if "resumé" (another spelling) should come before "résumé", which would seem logical: English and German dictionaries only state that unaccented words precede the accented words.

Here another characteristic is introduced. In French, because of the large number of multiple quasi-homograph groups formed of more than 2 instances, main dictionaries follow a rule that is the following: accents are generally not taken into account for sorting, but in case of homographic ties, the *last difference* in the word determines the correct order between two given words, a priority order being then assigned to each type of accent. For example, "coté" should be sorted after "côte" but before "côté". This is easy to implement: a number is assigned to each

character of original data to be sorted, representing either an accent or no accent at all, but these numbers are stacked instead of being added to a linear list: in other words, the resulting string is made starting from the last character of the original data and backward.

Example: to obtain the following order respecting this rule: "cote", "côte", "coté", "côté", numbers could be assigned indicating respectively "****", "**c*", "a****", "a*c*", where "*" means no accent, "a" means acute accent, "c" circumflex accent. Here this scheme is sufficient to break the tie correctly at this second level.

3. The third decomposition breaks ties for quasi-homographs different only because upper-case and lower-case characters are used. This time, the tradition is well established in English and German dictionaries, where lower case always precedes upper case in homographs, while the tradition is not well established in French dictionaries, which generally use only accented capital letters for common word entries. In known French dictionaries where upper and lower case letters are mixed, the capitals generally come first, but this is not an established and stated rule, because there are numerous exceptions. So for a Common Template it is advisable to use English and German traditions, if one wants to group the largest possible number of languages together. Let's note here by the way that in Denmark, upper case comes before lower case, a different but well established rule. This is a second fact calling for adaptability in the model used in this standard.

Example: to have the following order: "august", "August", numbers could be assigned indicating respectively "lIIIII", "uIIIII", where "l" means lower case and "u" upper case.

4. The fourth decomposition breaks the final tie that does not correspond to any tradition, the tie due to quasi-homographs that differ only because they contain special characters. Breaking this tie is essential to ensure the absolute predictability of sorts and also to be able to sort strings composed only of special characters. Since the traces of special characters were removed from the original data to form the three first orders of decomposition, simply putting them in row in the fourth order of decomposition would mean that their position would be lost. These positions are quite important to solve remaining ties and in consequence we must retain here the original positions of these special characters: two quasi-homographs could each contain a common special character in different positions and thus be strictly different (ex.: "ab*cd" is still different from "a*bcd" despite they share one and only one common special character).

Example: to have the following order: "coop", "co-op", "coop-", numbers could be assigned respectively according to the following pattern: "d", "d3-" and "d5-", where "d" is an always-present delimiter that separates this decomposition from the first three in case all four decompositions are to be concatenated to form a single sorting key based on numeric values (see discussion in the next paragraph). "3-" means a dash in position 3 of the original string. "5-" means a dash in position 5, and so on.

These four decompositions can be structured using a four-level key, concatenating the subkeys from the highest significance to the lowest. If coded assignment of numbers is done properly, instead of necessitating a cumbersome exception process for dealing with homographs, all decompositions may be made at once and resulting strings concatenated and passed through a standard sort program sorting in numeric order. To attain this result, it is sufficient that numbers chosen for the first decomposition code set be greater than numbers chosen for the second one, the second one's greater than the third one's, and that the delimiter chosen for the fourth decomposition be less than the lowest possible number coded elsewhere for the sort (delimiter called logical zero), in which case no restriction applies to the content of the fourth

decomposition. An easier implementation might just choose to put the lowest value possible as a delimiter between each subkey, in which case no restriction ever applies.

This method has been fully described with tables for the first time in *Règles du classement alphabétique en langue française et procédure informatisée pour le tri*, Alain LaBonté, Ministère des Communications du Québec, 19 août 1988, ISBN 2-550-19046-7.

Reduction techniques have been designed to considerably shorten space requirements. As no implementation is required to use specific numbers for weights and does not require reduction nor compression, this issue is outside the scope of this standard but it is interesting to note that implementation can be optimized. This has been improved over time and is highly feasible.

A public-domain reduction technique is described in details (with ample examples) in *Technique de réduction - Tris informatiques à quatre clés*, Alain LaBonté, Ministère des Communications du Québec, June 1989 (ISBN 2-550-19965-0).

- vi. For a number of languages, the Common Template presented in this standard will need to be adapted, both in the table values for the four orders of keys (which can require redefining characters or introducing multicharacter collating elements into the table) and in the potential context analysis processing necessary to achieve culturally correct results for users of these languages. To illustrate this (without discussing context analysis which is not necessary in what follows), examples of dictionary sequences are given here for two languages which native order is not in the Common Template table:

Traditional Spanish (note "ch" greater than "cu" and "ña" greater than "no"):
cuneo<cúneo<chapeo<nodo<ñaco

(Comparative French/English/German sort:
chapeo<cuneo<cúneo<ñaco<nodo)

Danish (note "a" less than "c", "cz" less than "cæ" and "cø", and "aa" equivalent to "å" greater than "z" even in cases where it is pronounced differently):

Alzheimer<czar<casium<cåibat<Aachen<Aalborg<Århus

(Comparative French/English/German sort:
Aachen<Aalborg< Alzheimer<Århus<casium<cåibat<czar)

- vii. It is important that in all coding environments, and in all programming environments, the order be consistent so that sort programs can give reliable results re-useable in programs; conversely, comparisons of two character strings where an order is expected should be in line with results given by sort programs. Hence it is advisable that all processes which expect a given order all use the same comparison API. This standard has built on this requirement that was not respected before.

Furthermore it should be possible to have access, externally, to the ultimate binary strings on which real comparison is made. This will allow old processes which can not be changed easily but which are able to sort raw binary data, to sort in a consistent way with new processes. This standard allows this, while it also provides a way to completely avoid the use of such binary strings.

Annex E -- BIBLIOGRAPHY

The following standards and documents are considered relevant to this standard, in addition to the normative references.

CAN/CSA Z243.4.1-1998 – Canadian Alphanumeric Ordering Standard – A National Standard of Canada, Canadian Standards Association

DS 377 (1980) – DS 377:1980 Alfabetiseringsregler – Dansk Standard

ISO/IEC 646, Information technology -- ISO 7-bit coded character set for information interchange

ISO/IEC 2022, Information technology – Code extension techniques

ISO/IEC 6937, Information technology – Coded character sets for text communication

ISO/IEC 8859-1, Information technology -- 8-bit single-byte coded graphic character sets -- Part 1: Latin alphabet No. 1

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