



INTERNATIONAL STANDARD ISO/IEC 13211-1:1995
TECHNICAL CORRIGENDUM 2

Published 2012-02-15

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION
INTERNATIONAL ELECTROTECHNICAL COMMISSION • МЕЖДУНАРОДНАЯ ЭЛЕКТРОТЕХНИЧЕСКАЯ КОМИССИЯ • COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

Information technology — Programming languages — Prolog —
Part 1:
General core

TECHNICAL CORRIGENDUM 2

Technologies de l'information — Langages de programmation — Prolog —

Partie 1: Noyau général

RECTIFICATIF TECHNIQUE 2

Technical Corrigendum 2 to ISO/IEC 13211-1:1995 was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 22, *Programming languages, their environments and system software interfaces*.

Information technology - Programming languages - Prolog - Part 1: General Core TECHNICAL CORRIGENDUM 2

Allow bar character | as infix operator, forbid '{ }' and '[]' as operators.

6.3.4.3 Operators

Add prior to syntax rules:

A bar (6.4) shall be equivalent to the atom ' | ' when ' | ' is an operator.

Add the syntax rule:

op = bar ;

Abstract: |

Priority: n n

Specifier: s s

Condition: ' | ' is an operator

Add at the end of 6.3.4.3 before NOTES:

There shall not be an operator '{ }' or '[]'.

An operator ' | ' shall be only an infix operator with priority greater than or equal to 1001.

Add to note 1

Bar is also a sole character (6.5.3), and a token (6.4) but not an atom.

Replace note 3

3 The third argument of op/3 (8.14.3) may be any atom except ',' so the priority of the comma operator cannot be changed.

by

3 The third argument of op/3 (8.14.3) may be any atom except ' , ' , ' [] ' , and ' { } ' so the priority of the comma operator cannot be changed, and so empty lists and curly bracket pairs cannot be declared as operators.

6.3.4.4

Add in Table 7 - The operator table:

Priority Specifier Operator(s)

400 yfx div

200 fy +

6.4 Tokens

Add as the last syntax rule:

```
bar (* 6.4 *)
  = [ layout text sequence (* 6.4.1 *) ] ,
    bar token (* 6.4.8 *) ;
```

6.4.8 Other tokens

Add as the last syntax rule:

```
bar token (* 6.4.8 *)
  = bar char (* 6.5.3 *) ;
```

6.5.3 Solo characters

Add alternative for solo char:

```
| bar char (* 6.5.3 *)
```

Add as the last syntax rule:

```
bar char (* 6.5.3 *) = "|" ;
```

Add the new subclause into the place indicated by its number:

7.1.1.5 Witness variable list of a term

The witness variable list of a term T is a list of variables and a witness of the variable set (7.1.1.2) of T . The variables appear according to their first occurrence in left-to-right traversal of T .

NOTES

1 For example, $[X, Y]$ is the witness variable list of each of the terms $f(X, Y)$, $X+Y+X+Y$, $X+Y+X$, and $X*Y+X*Y$.

2 The concept of a witness variable list of a term is required when defining `term_variables/2` (8.5.5).

Add the new subclause into the place indicated by its number:

7.1.6.9 List prefix of a term

LP is a list prefix of a term P if:

a) LP is an empty list, or

b) P is a compound term whose principal functor is the list constructor and the heads of LP and P are identical, and the tail of LP is a list prefix of the tail of P .

NOTE — For example, $[], [1]$, and $[1, 2]$ are all list prefixes of $[1, 2, 3]$, $[1, 2|X]$, and $[1, 2|nonlist]$.

Correct example for call/1.

7.8.3.4 example no. 6

For program

```
b(X) :-
    Y = (write(X), X),
    call(Y).
replace
b(3).
    Outputs '3', then
    type_error(callable, 3).
by
b(3).
    type_error(callable, (write(3), 3)).
```

Adjust Template and Modes of catch/3, remove error conditions. In this manner all errors of the goal are caught by catch/3.

7.8.9 catch/3

Replace

7.8.9.2 Template and modes

```
catch(+callable_term, ?term, ?term)
```

7.8.9.3 Errors

- a) G is a variable
— `instantiation_error`.
- b) G is neither a variable nor a callable term
— `type_error(callable, G)`

by

7.8.9.2 Template and modes

```
catch(goal, ?term, goal)
```

7.8.9.3 Errors

None.

7.9.1 Description (Evaluating an expression)

Replace 7.9.1 Note 1

1 An error occurs if *T* is an atom or variable.

by

1 An error occurs if *T* is a variable or if there is no operation *F* in step 7.9.1 c).

7.9.2 Errors (Evaluating an expression)

Replace error condition i and j which both were added in Technical Corrigendum 1

i) The value of an argument *Culprit* is not a member of the set *I*

— `type_error(integer, Culprit)`.

j) The value of an argument *Culprit* is not a member of the set *F*

— `type_error(float, Culprit)`.

by

i) *E* is a compound term with no corresponding operator in step 7.9.1 c but there is an operator corresponding to the same principal functor with different types such that

a) the *i*-th argument of the corresponding operator has type *Type*, and

b) the value *Culprit* of the *i*-th argument of *E* has a different type

— `type_error(Type, Culprit)`.

Add new error class, new types, and new domain.

7.12.2 Error classification

Remove in subclause b variable from the enumerated set ValidType and add pair to the set ValidType. Add in subclause c order to the set ValidDomain.

Add additional error class:

k) There shall be an Uninstantiation Error when an argument or one of its components is not a variable, and a variable or a component as variable is required. It has the form `uninstantiation_error(Culprit)` where *Culprit* is the argument or one of its components which caused the error.

8.1.3 Errors (The format of built-in predicate definitions)

Replace in Note 5

5 When a built-in predicate has a single mode and template, an argument whose mode is – is always associated with an error condition: a type error when the argument is not a variable.

the words

a type error

by

an un instantiation error

Add testing built-in predicate subsumes_term/2.

Add the new subclauses into the place indicated by their number:

8.2.4 subsumes_term/2

This built-in predicate provides a test for syntactic one-sided unification.

8.2.4.1 Description

`subsumes_term(General, Specific)` is true iff there is a substitution θ such that

- a) `General $\theta$` and `Specific $\theta$` are identical, and
- b) `Specific $\theta$` and `Specific` are identical.

Procedurally, `subsumes_term(General, Specific)` simply succeeds or fails accordingly. There is no side effect or unification.

8.2.4.2 Template and modes

`subsumes_term(@term, @term)`

8.2.4.3 Errors

None.

8.2.4.4 Examples

`subsumes_term(a, a).`
Succeeds.

`subsumes_term(f(X,Y), f(Z,Z)).`
Succeeds.

`subsumes_term(f(Z,Z), f(X,Y)).`
Fails.

`subsumes_term(g(X), g(f(X))).`
Fails.

`subsumes_term(X, f(X)).`
Fails.

`subsumes_term(X, Y), subsumes_term(Y, f(X)).`
Succeeds.

NOTES

1 The final two examples show that `subsumes_term/2` is not transitive. A transitive definition corresponding to the term-lattice partial order is `term_instance/2` (3.95).

```
term_instance(Term, Instance) :-
    copy_term(Term, Copy),
    subsumes_term(Copy, Instance).
```

```
term_instance(g(X), g(f(X))).
Succeeds.
```

2 Many existing processors implement a built-in predicate `subsumes/2` which unifies the arguments. This often leads to erroneous programs. The following definition is mentioned only for backwards compatibility.

```
subsumes(General, Specific) :-
    subsumes_term(General, Specific),
    General = Specific.
```

Add testing built-in predicates `callable/1`, `ground/1`, `acyclic_term/1`.

Add the new subclauses into the place indicated by their number:

8.3.9 callable/1

8.3.9.1 Description

`callable(Term)` is true iff `Term` is a callable term (3.24).

NOTE — Not every callable term can be converted to the body of a clause, for example `(1, 2)`.

8.3.9.2 Template and modes

```
callable(@term)
```

8.3.9.3 Errors

None.

8.3.9.4 Examples

```
callable(a).
Succeeds.
```

```
callable(3).
Fails.
```

```
callable(X).
Fails.
```

```
callable((1,2)).
Succeeds.
```

8.3.10 ground/1

8.3.10.1 Description

`ground(Term)` is true iff `Term` is a ground term (3.82).

8.3.10.2 Template and modes

`ground(@term)`

8.3.10.3 Errors

None.

8.3.10.4 Examples

```
ground(3).  
Succeeds.
```

```
ground(a(1, _)).  
Fails.
```

8.3.11 `acyclic_term/1`

8.3.11.1 Description

`acyclic_term(Term)` is true iff `Term` is acyclic, that is, it is a variable or a term instantiated (3.96) with respect to the substitution of a set of equations not subject to occurs check (7.3.3).

8.3.11.2 Template and modes

`acyclic_term(@term)`

8.3.11.3 Errors

None.

8.3.11.4 Examples

```
acyclic_term(a(1, _)).  
Succeeds.
```

```
X = f(X), acyclic_term(X).  
Undefined.  
[STO 7.3.3, does not succeed in many implementations,  
but fails, produces an error, or loops]
```

Add built-in predicates `compare/3`, `sort/2`, `keysort/2` based on term order.

8.4 Term comparison, 8.4.1

Move the two paragraphs from subclause 8.4 to subclause 8.4.1. Add into subclause 8.4:

These built-in predicates compare and sort terms based on the ordering of terms (7.2).

Add the new subclauses into the place indicated by their number:

8.4.2 compare/3 – three-way comparison

8.4.2.1 Description

`compare(Order, X, Y)` is true iff `Order` unifies with `R` which is one of the following atoms:
 '=' iff `X` and `Y` are identical terms (3.87), '<' iff `X term_precedes Y` (7.2), and '>' iff `Y term_precedes X`.

Procedurally, `compare(Order, X, Y)` is executed as follows:

- a) If `X` and `Y` are identical, then let `R` be the atom '=' and proceeds to 8.4.2.1 d.
- b) Else if `X term_precedes Y` (7.3), then let `R` be the atom '<' and proceeds to 8.4.2.1 d.
- c) Else let `R` be the atom '>'.
- d) If `R` unifies with `Order`, then the goal succeeds.
- e) Else the goal fails.

8.4.2.2 Template and modes

```
compare(-atom, ?term, ?term)
compare(+atom, @term, @term)
```

8.4.2.3 Errors

- a) `Order` is neither a variable nor an atom
 — `type_error(atom, Order)`.
- b) `Order` is an atom but not <, =, or >
 — `domain_error(order, Order)`.

8.4.2.4 Examples

```
compare(Order, 3, 5).
    Succeeds, unifying Order with (<).

compare(Order, d, d).
    Succeeds, unifying Order with (=).

compare(Order, Order, <).
    Succeeds, unifying Order with (<).

compare(<, <, <).
    Fails.

compare(1+2, 3, 3.0).
```

```

type_error(atom, 1+2).

compare(>=, 3, 3.0).
domain_error(order, >=).

```

8.4.3 sort/2

8.4.3.1 Description

`sort(List, Sorted)` is true iff `Sorted` unifies with the sorted list of `List` (7.1.6.5).

Procedurally, `sort(List, Sorted)` is executed as follows:

- a) Let `SL` be the sorted list of list `List` (7.1.6.5).
- b) If `SL` unifies with `Sorted`, then the goal succeeds.
- c) Else the goal fails.

NOTE — The following definition defines the logical and procedural behaviour of `sort/2` when no error conditions are satisfied and assumes that `member/2` is defined as in 8.10.3.4.

```

sort([], []).
sort(List, Sorted) :-
    setof(X, member(X, List), Sorted). /* 8.10.3, 8.10.3.4 */

```

8.4.3.2 Template and modes

```

sort(@list, -list)
sort(+list, +list)

```

8.4.3.3 Errors

- a) `List` is a partial list
— `instantiation_error`.
- b) `List` is neither a partial list nor a list
— `type_error(list, List)`.
- c) `Sorted` is neither a partial list nor a list
— `type_error(list, Sorted)`.

8.4.3.4 Examples

```

sort([1, 1], Sorted).
    Succeeds unifies Sorted with [1].

sort([1+Y, z, a, V, 1, 2, V, 1, 7.0, 8.0, 1+Y, 1+2,
      8.0, -a, -X, a], Sorted).
    Succeeds, unifying Sorted with
    [V, 7.0, 8.0, 1, 2, a, z, -X, -a, 1+Y, 1+2]

sort([X, 1], [1, 1]).
    Succeeds, unifying X with 1.

```

```

sort([1, 1], [1, 1]).
  Fails.

sort([V], V).
  Undefined.
  [STO 7.3.3, corresponds to the goal [V] = V. In many
  implementations this goal succeeds and violates
  the mode sort(@list, -list).]

sort([f(U), U, U, f(V), f(U), V], L).
  Succeeds unifying L with [U, V, f(U), f(V)] or
  [V, U, f(V), f(U)].
  [The solution is implementation dependent.]

```

8.4.4 keysort/2

8.4.4.1 Description

`keysort(Pairs, Sorted)` is true iff `Pairs` is a list of compound terms with principal functor `(-)/2` and `Sorted` unifies with a permutation `KVs` of `Pairs` such that the `Key` entries of the elements `Key-Value` of `KVs` are in weakly increasing term order (7.2). Elements with an identical `Key` appear in the same relative sequence as in `Pairs`.

Procedurally, `keysort(Pairs, Sorted)` is executed as follows:

- Let `Ts` be the sorted list (7.1.6.5) containing as elements terms `t(Key, P, Value)` for each element `Key-Value` of `Pairs` with `P` such that `Key-Value` is the `P`-th element in `Pairs`.
- Let `KVs` be the list with elements `Key-Value` occurring in the same sequence as elements `t(Key, _, Value)` in `Ts`.
- If `KVs` unifies with `Sorted`, then the goal succeeds.
- Else the goal fails.

NOTE — The following definition defines the logical and procedural behaviour of `keysort/2` when no error conditions are satisfied. The auxiliary predicate `numbered_from/2` is not needed in many existing processors because `Ps` happens to be a sorted list of variables.

```

keysort(Pairs, Sorted) :-
    pairs_ts_ps(Pairs, Ts, Ps),
    numbered_from(Ps, 1),
    sort(Ts, STs),
    pairs_ts_ps(Sorted, STs, _).
/* 8.4.3 */

pairs_ts_ps([], [], []).
pairs_ts_ps([Key-Value|Pairs], [t(Key,P,Value)|Ts], [P|Ps]) :-
    pairs_ts_ps(Pairs, Ts, Ps).

numbered_from([], _).
numbered_from([I0|Is], I0) :-
    I1 is I0 + 1,
    numbered_from(Is, I1).

```

8.4.4.2 Template and modes

```
keysort(@list, -list)
keysort(+list, +list)
```

8.4.4.3 Errors

- a) `Pairs` is a partial list
— `instantiation_error`.
- b) `Pairs` is neither a partial list nor a list
— `type_error(list, Pairs)`.
- c) `Sorted` is neither a partial list nor a list
— `type_error(list, Sorted)`.
- d) An element of a list prefix of `Pairs` is a variable
— `instantiation_error`.
- e) An element `E` of a list prefix of `Pairs` is neither a variable nor a compound term with principal functor `(-)/2`
— `type_error(pair, E)`.
- f) An element `E` of a list prefix of `Sorted` is neither a variable nor a compound term with principal functor `(-)/2`
— `type_error(pair, E)`.

8.4.4.4 Examples

```
keysort([1-1, 1-1], Sorted).
    Succeeds unifying Sorted with [1-1, 1-1].

keysort([2-99, 1-a, 3-f(_), 1-z, 1-a, 2-44], Sorted).
    Succeeds unifying Sorted with [1-a, 1-z, 1-a,
    2-99, 2-44, 3-f(_)].

keysort([X-1, 1-1], [2-1, 1-1]).
    Succeeds unifying X with 2.

Pairs = [1-2|Pairs], keysort(Pairs, Sorted).
    Undefined.
    [STO 7.3.3.. type_error(list, [1-2, 1-2, ...]) or
    loops in many implementations.]

keysort([V-V], V).
    Undefined.
    [STO 7.3.3, corresponds to the goal [V-V] = V.
    In many implementations this goal succeeds
    and violates the mode keysort(@list, -list).]
```

Add built-in predicate `term_variables/2`.

Add the new subclauses into the place indicated by their number:

8.5.5 `term_variables/2`

8.5.5.1 Description

`term_variables(Term, Vars)` is true iff `Vars` unifies with the witness variable list of `Term` (7.1.1.5).

Procedurally, `term_variables(Term, Vars)` is executed as follows:

- a) Let `TVars` be the witness variable list of `Term` (7.1.1.5).
- b) If `Vars` unifies with `TVars`, then the goal succeeds.
- c) Else the goal fails.

NOTE — The order of variables in `Vars` ensures that, for every term `T`, the following goals are true:

```
term_variables(T, Vs1), term_variables(T, Vs2), Vs1 == Vs2.
```

```
term_variables(T, Vs1), term_variables(Vs1, Vs2), Vs1 == Vs2.
```

8.5.5.2 Template and modes

```
term_variables(@term, -list)
term_variables(?term, ?list)
```

8.5.5.3 Errors

- a) `Vars` is neither a partial list nor a list
— `type_error(list, Vars)`.

8.5.5.4 Examples

```
term_variables(t, Vars).
Succeeds, unifying Vars with [].
```

```
term_variables(A+B*C/D, Vars).
Succeeds, unifying Vars with [A, B, C, D].
```

```
term_variables(t, [_ , _|a]).
type_error(list, [_ , _|a]).
```

```
S=B+T, T=A*B, term_variables(S, Vars).
Succeeds, unifying Vars with [B, A], T with A*B,
and S with B+A*B.
```

```
T=A*B, S=B+T, term_variables(S, Vars).
Same answer as above example.
```

```
term_variables(A+B+B, [B|Vars]).
Succeeds, unifying A with B and Vars with [B].
```

```
term_variables(X+Vars, Vars), Vars = [_ , _].
Undefined.
[STO 7.3.3, corresponds to the goal [X, Vars] = Vars.]
```

8.9.3.3 Errors (retract/1)

Replace in error condition c

—`permission_error(access, static_procedure, Pred)`.

by

—`permission_error(modify, static_procedure, Pred)`.

Add built-in predicate retractall/1.

Add the new subclauses into the place indicated by their number:

8.9.5 retractall/1

8.9.5.1 Description

`retractall(Head)` is true.

Procedurally, `retractall(Head)` is executed as follows:

a) Searches sequentially through each dynamic user-defined procedure in the database and removes all clauses whose head unifies with `Head`, and the goal succeeds.

NOTES

1 The dynamic predicate remains known to the system as a dynamic predicate even when all of its clauses are removed.

2 Many existing processors define `retractall/1` as follows.

```
retractall(Head) :-
    retract((Head :- _)),
    fail.
retractall(_).
```

8.9.5.2 Template and modes

`retractall(@callable_term)`

8.9.5.3 Errors

a) `Head` is a variable

—`instantiation_error`.

b) `Head` is neither a variable nor a callable term

—`type_error(callable, Head)`.

c) The predicate indicator `Pred` of `Head` is that of a static procedure

—`permission_error(modify, static_procedure, Pred)`.

8.9.5.4 Examples

The examples defined in this subclause assume the database has been created from the following Prolog text:

```

:- dynamic(insect/1).
insect(ant).
insect(bee).

retractall(insect(bee)).
    Succeeds, retracting the clause 'insect(bee)'.

retractall(insect(_)).
    Succeeds, retracting all the clauses of predicate insect/1.

retractall(insect(spider)).
    Succeeds.

retractall(mammal(_)).
    Succeeds.

retractall(3).
    type_error(callable, 3).

retractall(retractall(_)).
    permission_error(modify, static_procedure, retractall/1).

```

8.11.5.3 Errors (open/4, open/3)

Replace error condition f

f) Stream is not a variable

— type_error(variable, Stream).

by

f) Stream is not a variable

— uninstantiation_error(Stream).

8.14.3.3 Errors (op/3)

Replace

l) Op_specifier is a specifier such that Operator would have an invalid set of specifiers (see 6.3.4.3).

— permission_error(create, operator, Operator).

by

l) Operator is an atom, Priority is a priority, and Op_specifier is a specifier such that Operator would have an invalid set of priorities and specifiers (see 6.3.4.3).

— permission_error(create, operator, Operator).

Add additional error:

m) Operator is a list, Priority is a priority, and Op_specifier is a specifier such that an element Op of the list Operator would have an invalid set of priorities and specifiers (see 6.3.4.3).

— permission_error(create, operator, Op).

8.14.3.4

Add the following examples:

```
op(500, xfy, {}).
    permission_error(create, operator, {}).

op(500, xfy, [{}]).
    permission_error(create, operator, {}).

op(1000, xfy, '|').
    permission_error(create, operator, '|').

op(1000, xfy, ['|']).
    permission_error(create, operator, '|').

op(1150, fx, '|').
    permission_error(create, operator, '|').

op(1105, xfy, '|').
    Succeeds, making | a right associative
    infix operator with priority 1105.

op(0, xfy, '|').
    Succeeds, making | no longer an infix operator.
```

Add built-in predicate `call/2..8` and `false/0`.

Add the new subclauses into the place indicated by their number:

8.15.4 `call/2..8`

These built-in predicates provide support for higher-order programming.

NOTE — A built-in predicate `apply/2` was implemented in some processors. Most uses can be directly replaced by `call/2..8`.

8.15.4.1 Description

`call(Closure, Arg1, ...)` is true iff `call(Goal)` is true where `Goal` is constructed by appending `Arg1, ...` additional arguments to the arguments (if any) of `Closure`.

Procedurally, a goal of predicate `call/N` with $N \geq 2$ is executed as follows:

- Let `call(p(X1, ..., XM), Y2, ..., YN)` be the goal to be executed, $M \geq 0$,
- Execute `call(p(X1, ..., XM, Y2, ..., YN))` instead.

8.15.4.2 Template and modes

```
call(+callable_term, ?term, ...)
```

8.15.4.3 Errors

- `Closure` is a variable
— `instantiation_error`.

b) Closure is neither a variable nor a callable term

— `type_error(callable, Closure)`.

c) The number of arguments in the resulting goal exceeds the implementation defined maximum arity (7.11.2.3)

— `representation_error(max_arity)`.

d) `call/N` is called with $N \geq 9$ and it shall be implementation dependent whether this error condition is satisfied

— `existence_error(procedure, call/N)`.

e) Goal cannot be converted to a goal

— `type_error(callable, Goal)`.

NOTE — A standard-conforming processor may implement `call/N` in one of the following ways because error condition d is implementation dependent (3.91).

1) Implement only the seven built-in predicates `call/2` up to `call/8`.

2) Implement `call/2..N` up to any N that is within $8..max_arity$ (7.11.2.3). Produce existence errors for larger arities below `max_arity`.

3) Implement `call/9` and above only for certain execution modes.

8.15.4.4 Examples

```
call(integer, 3).
Succeeds.
```

```
call(functor(F,c), 0).
Succeeds, unifying F with c.
```

```
call(call(call(atom_concat, prolog), log), Atom).
Succeeds, unifying Atom with prolog.
```

```
call(;; X = 1, Y = 2).
Succeeds, unifying X with 1. On re-execution,
succeeds, unifying Y with 2.
```

```
call(;; (true->fail), X=1).
Fails.
```

The following examples assume that `maplist/2` is defined with the following clauses:

```
maplist(_Cont, []).
maplist(_Cont, [E|Es]) :-
    call(Cont, E),
    maplist(Cont, Es).
```

```
maplist(>(3), [1, 2]).
Succeeds.
```

```
maplist(>(3), [1, 2, 3]).
Fails.
```

```
maplist(=(X), Xs).
```

Succeeds,
 unifying Xs with [].
 On re-execution, succeeds,
 unifying Xs with [X].
 On re-execution, succeeds,
 unifying Xs with [X, X].
 On re-execution, succeeds,
 unifying Xs with [X, X, X].
 Ad infinitum.

8.15.5 false/0

8.15.5.1 Description

false is false.

8.15.5.2 Template and modes

false

8.15.5.3 Errors

None.

8.15.5.4 Examples

false.
 Fails.

Correct error conditions of atom_chars/2, atom_codes/2, number_chars/2, number_codes/2.

8.16.4.3 Errors (atom_chars/2)

Replace error condition a, c, and d. Add error condition e.

- a) Atom is a variable and List is a partial list.
 — instantiation_error.
- c) List is neither a partial list nor a list
 — type_error(list, List).
- d) Atom is a variable and an element of a list prefix of List is a variable.
 — instantiation_error.
- e) An element E of a list prefix of List is neither a variable nor a one-char atom
 — type_error(character, E).

8.16.5.3 Errors (atom_codes/2)

Replace error condition a, c, and d. Add error condition e and f.

- a) Atom is a variable and List is a partial list.
— instantiation_error.
- c) List is neither a partial list nor a list
— type_error(list, List).
- d) Atom is a variable and an element of a list prefix of List is a variable.
— instantiation_error.
- e) An element E of a list prefix of List is neither a variable nor an integer
— type_error(integer, E).
- f) An element of a list prefix of List is neither a variable nor a character code
— representation_error(character_code).

8.16.7.3 Errors (number_chars/2)

Replace error condition a, c, and d. Add error condition f.

- a) Number is a variable and List is a partial list.
— instantiation_error.
- c) List is neither a partial list nor a list
— type_error(list, List).
- d) Number is a variable and an element of a list prefix of List is a variable.
— instantiation_error.
- f) An element E of a list prefix of List is neither a variable nor a one-char atom
— type_error(character, E).

8.16.8.3 Errors (number_codes/2)

Replace error conditions a, c, and d. Add error condition f and g.

- a) Number is a variable and List is a partial list.
— instantiation_error.
- c) List is neither a partial list nor a list
— type_error(list, List).
- d) Number is a variable and an element of a list prefix of List is a variable.
— instantiation_error.
- f) An element E of a list prefix of List is neither a variable nor an integer
— type_error(integer, E).
- g) An element of a list prefix of List is neither a variable nor a character code
— representation_error(character_code).

Add evaluable functors (+)/1 (unary plus) and (div)/2 (flooring integer division) to simple arithmetic functors (9.1). Add operators corresponding to (-)/1 and (/)/2 (integer division).

9.1.1

Add to table:

Evaluable functor Operation

(div) /2 *intfloordiv_I*

(+) /1 *pos_I, pos_F*

Add '*div*' to enumeration in Note. Add to Note:

'+', '-' are prefix predefined operators.

9.1.3

Add specifications:

intfloordiv_I : $I \times I \rightarrow I \cup \{\text{int_overflow}, \text{zero_divisor}\}$

pos_I : $I \rightarrow I$

Add as axioms:

intfloordiv_I(*x*,*y*) = $\lfloor x/y \rfloor$

if $y \neq 0 \wedge \lfloor x/y \rfloor \in I$

= **int_overflow**

if $y \neq 0 \wedge \lfloor x/y \rfloor \notin I$

= **zero_divisor**

if $y = 0$

pos_I (*x*) = *x*

9.1.4

Add specification:

pos_F : $F \rightarrow F$

Add as axiom:

pos_F (*x*) = *x*

Add evaluable functors *max*/2, *min*/2, (^)/2, *asin*/1, *acos*/1, *atan2*/2, *tan*/1. Add evaluable atom *pi*/0.

Add the new subclauses into the place indicated by their number:

9.3.8 max/2 – maximum

9.3.8.1 Description

max (*X*, *Y*) evaluates the expressions *X* and *Y* with values *V_X* and *V_Y* and has the value of the maximum of *V_X* and *V_Y*. If *V_X* and *V_Y* have the same type then the value *R* satisfies $R \in \{V_X, V_Y\}$.

If *V_X* and *V_Y* have different types then let *V_I* and *V_F* be the values of type integer and float. The

value R shall satisfy

$R \in \{VI, \text{float}(VI), VF, \text{undefined}\}$

and the value shall be implementation dependent.

NOTE — The possible values of $\text{float}(VI)$ include the exceptional value **float_overflow** $\notin F$ (9.1.6).

9.3.8.2 Template and modes

```
max(float-exp, float-exp) = float
max(float-exp, int-exp) = number
max(int-exp, float-exp) = number
max(int-exp, int-exp) = integer
```

9.3.8.3 Errors

a) X is a variable

— `instantiation_error`.

b) Y is a variable

— `instantiation_error`.

c) VX and VY have different type and it shall be implementation dependent whether this error condition is satisfied

— `evaluation_error(undefined)`.

d) VX and VY have different type and one of them is an integer VI with

$\text{float}_{I \rightarrow F}(VI) = \text{float_overflow}$ (9.1.6) and it shall be implementation dependent whether this error condition is satisfied

— `evaluation_error(float_overflow)`.

9.3.8.4 Examples

```
max(2, 3).
```

Evaluates to 3.

```
max(2.0, 3).
```

Evaluates to 3, 3.0, or `evaluation_error(undefined)`.

[The result is implementation dependent.]

```
max(2, 3.0).
```

Evaluates to 3.0 or `evaluation_error(undefined)`.

[The result is implementation dependent.]

```
max(0, 0.0).
```

Evaluates to 0, 0.0, or `evaluation_error(undefined)`.

[The result is implementation dependent.]

9.3.9 min/2 – minimum

9.3.9.1 Description

`min(X, Y)` evaluates the expressions `X` and `Y` with values `VX` and `VY` and has the value of the minimum of `VX` and `VY`. If `VX` and `VY` have the same type then the value `R` satisfies $R \in \{VX, VY\}$.

If `VX` and `VY` have different types then let `VI` and `VF` be the values of type integer and float. The value `R` shall satisfy

$R \in \{VI, \text{float}(VI), VF, \text{undefined}\}$

and the value shall be implementation dependent.

NOTE — The possible values of `float(VI)` include the exceptional value `float_overflow` $\notin F$ (9.1.6).

9.3.9.2 Template and modes

```
min(float-exp, float-exp) = float
min(float-exp, int-exp) = number
min(int-exp, float-exp) = number
min(int-exp, int-exp) = integer
```

9.3.9.3 Errors

a) `X` is a variable

— `instantiation_error`.

b) `Y` is a variable

— `instantiation_error`.

c) `VX` and `VY` have different type and it shall be implementation dependent whether this error condition is satisfied

— `evaluation_error(undefined)`.

d) `VX` and `VY` have different type and one of them is an integer `VI` with

`floatI→F(VI) = float_overflow` (9.1.6) and it shall be implementation dependent whether this error condition is satisfied

— `evaluation_error(float_overflow)`.

9.3.9.4 Examples

```
min(2, 3).
```

Evaluates to 2.

```
min(2, 3.0).
```

Evaluates to 2, 2.0, or `evaluation_error(undefined)`.

[The result is implementation dependent.]

```
min(2.0, 3).
```

Evaluates to 2.0 or `evaluation_error(undefined)`.

[The result is implementation dependent.]

```
min(0, 0.0).
```

Evaluates to 0, 0.0, or `evaluation_error(undefined)`.

[The result is implementation dependent.]

9.3.10 (^)/2 – integer power