INTERNATIONAL STANDARD

ISO 13584-20

First edition
1998-07-01

Industrial automation systems and integration — Parts library —

Part 20:
Logical resource: Logical model of expressions

Systèmes d'automatisation industrielle et intégration — Bibliothèque de composants —

Partie 20: Ressource logique: Modèle logique d'expressions

Reference number
ISO 13584-20:1998(E)

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Printed in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organisations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardisation.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 13584-20 was prepared by Technical Committee ISO/TC 184, *Industrial automation systems and integration,* Subcommittee SC 4, *Industrial data.*

ISO 13584 consists of the following parts, under the general title *Industrial automation systems and integration — Parts library*:

— *Part 1: Overview and fundamental principles*

— *Part 10: Conceptual description: Conceptual model of parts library*

— *Part 20: Logical resource: Logical model of expressions*

— *Part 24: Logical resource: Logical model of supplier library*

— *Part 26: Logical resource: Supplier identification*

— *Part 31: Implementation resource: Geometric programming interface*

— *Part 42: Description methodology: Methodology for structuring part families*

— *Part 101: View exchange protocol: Geometric view exchange protocol by parametric program*

— *Part 102: View exchange protocol: View exchange protocol by ISO 10303 conforming specification*

The structure of ISO 13584 is described in ISO 13584-1. The numbering of the parts of ISO 13584 reflects its structure:

— Parts 10 to 19 specify the conceptual descriptions,

— Parts 20 to 29 specify the logical resources,

— Parts 30 to 39 specify the implementation resources,

— Parts 40 to 49 specify the description methodology,

— Parts 50 to 59 specify the conformance testing,

— Parts 100 to 199 specify the view exchange protocol,

— Parts 500 to 599 specify the standardised content.

Should further parts of ISO 13584 be published, they will follow the same numbering pattern.

Annexes A and B form an integral part of this part of ISO 13584. Annexes C, D, E and F are for information only.

Introduction

ISO 13584 is an International Standard for the computer-interpretable representation and exchange of part library data. The objective is to provide a neutral mechanism capable of transferring parts library data, independent of any application that is using a parts library data system. The nature of this description makes it suitable not only for the exchange of files containing parts, but also as a basis for implementing and sharing databases of parts library data.

ISO 13584 is organised as a series of parts, each published separately. The parts of ISO 13854 fall into one of the following series: conceptual descriptions, logical resources, implementation resources, description methodology, conformance testing, view exchange protocol, and standardised content. The series are described in ISO 13584-1. This part of ISO 13584 is a member of the logical resources series.

This part of ISO 13584 provides the general purpose EXPRESS resource constructs needed for expression modelling. These EXPRESS resource constructs are intended to be detailed in other parts of ISO 13584. They are also intended to be used outside ISO 13584 wherever EXPRESS information models of expressions prove to be useful.

Industrial automation systems and integration — Parts library — Part 20: Logical resource: Logical model of expressions

1 Scope

This part of ISO 13584 specifies:

— an EXPRESS schema for generic expressions;

— an EXPRESS schema for expressions, that models the subset of the allowed expressions in the EXPRESS language defined in ISO 10303-11 that corresponds to integer, real, Boolean and string data types. This schema uses the resources defined in the generic expression schema.

The following are within the scope of this part of ISO 13584:

— the exchange of expressions that involve both constants and variables;

— the function that checks whether or not a numeric expression should evaluate to an integer value;

— the constraints which ensure that an expression is semantically correct;

— the computation of the variables or functions used in an expression;

— the function that checks if an expression may be mapped on to the SQL query language.

The following are outside the scope of this part of ISO 13584:

— the assignment of values to variables within some context;

— the triggering mechanism that computes the value of an expression in a given context.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13584. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13584 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO/IEC 9075: 1992, *Information technology — Database languages — SQL.*

ISO 10303-11: 1994, *Industrial automation systems and integration — Product data representation and exchange — Part 11: Description methods: The EXPRESS language reference manual.*

ISO 10303-44: 1994, *Industrial automation systems and integration — Product data representation and exchange — Part 44: Integrated generic resources: Product structure configuration.*

3 Terms and definitions

For the purposes of this part of ISO 13584, the following terms and definitions apply.

3.1 Terms and definitions from ISO 10303-11

For the purposes of this part of ISO 13584, the following terms and definitions given in ISO 10303-11:1994 (which are repeated below for convenience) apply.

3.1.1

data type
a domain of values.

[ISO 10303-11:1994]

3.1.2

entity
a class of information defined by common properties.

[ISO 10303-11:1994]

3.1.3

entity data type
a representation of an entity. An entity data type establishes a domain of values defined by common attributes and constraints.

[ISO 10303-11:1994]

3.1.4

entity (data type) instance
a named unit of data which represents a unit of information within the class defined by an entity. It is a member of the domain established by an entity data type.

[ISO 10303-11:1994]

3.2 Terms and definitions from ISO 10303-44

For the purpose of this part of ISO 13584, the following terms and definitions given in ISO 10303-44:1994 (which are repeated below for convenience) apply.

3.2.1

ancestor node
any node that can be reached from a given node, by successive traversals of links in the reverse direction. For a given node, its ancestor nodes include all parent nodes, all parent nodes of these parent nodes, etc.

[ISO 10303-44:1994]

3.2.2

child node
node to which a link is pointing.

[ISO 10303-44:1994]

3.2.3

descendent node
any node that can be reached from a given node, by successive traversals of links. For a given node, its descendent nodes include all children nodes, all children nodes of these children nodes, etc.

[ISO 10303-44:1994]

3.2.4

directed acyclic graph
collection of nodes and directed links such that no node is an ancestor (or descendant) of itself.

[ISO 10303-44:1994]

3.2.5

link
uni-directional relationship from one node to another node within a directed acyclic graph.

[ISO 10303-44:1994]

3.2.6

node
element of a directed acyclic graph, connected to other such elements by links.

[ISO 10303-44:1994]

3.2.7

parent node
node from which a link is initiated.

[ISO 10303-44:1994]

3.3 Other terms and definitions

For the purpose of this part of ISO 13584, the following apply.

3.3.1

arity of an operator
the maximum number of operands that shall be associated with an operator.

3.3.2

binary operator
an operator whose arity is equal to two.

3.3.3

environment
association between syntax and semantics.

NOTE In the context of this part of ISO 13584, the **environment** entity associates to a **generic_variable** (syntax) its corresponding meaning (semantics) represented by the **variable_semantics** entity.

3.3.4

evaluation
the computation of the value represented by an expression.

3.3.5

expression
set of variables or constants or both that are combined by operators.

NOTE 1 An expression specifies a function whose arguments are the variables occurring in the expression.

NOTE 2 The underlying structure is a directed acyclic graph, where nodes are operators, constants or variables, and where links represent the uni-directional relationship from each operators to its arguments, that are themselves expressions.

3.3.6

expression data type
domain where the result of an expression shall take its values.

NOTE In this part of ISO 13584, type control and type synthesis are only performed for the **ISO13584_expressions_schema.** Type control is ensured by the structure and the rules of this EXPRESS schema. Type synthesis is done by the EXPRESS TYPEOF function that computes whether an **expression** is a **numeric_expression**, a **Boolean_expression** or a **string_expression**, and by the **is_int** function that computes whether or not a **numeric_expression** evaluates to an INTERGER value.

3.3.7

interpretation
function that returns the semantics associated to each variable.

NOTE This function uses an environment that associates a variable to its corresponding semantics (and may be to its possible value).

3.3.8

multiple arity operator
an operator whose arity is greater than two.

3.3.9

operator
function that combines one or several values, named its operands, to produce a value, named its result.

NOTE The definition of an operator includes the data type definition of its operands and of its result.

3.3.10

semantics
meaning of a given concept.

EXAMPLE The semantics of a variable is the meaning carried by this variable.

NOTE In the context of this part of ISO 13584, the semantics is represented by the **variable_semantics** entity. This entity is an ABSTRACT SUPERTYPE, that can be specialised to carry specific meanings and values.

3.3.11

syntactic representation
sequence of characters that represents a given concept.

NOTE 1 In usual programming languages, the sequence of characters used to represent the different concepts shall obey to a set of rules known as the syntax of the language.

NOTE 2 In the context of this part of ISO 13584, a syntactic representation is an entity (data type) instance name.

3.3.12

type control
operation that allows the determination whether or not a given expression is correctly typed.

NOTE 1 An expression is correctly typed if the data type of each operand of each operator of this expression complies with the required data type.

NOTE 2 In this part of ISO 13584, type control is ensured by the constraints of the EXPRESS schema.

3.3.13

type synthesis
determination of an expression data type.

NOTE In the **ISO13584_expressions_schema** schema, the data type of each constant, variable or operator result is carried by the entity that represents it; therefore, the data type of an **expression** may be deduced from the result of the EXPRESS TYPEOF function applied to the node that represents this **expression**.

3.3.14

unary operator
an operator whose arity is equal to one.

3.3.15

variable
representation of a value that shall belong to a specified data type.

4 Abbreviated terms

For the purpose of this part of ISO 13584 the following abbreviated term applies.

— SQL : The structured Query Language defined by ISO/IEC 9075:1992.

5 Fundamental concepts and assumptions

5.1 Static and dynamic data

When exchanging parts library information, there is a need to exchange not only static properties, that may be modelled as data, but also dynamic behaviour that expresses e.g. how the value of a property may be deduced from the values of other properties. Expressions are one of the structures that enable the modelling of dynamic behaviours.

This part of ISO 13584 specifies a form for the unambiguous representation and exchange of computer interpretable expressions.

5.2 Syntax of expressions

The syntax of an expression consists of a set of symbols that represent the constants, the variables and the operators of this expression. In textual languages these symbols obey a set of rules usually defined in a grammar.

In this part of ISO 13584, the constants, the variables and the operators are represented as entity data types. The rules these entities shall obey are modelled in the EXPRESS schema that defines these entity data types.

5.3 Semantics of expressions

5.3.1 Semantic of expressions

An expression consists of operators and operands. The semantics of an expression is defined by the:

— range of the function performed by each operator;

— interpretation function that associates the corresponding value to each operand;

— evaluation function that computes the result of each operator when applied to its operands.

In this part of ISO 13584, the interpretation function shall be modelled by subtyping the **variable_semantics** entity. The evaluation function is not addressed in this part of ISO 13584.

5.3.2 Exchange time and evaluation time

The processing of expressions can be distinguished between two types of procedures.

— At exchange time an expression is represented by its structure. The corresponding directed acyclic graph is modelled and exchanged, and it is not required that the variables are bound to any value, but their semantics are known. Static analyses (acyclicity of a graph, type checking, mappability to the SQL language) can be performed at this level.

— At evaluation time, the expression can be assigned a value. At this stage, all the variables occurring in the expression must be bound to a value. Dynamic evaluation of an expression, testing and debugging, can be performed at this level.

Only the static analysis that correspond to exchange time are addressed in this part of ISO 13584. The informative annex F provides an overview of the different analyses of expressions.

5.4 Levels of abstraction in expression modelling

The operators used in the **ISO13584_generic_expressions_schema** allow the specification of abstract generic expressions that can be specialised for different purposes and on different data types.

5.4.1 Specialisation of the ISO13584_generic_expressions_schema

The **ISO13584_expressions_schema** is one specialisation of the **ISO13584_generic_expressions_schema**. The operators used in the **ISO13584_expressions_schema** belong to a subset of the operators defined in ISO 10303-11. Their range and evaluation function shall conform to the specification given in ISO 10303-11.

The operands are either constants, represented by literal values, variables or other expressions. Variables are strongly typed and it is assumed that, when the expression is evaluated in some context, an interpretation function provides each variable with a value conforming to its data type. When this condition is false, the expression evaluation results in an error.

The informative annex E discusses the details of such a specialisation process and outlines a methodology for other possible specialisation's of the **ISO13584_generic_expressions_schema**.

5.4.2 Specialisation of the ISO13584_expressions_schema

The **ISO13584_expression_schema** may itself be specialised to meet the requirements that are not addressed by the numeric-valued, string-valued or Boolean-valued operators defined in the EXPRESS language reference manual.

The specialisation of the **ISO13584_expressions_schema** consists either (1) in enlarging the schema by adding the definitions of new entities which carry the semantics of functions returning an integer, a real, a Boolean or a string value, or (2) in defining new sub-types of the **variable_semantics**.

The entities that carry the semantics of functions shall be defined as subtypes of the corresponding **defined_function** entity. Indeed, a function returning an integer, a real, a Boolean or a string value respectively shall be defined as a subtype of the **integer_defined_function**, **real_defined_function**, **boolean_defined_function** and **string_defined_function**.

Such a specialisation is compatible with the strong data type checking that results from the rules of the **ISO13584_expression_schema.**

The informative annex E discusses the details of such a specialisation process and outlines a methodology for specialisation of the **ISO13584_expressions_schema**.

5.5 Modelling a variable

A variable has three aspects:

— it is a (syntactic) symbol that may be used to build an expression;

— it is associated with a data type that defines the domain of its value;

— it is associated with a semantics that defines its meaning, and therefore its value at evaluation time.

5.5.1 Syntactic representation

In this part of ISO 13584, a variable is an instance of the **generic_variable** entity. An instance of such a data type is associated with an identifier, known as the instance identity, that constitutes the symbol of the corresponding variable when it is used in an expression.