

# Batch control —

## Part 2: Data structures and guidelines for languages

The European Standard EN 61512-2:2002 has the status of a  
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ICS 35.240.50

# National foreword

This British Standard is the official English language version of EN 61512-2:2002. It is identical with IEC 61512-2:2001.

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/1, System considerations, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;
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EUROPEAN STANDARD

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English version

**Batch control**  
**Part 2: Data structures and guidelines for languages**  
(IEC 61512-2:2001)

Contrôle-commande des processus  
de fabrication par lots (batch)  
Partie 2: Structures de données et  
règles générales relatives aux langages  
(CEI 61512-2:2001)

Chargenorientierte Fahrweise  
Teil 2: Datenstrukturen und Leitfaden  
für Sprachen  
(IEC 61512-2:2001)

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**CENELEC**

European Committee for Electrotechnical Standardization  
Comité Européen de Normalisation Electrotechnique  
Europäisches Komitee für Elektrotechnische Normung

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## **Foreword**

The text of the International Standard IEC 61512-2:2001, prepared by SC 65A, System aspects, of IEC TC 65, Industrial-process measurement and control, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 61512-2 on 2002-10-01 without any modification.

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Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A, B and ZA are normative and annexes C, D and E are informative.

Annex ZA has been added by CENELEC.

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## **Endorsement notice**

The text of the International Standard IEC 61512-2:2001 was approved by CENELEC as a European Standard without any modification.

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## CONTENTS

|                                                           |    |
|-----------------------------------------------------------|----|
| INTRODUCTION.....                                         | 7  |
| 1 Scope.....                                              | 8  |
| 2 Normative references .....                              | 8  |
| 3 Definitions .....                                       | 8  |
| 4 Data model.....                                         | 9  |
| 4.1 Introduction .....                                    | 9  |
| 4.2 Overview model.....                                   | 10 |
| 4.3 Recipe model .....                                    | 11 |
| 4.3.1 Recipe entity .....                                 | 11 |
| 4.3.2 Parts of recipe entities.....                       | 15 |
| 4.3.3 Recipe entity relation (procedural structure) ..... | 17 |
| 4.3.4 Recipe building blocks.....                         | 17 |
| 4.3.5 Equipment requirements.....                         | 19 |
| 4.3.6 Recipe parameters .....                             | 21 |
| 4.4 Equipment model .....                                 | 22 |
| 4.5 Production planning and scheduling .....              | 24 |
| 4.6 Production information management .....               | 26 |
| 5 Relational tables for information exchange .....        | 29 |
| 5.1.1 Method .....                                        | 30 |
| 5.1.2 Exchange tables .....                               | 30 |
| 5.1.3 Common exchange information.....                    | 31 |
| 5.2 Master recipe information .....                       | 41 |
| 5.2.1 Recipe definitions .....                            | 41 |
| 5.2.2 Recipe structure .....                              | 41 |
| 5.2.3 Table overview and integrity constraints .....      | 42 |
| 5.2.4 Recipe table summary .....                          | 45 |
| 5.2.5 Recipe table definitions .....                      | 45 |
| 5.3 Process cell equipment model exchange .....           | 55 |
| 5.3.1 Equipment description .....                         | 55 |
| 5.3.2 Table overview and integrity constraints .....      | 55 |
| 5.3.3 Equipment description table overview.....           | 56 |
| 5.3.4 Equipment information table summary .....           | 56 |
| 5.3.5 Equipment table definitions.....                    | 57 |
| 5.4 Schedule information exchange.....                    | 60 |
| 5.4.1 Schedule table overview .....                       | 60 |
| 5.4.2 Schedule table summary .....                        | 61 |
| 5.4.3 Schedule table definitions.....                     | 61 |

|       |                                                                                                                                |     |
|-------|--------------------------------------------------------------------------------------------------------------------------------|-----|
| 5.5   | Production information exchange.....                                                                                           | 63  |
| 5.5.1 | Control recipe information.....                                                                                                | 64  |
| 5.5.2 | Equipment information.....                                                                                                     | 64  |
| 5.5.3 | Batch history .....                                                                                                            | 64  |
| 5.6   | Exchange table domains .....                                                                                                   | 67  |
| 6     | Procedure function charts.....                                                                                                 | 68  |
| 6.1   | Procedure function chart notation.....                                                                                         | 69  |
| 6.1.1 | Symbols .....                                                                                                                  | 69  |
| 6.1.2 | Procedure and unit procedure initiation .....                                                                                  | 80  |
| 6.1.3 | Non-procedural master recipe information .....                                                                                 | 82  |
| 6.2   | Control recipe depiction.....                                                                                                  | 83  |
| 6.3   | Exception handling.....                                                                                                        | 83  |
|       | Annex A (normative) Data modelling technique .....                                                                             | 84  |
|       | Annex B (normative) SQL definition listing .....                                                                               | 86  |
|       | Annex C (informative) Abbreviations .....                                                                                      | 98  |
|       | Annex D (informative) Language guidelines .....                                                                                | 99  |
|       | Annex E (informative) Procedure function chart processing examples.....                                                        | 101 |
|       | Annex ZA (normative) Normative references to international publications with their<br>corresponding European Publications..... | 103 |
|       | Figure 1 – Overview model .....                                                                                                | 10  |
|       | Figure 2 – Recipe entities .....                                                                                               | 12  |
|       | Figure 3 – Parts of recipe entities .....                                                                                      | 16  |
|       | Figure 4 – Recipe building block .....                                                                                         | 17  |
|       | Figure 5 – Building block concept .....                                                                                        | 19  |
|       | Figure 6 – Recipe entity equipment requirements .....                                                                          | 20  |
|       | Figure 7 – Parameter model.....                                                                                                | 21  |
|       | Figure 8 – Equipment structure .....                                                                                           | 22  |
|       | Figure 9 – Equipment entity relations .....                                                                                    | 23  |
|       | Figure 10 – Equipment classes .....                                                                                            | 24  |
|       | Figure 11 – Batch schedule .....                                                                                               | 25  |
|       | Figure 12 – Production information .....                                                                                       | 27  |
|       | Figure 13 – Data transfer using exchange tables .....                                                                          | 30  |
|       | Figure 14 – Common information exchange tables.....                                                                            | 31  |
|       | Figure 15 – Nested recipe elements make up a recipe .....                                                                      | 42  |
|       | Figure 16 – Exchange table relationships.....                                                                                  | 43  |
|       | Figure 17 – How entries relate in the tables .....                                                                             | 44  |
|       | Figure 18 – Equipment information exchange tables .....                                                                        | 55  |
|       | Figure 19 – Schedule structure .....                                                                                           | 60  |
|       | Figure 20 – Batch history .....                                                                                                | 64  |
|       | Figure 21 – Recipe procedural element symbols .....                                                                            | 69  |
|       | Figure 22 – Procedural elements that encapsulate lower-level recipe procedural elements ...                                    | 70  |
|       | Figure 23 – Begin symbol .....                                                                                                 | 70  |

|                                                                              |    |
|------------------------------------------------------------------------------|----|
| Figure 24 – End symbol .....                                                 | 71 |
| Figure 25 – Allocation symbol .....                                          | 71 |
| Figure 26 – Element synchronization examples .....                           | 72 |
| Figure 27 – Implicit transition .....                                        | 72 |
| Figure 28 – Explicit transition .....                                        | 73 |
| Figure 29 – Beginning of sequence selection .....                            | 74 |
| Figure 30 – End of sequence selection .....                                  | 74 |
| Figure 31 – Beginning of simultaneous sequences .....                        | 75 |
| Figure 32 – End of simultaneous sequences .....                              | 75 |
| Figure 33 – Valid sequence selection diagram .....                           | 76 |
| Figure 34 – Valid simultaneous sequence diagram .....                        | 77 |
| Figure 35 – Looping with explicit recipe procedural elements .....           | 78 |
| Figure 36 – Invalid procedure function chart .....                           | 79 |
| Figure 37 – Depiction of procedure and unit procedure initiation .....       | 80 |
| Figure 38 – Relative relationship of procedural entities .....               | 81 |
| Figure 39 – Relative relationship of procedural entities – Alternate 1 ..... | 82 |
|                                                                              |    |
| Table 1 – Recipe entity .....                                                | 12 |
| Table 2 – Subclasses – overview .....                                        | 13 |
| Table 3 – Recipe .....                                                       | 13 |
| Table 4 – Recipe component .....                                             | 14 |
| Table 5 – Recipe building block .....                                        | 14 |
| Table 6 – General recipe entity .....                                        | 14 |
| Table 7 – Site recipe entity .....                                           | 14 |
| Table 8 – Master recipe entity .....                                         | 15 |
| Table 9 – Control recipe entity .....                                        | 15 |
| Table 10 – Parameter .....                                                   | 16 |
| Table 11 – Equipment requirement .....                                       | 16 |
| Table 12 – Other information .....                                           | 17 |
| Table 13 – Procedural structural element .....                               | 17 |
| Table 14 – Equipment procedural element .....                                | 18 |
| Table 15 – Equipment entity .....                                            | 20 |
| Table 16 – Equipment property .....                                          | 20 |
| Table 17 – Equipment property type .....                                     | 21 |
| Table 18 – Equipment relation .....                                          | 23 |
| Table 19 – Equipment class .....                                             | 24 |
| Table 20 – Batch schedule entry .....                                        | 25 |
| Table 21 – Schedule parameter .....                                          | 25 |
| Table 22 – Schedule relation .....                                           | 26 |
| Table 23 – Production information .....                                      | 27 |
| Table 24 – Batch specific information .....                                  | 27 |
| Table 25 – Batch history .....                                               | 27 |

|                                                        |     |
|--------------------------------------------------------|-----|
| Table 26 – Common information .....                    | 28  |
| Table 27 – Executed procedural entity .....            | 29  |
| Table 28 – Batch report .....                          | 29  |
| Table 29 – BXT_Exchange.....                           | 31  |
| Table 30 – BXT_Exchange table contents.....            | 32  |
| Table 31 – BXT_EnumerationSet .....                    | 32  |
| Table 32 – Standard enumeration sets.....              | 32  |
| Table 33 – BXT_Enumeration .....                       | 34  |
| Table 34 – Standard enumerations .....                 | 34  |
| Table 35 – Recipe exchange tables .....                | 45  |
| Table 36 – BXT_MRecipeElement.....                     | 46  |
| Table 37 – BXT_MRecipeStep .....                       | 47  |
| Table 38 – BXT_MRecipeTransition .....                 | 48  |
| Table 39 – BXT_MRecipeLink .....                       | 50  |
| Table 40 – BXT_MRecipeElementParameter.....            | 51  |
| Table 41 – Standard sub-parameters .....               | 52  |
| Table 42 – BXT_MRecipeStepParameter .....              | 52  |
| Table 43 – BXT_MRecipeOtherInformation .....           | 53  |
| Table 44 – BXT_MRecipeElementEquip.....                | 54  |
| Table 45 – BXT_MRecipeStepEquip .....                  | 54  |
| Table 46 – Equipment information exchange tables ..... | 56  |
| Table 47 – BXT_EquipElement .....                      | 57  |
| Table 48 – BXT_EquipLink.....                          | 57  |
| Table 49 – BXT_EquipInclude.....                       | 58  |
| Table 50 – BXT_EquipProperty.....                      | 58  |
| Table 51 – BXT_EquipInterface .....                    | 59  |
| Table 52 – BXT_EquipInterfaceDefinition.....           | 59  |
| Table 53 – BXT_EquipInterfaceParameter .....           | 59  |
| Table 54 – Schedule information exchange tables .....  | 61  |
| Table 55 – BXT_ScheduleEntry .....                     | 61  |
| Table 56 – BXT_ScheduleEquip.....                      | 62  |
| Table 57 – BXT_ScheduleProperty .....                  | 63  |
| Table 58 – BXT_ScheduleParameter .....                 | 63  |
| Table 59 – BXT_HistoryElement .....                    | 65  |
| Table 60 – BXT_HistoryLog .....                        | 66  |
| Table 61 – Exchange table domains .....                | 67  |
| Table A.1 – UML notation .....                         | 84  |
| Table A.2 – ERD notation .....                         | 169 |

## INTRODUCTION

Part 1 of this International Standard on batch control provides models and terminology applicable to batch control. Part 2 addresses data structures and guidelines for languages. Data structures are addressed by the data model that is defined in clause 4 that more precisely identifies objects and relationships that were addressed by models and concepts of part 1. Data structures are also addressed by relational tables for information exchange that are defined in clause 5. Languages are addressed by a recipe depiction methodology that is defined in clause 6.

The intended use of the data model is to provide a starting point for developing interface specifications for software components that address any subset of part 1 of this standard. The data model addresses all of part 1 of this standard as an integrated object model, but it does not presume or preclude any specific system architecture or information exchange. The model does not assume any specific division of functionality between systems.

A specific method for the exchange of selected data is defined in clause 5. Relational tables are used as the information exchange method because, within the bounds of the information treated, they:

- utilise broadly available technologies;
- are amenable to translation to other technologies;
- are adequate;
- are consistent with other sections of the standard.

Multiple methods of information transfer have not been defined, nor has there been an attempt to identify all information that might be exchanged. In the future, additional methods may be defined to provide alternate ways of exchanging data.

Clause 6 defines the symbols and rules for a graphical language that can be used to depict recipes. Recipes are the central feature of batch control and they can address a wide range of complexity, but there is no one depiction that is ideal for all circumstances. A simple table, for example, might be the most appropriate recipe form for simple cases. This standard specifies a method for depiction of master and control recipe procedures that can be applied over a broader range of complexity.

Although this standard is intended primarily for batch processes, it may be of considerable value for other types of processes.

## BATCH CONTROL –

### Part 2: Data structures and guidelines for languages

#### 1 Scope

This part of this standard on batch control defines data models that describe batch control as applied in the process industries, data structures for facilitating communications within and between batch control implementations and language guidelines for representing recipes. Refer to Annex A for an explanation of the UML notation that is used in this part of this standard. Refer to Annex B for a summary of all of the SQL definitions from clause 5.

#### 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 61512. 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 IEC 61512 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.

IEC 60848:1988, *Preparation of function charts for control systems*

IEC 60050-351:1998, *Industrial-process measurement and control – Terms and definitions*

IEC 61131-3:1993, *Programmable controllers – Part 3: Programming languages*

IEC 61512-1:1997, *Batch control – Part 1: Models and terminology*

ISO/IEC 9075:1992, *Information processing systems – Database language – SQL with integrity enhancement*

#### 3 Definitions

For the purposes of this part of IEC 61512, the following definitions as well as those expressed in part 1 of this International Standard apply, except where differences are explicitly stated in this part. Definitions in IEC 60050-351 were also used as a basis.

##### 3.1

##### **allocation symbol**

a graphical symbol that is used to represent the encapsulation of the resource allocation and de-allocation rules for a recipe procedural element

### 3.2

#### **building block**

a recipe entity that exists in a library

### 3.3

#### **enumeration set**

a list of predefined strings and their associated numerical values

### 3.4

#### **exchange table**

a database table that is used to exchange batch-related information between systems

### 3.5

#### **link**

an object that specifies the connection between two other objects (for example, the connection between recipe entities or between recipe entities and transitions)

### 3.6

#### **procedure function chart**

a graphical representation of a recipe procedure that specifies the processing order for recipe procedural elements

### 3.7

#### **recipe element**

a structural entity that is used to represent recipe entities and symbols, except transitions and directed links, that are used in procedure function charts

### 3.8

#### **recipe entity**

the combination of a procedural element with an associated recipe information (for example, header, formula, equipment requirements, other information). General, site, master and control recipes are also recipe entities

## 4 Data model

### 4.1 Introduction

This clause defines data models that specify a set of objects, attributes and their basic relationships that cover the concepts of part 1 of this standard at a high level of abstraction. The models apply to interfaces to batch control systems in a technology independent manner. The models are not intended to address the internal system architecture of batch control systems.

The intended use of these models is to provide a starting point for the development of interface specifications for software components that address any subset of part 1 of this standard.

The models address all of part 1 of this standard as an integrated object model, but they do not presume or preclude any specific system architecture or information exchange. The models do not assume any specific division of functionality between systems.

In the cases where the objects and relationships defined in this clause are presented through an interface, then that interface shall use the object names, the attribute names and the relationships of this clause commensurate with the interface technology chosen and the capabilities offered. An example of such an interface is the SQL relational table interface that is defined in clause 5.

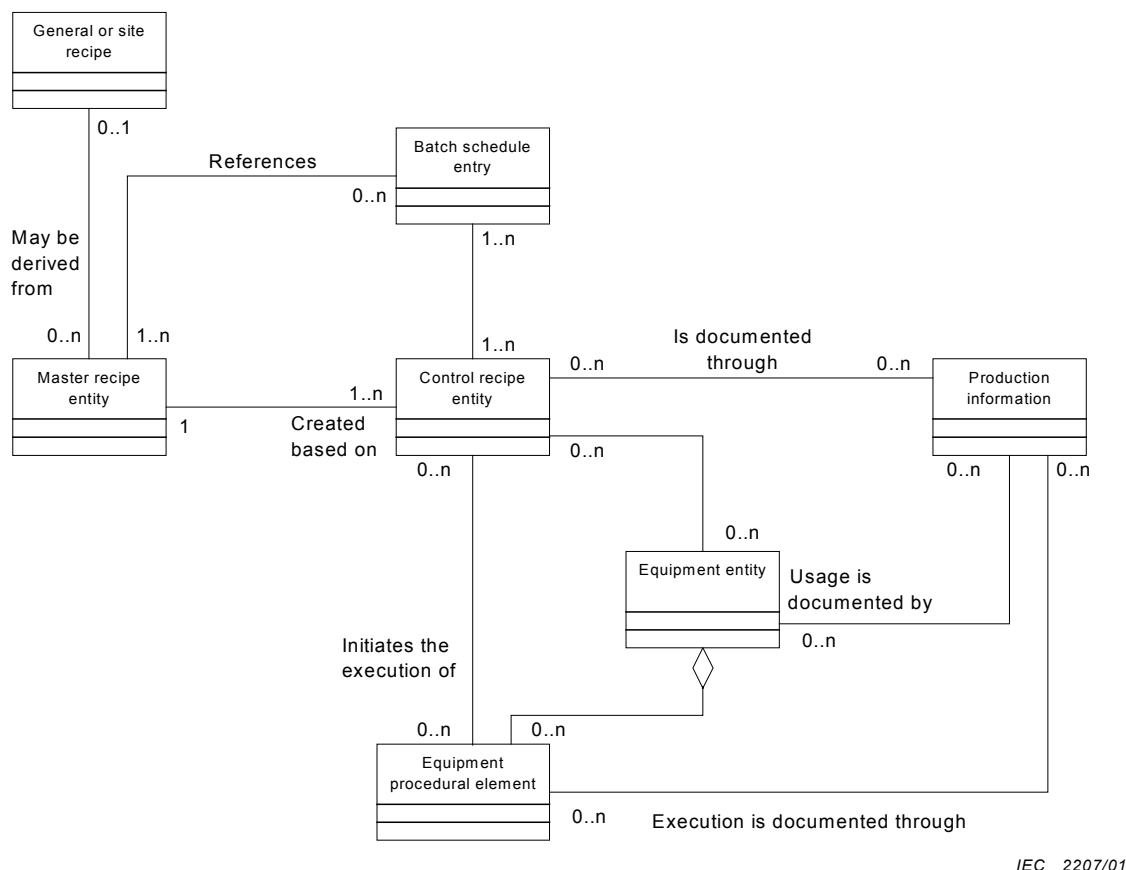
An exchange format or interface specification may implement only some objects or parts of objects (for example, not all properties are defined). An exchange format or interface specification may also provide additional objects or properties (for example, phase duration information), including the expansion of any data model attribute into multiple attributes. Any such implementation shall be consistent with the data model that is presented here and the concepts of part 1 of this standard.

The models that are described in this clause are based on the Unified Modeling Language (UML) (see clause A.1).

The tables describe only the class attributes of the objects. The relationships between objects are described in the figures.

## 4.2 Overview model

This model (see figure 1) gives a high level overview of the main classes that are defined and the relations between these classes for the batch domain that is described by the control activity model of part 1 of this standard. The individual object classes are more thoroughly described in the subsequent models in this subclause.



IEC 2207/01

**Figure 1 – Overview model**

A general or site recipe is made up of a hierarchy of *general recipe entities* that correspond to the procedural entities (process stages, process operations, and process actions).

A master recipe may be derived from a general or a site recipe. The master recipe itself may be seen as a top-level master recipe entity. A master recipe is made up of a hierarchy of *master recipe entities* that correspond to the procedural entities (i.e., procedures, unit procedures, operations, phases).

A *batch schedule entry* specifies production of a specific batch through the execution of a recipe. A batch schedule is, in principle, a list that specifies the production of batches, and it includes information about timing. The product-specific information necessary for this purpose is derived from a related *master recipe entity*.

Based on a *batch schedule entry*, a control recipe starts as a copy of a specific version of a master recipe, and it is then modified to create the recipe that will produce the batch. A control recipe includes the information necessary for equipment control.

*Control recipe entities* are created based on *master recipe entities*. A control recipe may be enhanced with additional information (for example, scaling, equipment assignment), and it may be modified (including creating or removing control recipe entities).

*Equipment entities* are selected and allocated to the *control recipe entities*.

A *control recipe entity* may be linked to an *equipment procedural entity* within the *equipment entity* (normally the unit). The *equipment procedural entity* may be initiated, and its parameters may be assigned recipe values.

*Production information* is generated during the production of the batch. This information may be related to recipe entities, equipment entities and/or equipment procedural elements.

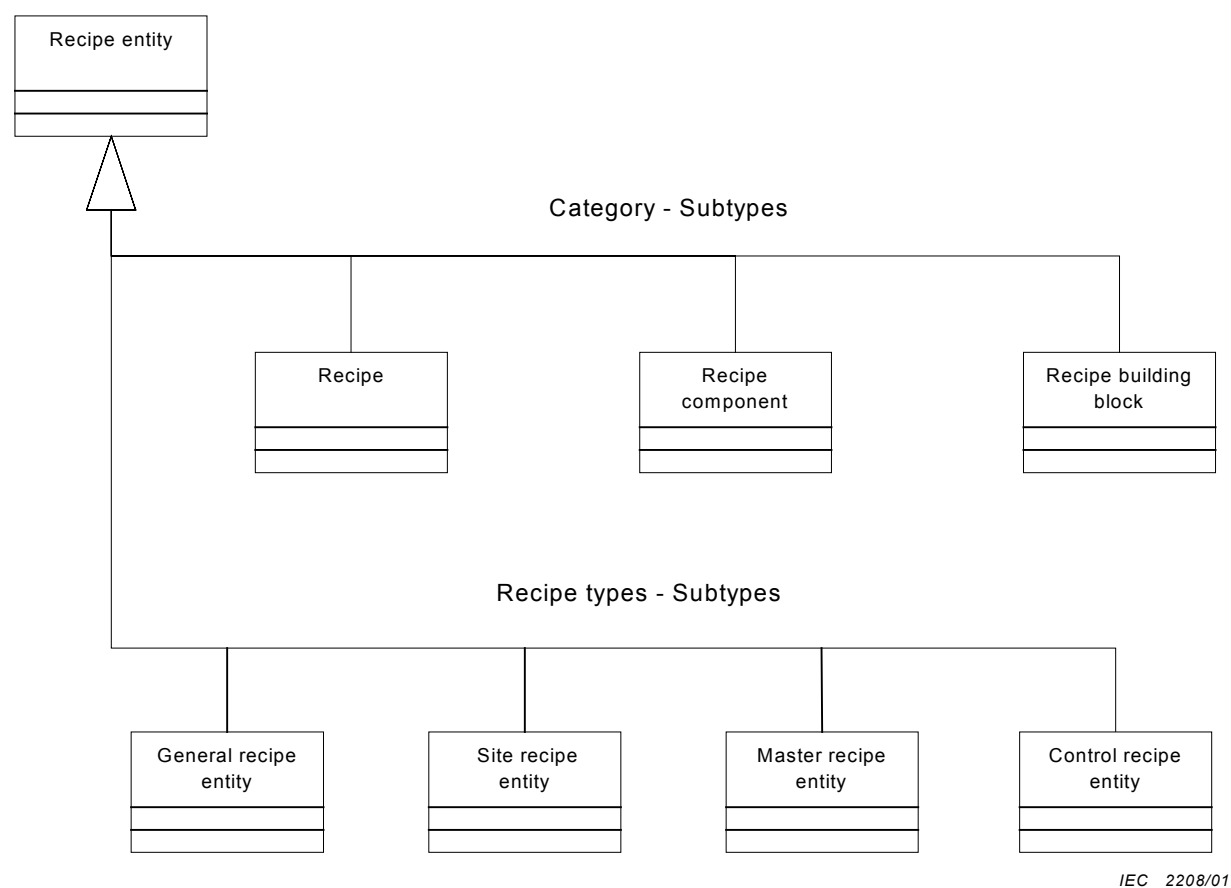
## 4.3 Recipe model

### 4.3.1 Recipe entity

Recipes are organized hierarchically, with various categories of information at each level. The recipe entity is the construct that is used to represent the tight coupling of the data at a particular level.

The recipe entity is the fundamental structure in all kinds of recipes (see figure 2). The recipe entity structurally takes the place of the recipe procedural element as defined in part 1 of this standard, but it may include any or all of the recipe components: procedural definitions, parameters with values, equipment requirements and other information.

The class specifications are shown in table 1.



IEC 2208/01

Figure 2 – Recipe entities

Table 1 – Recipe entity

| NAME                  | RECIPE ENTITY                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | A recipe entity is the combination of a procedural element with associated recipe information (e.g., header, formula, equipment requirements and other information). General, site, master and control recipes are recipe entities. One example is a unit recipe (IEC 61512-1, 5.3.2). "Unit recipe: The part of a control recipe that uniquely defines the contiguous production requirements for a unit" (IEC 61512-1, 3.62). |
| ATTRIBUTES            |                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| RecipeEntityID        | Provides unique identification                                                                                                                                                                                                                                                                                                                                                                                                  |

A recipe itself is considered to be a recipe entity (category: recipe). The recipe is built up of lower-level recipe entities (for example, unit recipes) (category: component). When constructing a specific recipe, the components may be created from library elements (category: building block).

The recipe entity concept is applied to all recipe types: general, site, master and control. When a recipe is executed, the representation in the batch history of the executed recipe entities will have much the same structure, and it is therefore shown as a subclass. An overview of the subclasses is shown in table 2. Subclass categories are shown in tables 3 to 5. Subclass types are shown in tables 6 to 9. General and site recipes are not discussed further in this subclause.

Table 2 – Subclasses – overview

|                       | GENERAL RECIPE ENTITY                                                                                           | SITE RECIPE ENTITY                                                                                                             | MASTER RECIPE ENTITY                                                                                           | CONTROL RECIPE ENTITY                                                                                                     |
|-----------------------|-----------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| RECIPE                | A complete and self-contained general recipe                                                                    | A complete and self-contained site recipe                                                                                      | A complete and self-contained master recipe                                                                    | A complete and self-contained control recipe                                                                              |
| RECIPE BUILDING BLOCK | A generic general recipe entity type that can be instantiated in a specific recipe or in another building block | <i>Building blocks for site recipes may not exist. Site recipes are normally modified using general recipe building blocks</i> | A generic master recipe entity type that can be instantiated in a specific recipe or in another building block | <i>Building blocks for control recipes do not exist. Control recipes are modified using master recipe building blocks</i> |
| RECIPE COMPONENT      | A component of a general recipe or library element – may be an instantiation of a building block                | A component of a site recipe or library element – may be an instantiation of a general recipe building block                   | A component of a master recipe or library element – may be an instantiation of a building block                | A component of a control recipe – may be an instantiation of a master recipe building block                               |

Table 3 – Recipe

| NAME                                                                        | RECIPE                                                                                                                               |
|-----------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription                                                       | The top level recipe entity                                                                                                          |
| ATTRIBUTES                                                                  |                                                                                                                                      |
| RecipeID                                                                    | Identifies the recipe. When combined with the "RecipeVersion" defines a unique instance of a recipe                                  |
| RecipeVersion                                                               | Identifies the version of a recipe. When combined with a "RecipeID" defines a unique instance of a recipe (e.g., Red Oak – A10.3)    |
| VersionDate*                                                                | Identifies the date and time that this version of the recipe was created or modified                                                 |
| ApprovalDate*                                                               | Identifies the date and time that this version of the recipe was approved                                                            |
| EffectiveDate*                                                              | Identifies the earliest date and time that this version of the recipe may be used                                                    |
| ExpirationDate*                                                             | Identifies the date and time that this version of the recipe expires                                                                 |
| ProductID*                                                                  | Identifies the product or product family that would be created by execution of this version of the recipe (e.g., Premium Beer)       |
| Author*                                                                     | Identifies the person or system that authored this version of the recipe (e.g., J. Smith)                                            |
| ApprovedBy*                                                                 | Identifies the person or system that approved this version of the recipe                                                             |
| Description                                                                 | Describes this version of the recipe and/or product (e.g., <i>Finest Premium Beer</i> )                                              |
| Status*                                                                     | Defines the status of the information (e.g., "approved for production", "approved for test", "not approved", "inactive", "obsolete") |
| *Not required for control recipe (available by reference to master recipe). |                                                                                                                                      |

Table 4 – Recipe component

| NAME                  | RECIPE COMPONENT                                                                                                                                                                                       |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | A recipe entity that is part of a recipe or building block (i.e., an instance of a building block in a particular recipe or containing a building block recipe entity)                                 |
| ATTRIBUTES            |                                                                                                                                                                                                        |
| Level                 | Indicates the procedural hierarchy level (i.e., process stage, process operation or process action for general and site recipes and unit procedure, operation or phase for master and control recipes) |
| RE_Use                | Defines if the recipe component is a copy of a building block or a reference to it                                                                                                                     |

Table 5 – Recipe building block

| NAME                  | RECIPE BUILDING BLOCK                                                                                                                      |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | A recipe entity that exists in a library. A building block can be parameterized and used when building recipes                             |
| ATTRIBUTES            |                                                                                                                                            |
| RecipeVersion         | Identifies the version of the recipe entity                                                                                                |
| VersionDate           | Identifies the date and time that this version of the recipe was created or modified                                                       |
| ApprovalDate          | Identifies the date and time that this version of the recipe was approved                                                                  |
| Author                | Identifies the person or system that authored this version of the recipe (e.g., J. Smith)                                                  |
| ApprovedBy            | Identifies the person or system that approved this version of the recipe                                                                   |
| Description           | Describes the function that is achieved through the execution of this version of the recipe entity                                         |
| Level                 | Indicates the level of the recipe entity                                                                                                   |
| UsageConstraint       | Defines other rules that determine the usage (e.g., always succeeded by..., or never runs in parallel with....)                            |
| Status                | Defines the status of the recipe entity (e.g., "approved for production", "approved for test", "not approved", "inactive", "obsolete")     |
| Function              | Defines how the recipe entity is executed (e.g., by referencing an equipment procedural element, through the execution of contained logic) |

Table 6 – General recipe entity

| NAME                  | GENERAL RECIPE ENTITY                                                                                                                     |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | All of a general or site recipe, a component of a general or site recipe or a building block for the creation of a general or site recipe |
| ATTRIBUTES            |                                                                                                                                           |
| ScaleReference        | Defines a reference scale for the parameter values                                                                                        |

Table 7 – Site recipe entity

| NAME                  | SITE RECIPE ENTITY                                                                                       |
|-----------------------|----------------------------------------------------------------------------------------------------------|
| FunctionalDescription | All of a site recipe, a component of a site recipe or a building block for the creation of a site recipe |
| ATTRIBUTES            |                                                                                                          |
| ScaleReference        | Defines a reference scale for the parameter values                                                       |

**Table 8 – Master recipe entity**

|                       |                                                                                                                                                          |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------|
| NAME                  | MASTER RECIPE ENTITY                                                                                                                                     |
| FunctionalDescription | All of a master recipe, a component of a master recipe or a building block for the creation of a master recipe                                           |
| ATTRIBUTES            |                                                                                                                                                          |
| ScaleReference        | Defines a reference scale for the parameter values                                                                                                       |
| ProcessCellID         | Identifies the equipment category for which the recipe entity was defined (e.g., process cell or process cells for which this master recipe was defined) |

**Table 9 – Control recipe entity**

|                       |                                                                                                                                     |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| NAME                  | CONTROL RECIPE ENTITY                                                                                                               |
| FunctionalDescription | A recipe entity that is all of or a part of a control recipe                                                                        |
| ATTRIBUTES            |                                                                                                                                     |
| BatchID               | Specifies the actual batch ID                                                                                                       |
| BatchSize             | Defines the requested size, or scale factor, for the batch, based on the scale factor for the batch as defined in the master recipe |
| Status                | Describes the execution status (e.g., not yet activated, active or completed)                                                       |

#### 4.3.2 Parts of recipe entities

The model (see figure 3 and tables 10 to 13) shows the categories of information of a recipe as specified in part 1 of this standard. The model indicates that these components may exist at any level of the decomposition of the recipe (for example, a unit recipe may have its own equipment requirements).

- The header category of information is contained in attributes to the recipe entity itself, instead of being a distinct object class in this model.
- The formula category of part 1 of this standard is modelled as a set of parameter objects. All levels of the recipe decomposition may have parameters, including the recipe itself. See 4.3.6 on parameters.
- The modeling of equipment requirements is discussed in 4.3.5.
- The other information category, as defined in part 1 of this standard, is represented as a single object class, even though other information may have multiple elements and different structures.
- The procedure category of part 1 of this standard is modeled as a set of procedural structural elements.

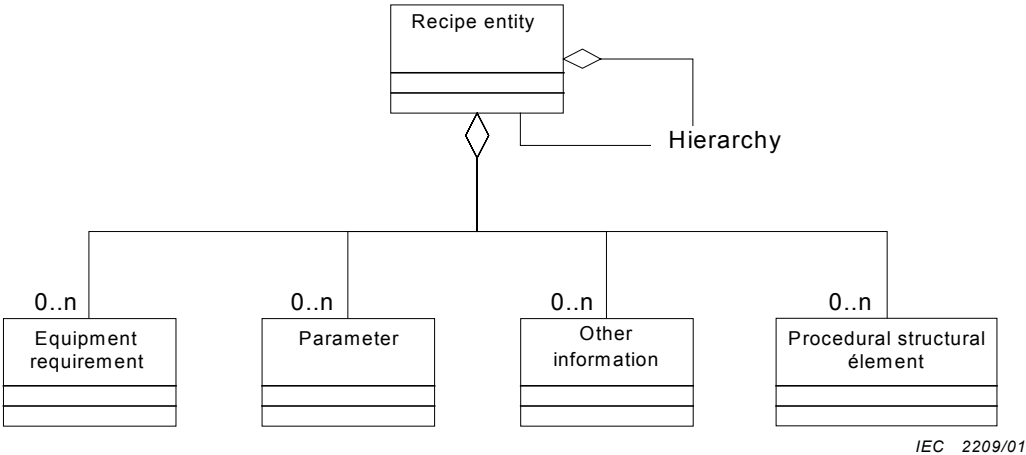


**Figure 3 – Parts of recipe entities**

**Table 10 – Parameter**

| NAME                  | PARAMETER                                                                                                                                                                                                                                        |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | Formula values or placeholders for values that are to be communicated to and from recipe entities during execution                                                                                                                               |
| ATTRIBUTES            |                                                                                                                                                                                                                                                  |
| ParameterID           | Provides a unique identification                                                                                                                                                                                                                 |
| ParameterType         | Specifies how the parameter value is interpreted (e.g., constant, reference equation)                                                                                                                                                            |
| Description           | Describes the parameter or use of the parameter                                                                                                                                                                                                  |
| EngineeringUnits      | Identifies the engineering units of measure for the value (e.g., kg, pounds)                                                                                                                                                                     |
| Value                 | Contains the parameter value. If the value is a relation, it contains the equation, form, deferral rule or whatever ties the related parameters together. If the value is a building block parameter, this attribute will hold the default value |
| Scaled                | Specifies the scaling rule. Simplest case: scaled or not scaled with batch reference size                                                                                                                                                        |
| Usage                 | Specifies the parameter as a process input, process output or process parameter                                                                                                                                                                  |

**Table 11 – Equipment requirement**

| NAME                  | EQUIPMENT REQUIREMENT                                                 |
|-----------------------|-----------------------------------------------------------------------|
| FunctionalDescription | Represents an equipment requirement as specified in the recipe entity |
| ATTRIBUTES            |                                                                       |
|                       |                                                                       |

Table 12 – Other information

| NAME                  | OTHER INFORMATION                                                                                                                                                                                                                                                                            |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | A category of recipe information that may contain batch processing support information that is not contained in other parts of the recipe (e.g., regulatory compliance information, materials and process safety information, <b>process flow diagrams</b> , packaging/labeling information) |
| ATTRIBUTES            |                                                                                                                                                                                                                                                                                              |
|                       |                                                                                                                                                                                                                                                                                              |

Table 13 – Procedural structural element

| NAME                  | PROCEDURAL STRUCTURAL ELEMENT                                                   |
|-----------------------|---------------------------------------------------------------------------------|
| FunctionalDescription | The recipe procedural elements and the ordering information for their execution |
| ATTRIBUTES            |                                                                                 |
|                       |                                                                                 |

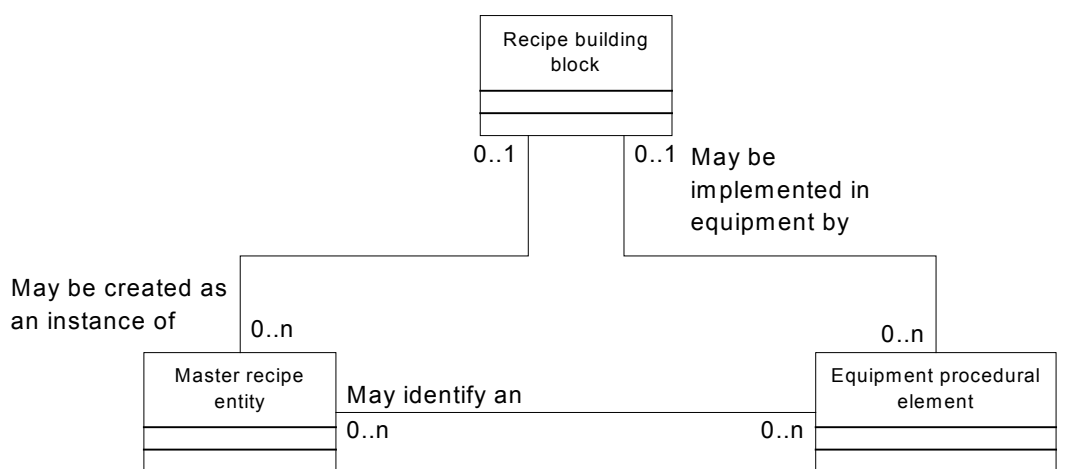
#### 4.3.3 Recipe entity relationships (procedural structure)

Recipe entities are hierarchically decomposed along the structures for procedural entities as defined in part 1 of this standard (i.e., a recipe procedure contains unit procedures that contain operations that contain phases). This hierarchy is modelled using recursive containment. Higher-level objects may contain lower-level objects.

Procedural structural elements include the recipe procedural elements and the connections (for example, link, transition) that are used to order them (for example, a unit recipe's procedural structural elements are the operations and the ordering of those operations contained within it). The procedural structural elements may be related to other procedural structural elements.

#### 4.3.4 Recipe building blocks

Recipe building blocks are an important concept in the data model (see figure 4). This figure represents the relations at a single level of the procedure hierarchy.



IEC 2210/01

Figure 4 – Recipe building block

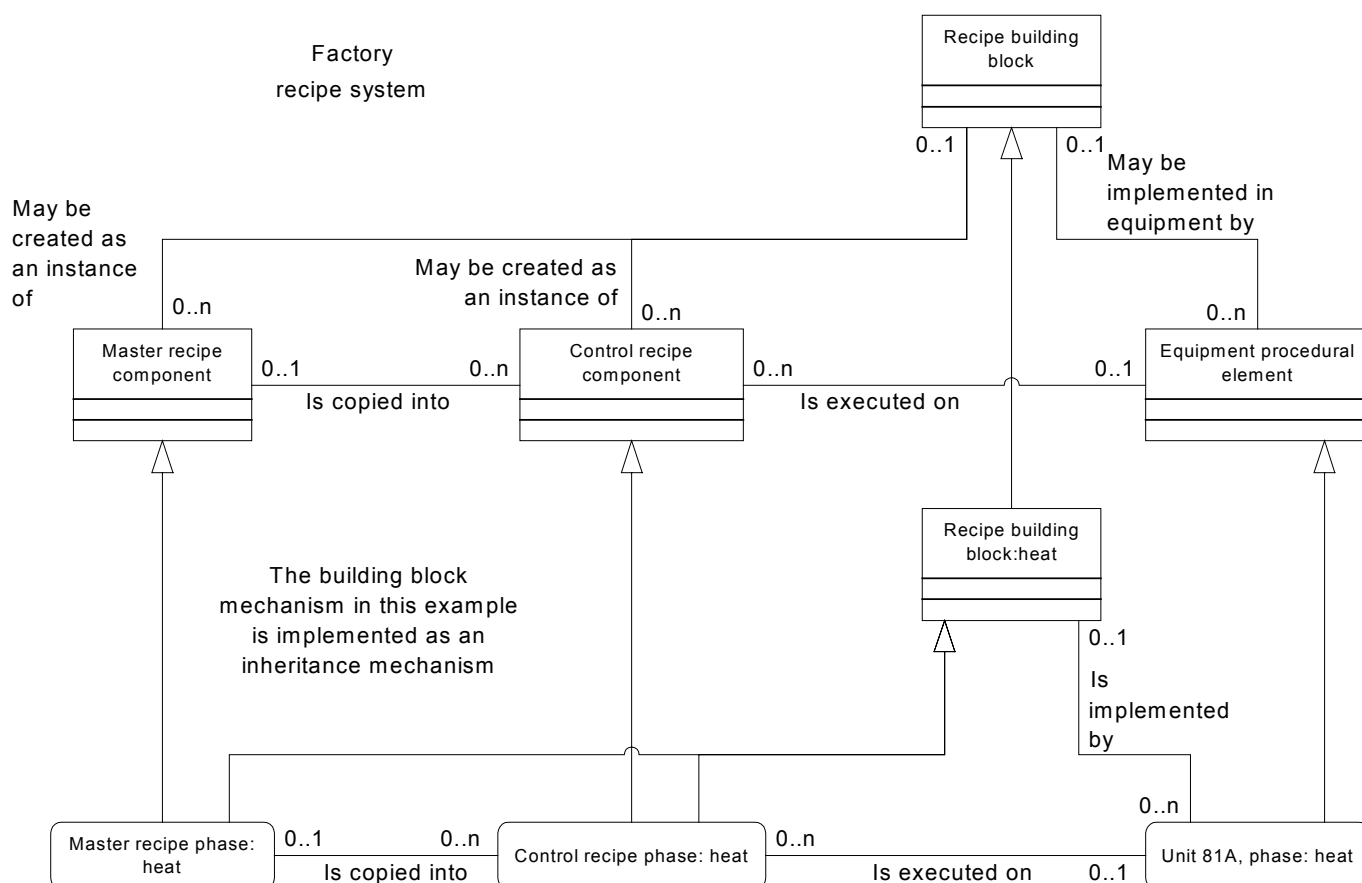
*Recipe building blocks* are the building blocks from which master recipes are created. When a *recipe building block* is instantiated in a master recipe as a *master recipe entity*, it may carry parameters, equipment requirements and other information that may be assigned master recipe specific values. Lower-level contents of the *recipe building block* (for example, subordinate recipe entities) may be copied into *master recipe entities*. These same lower-level contents may also be accessible by reference to the *recipe building block*.

A *recipe building block's* functionality may be implemented in equipment through *equipment procedural elements* (see table 14), which is necessary for the execution of the lowest-level recipe entities (i.e., the recipe entities that are intended to be linked to equipment procedural elements).

**Table 14 – Equipment procedural element**

| NAME                         | EQUIPMENT PROCEDURAL ELEMENT                                                                                        |
|------------------------------|---------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription        | A procedural element that is associated with a piece of equipment (e.g., an equipment phase or equipment operation) |
| ATTRIBUTES                   |                                                                                                                     |
| EquipmentProceduralElementID | Provides unique identification                                                                                      |
| Version                      | Identifies the version of the procedural element                                                                    |
| VersionDate                  | Identifies the date and time that this version was created or modified                                              |
| ApprovalDate                 | Identifies the date and time that this version was approved                                                         |
| Author                       | Identifies the person or system that authored this version (e.g., J. Smith)                                         |
| ApprovedBy                   | Identifies the person or system that approved this version                                                          |
| Description                  | Describes the function that is achieved through the execution of the recipe entity                                  |
| Level                        | Indicates the level of the equipment entity. The equipment entity may only be used at this level                    |
| Mode                         | Indicates the current mode of the procedural element                                                                |
| State                        | Indicates the current state of the procedural element                                                               |

The mechanisms may be illustrated by the following example (see figure 5) that could represent an object model of a part of an actual application. The generic concept of a building block is instantiated as a specific building block "heat". The "is based on" relation between the building blocks and the components is replaced by a subclass relation (this is one possible implementation, and it indicates that if the "heat" building block is changed, then the change will propagate to all recipes that use "heat"). Another implementation could be that "heat" is just copied when instantiated.



IEC 2211/01

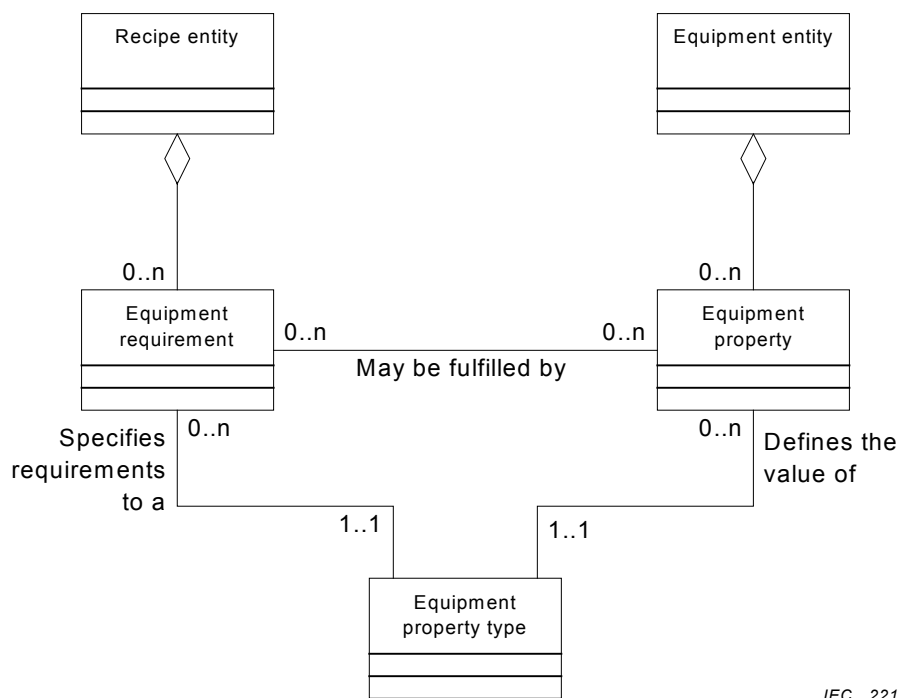
Figure 5 – Building block concept

#### 4.3.5 Equipment requirements

*Recipe entities* may contain *equipment requirements* (see figure 6 and tables 15, 16 and 17). Equipment requirements reference a specific *equipment property type* (for example, an *equipment property type* may be the 'size of vessel' or the 'lining of vessel'). A specific equipment requirement could then specify a minimum value for the size of a vessel.

This requirement may then be met by a piece of equipment with a certain equipment property that references the same equipment property type. For example, a specific unit, UNIT12, would have a value for the property type 'size of vessel'.

An equipment entity is a specific piece of equipment, and it may be replaced by a class of equipment (equipment class). See 4.4.



IEC 2212/01

**Figure 6 – Recipe entity equipment requirements**

**Table 15 – Equipment entity**

| NAME                  | EQUIPMENT ENTITY                                                                                                                                                           |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | A collection of physical processing and control equipment and equipment control that is grouped together to perform a certain control function or set of control functions |
| ATTRIBUTES            |                                                                                                                                                                            |
| EquipmentEntityID     | Provides unique identification                                                                                                                                             |
| EquipmentLevel        | Specifies the physical hierarchy level (for example, process cell, unit, equipment module, control module)                                                                 |
| Mode                  | Indicates the current mode of the equipment entity                                                                                                                         |
| State                 | Indicates the current state of the equipment entity                                                                                                                        |

**Table 16 – Equipment property**

| NAME                  | EQUIPMENT PROPERTY                                                                                                                                                         |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | Identifies a property that the equipment entity or class supplies. These properties are application specific (e.g., lining type, size, heat capability, steam temperature) |
| ATTRIBUTES            |                                                                                                                                                                            |
| PropertyID            | Provides unique identification                                                                                                                                             |
| Value                 | Identifies the value of the property (e.g., glass, 50 000, 650)                                                                                                            |
| ValueRange            | Defines the limits or constraints that are related to the value                                                                                                            |
| EngineeringUnits      | Defines the engineering units of the property                                                                                                                              |
| Description           | Describes the type of the equipment property                                                                                                                               |

Table 17 – Equipment property type

| NAME                  | EQUIPMENT PROPERTY TYPE                                                                                 |
|-----------------------|---------------------------------------------------------------------------------------------------------|
| FunctionalDescription | The general class of equipment attributes (e.g., lining type, size, heat capability, steam temperature) |
| ATTRIBUTES            |                                                                                                         |
|                       |                                                                                                         |

The *control recipe entities* will initially contain the equipment requirements that are copied from the *master recipe entity*, and these need to be fulfilled by the corresponding property of one or more equipment entities in order for specific equipment to be allocated. The initial *equipment requirement* may be replaced by specific equipment allocations. These allocations are also modelled as equipment requirements.

#### 4.3.6 Recipe parameters

Parameters are variables associated with recipe entities. These variables may be used by equipment procedural elements, they may be used by other activities (for example, scheduling) or they may be referenced by other parts of the recipe (for example, transition criteria) (see figure 7).

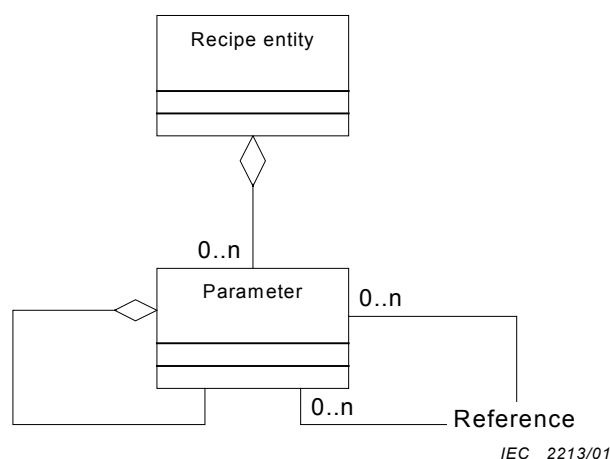


Figure 7 – Parameter model

Parameters may be categorized as process inputs, process outputs or process parameters.

Parameters may be made up of a collection of other parameters. The model supports the concept of structured parameters. Therefore, the model allows the possibility of including parameters of different types (process parameters, process inputs, process outputs) in the same structure as well as defining single type data structures.

Parameter value attributes may be organized by defining parameter value types. Parameter value types could include:

- IEC 61131-3 basic data types;
- compatibility matrix information that is used for determining clean-in-place (CIP) or sterilize-in-place (SIP) requirements;
- data sets that define material transactions (transfer, consumption, generation of material);

- data series (for example, a temperature profile that will be tracked).

Parameter values may be simple values, expressions or references to parameters that are defined at the same level or higher levels in the procedural hierarchy. Values that are expressions may include references to other parameters.

Parameters may be related in a number of ways, including the following:

- algebraic or boolean equations;
- product specific entry forms that use one or more parameters;
- standard operating procedures (SOPs) that display or otherwise utilize parameters (for example, dynamic values, recipe values);
- deferral of parameters to different recipe entities (at the same or another level);
- external applications that use parameters.

The formula is represented in the data model as recipe parameters (see table 10). A recipe's formula is a collection of selected parameters of the recipe procedure, and it may also include parameters that are defined at lower levels of the procedural hierarchy.

The scaling of parameters is often based on batch size or other key attributes. Scaling may be more complex than a simple linear relationship. More complex scaling methods can be accommodated with user defined algorithms and relationships.

#### 4.4 Equipment model

The physical structure of the plant needs to be taken into account in the evaluation of equipment selection during recipe execution (see figure 8 and table 18). In particular, the transfer capabilities between equipment or the ability to allocate shared equipment are important to routing a batch.

Equipment entities are defined as in the hierarchy that is specified in part 1 of this standard. This hierarchy is modelled through the recursive nature of the objects. This construct allows for the configuration of expandability and collapsibility.

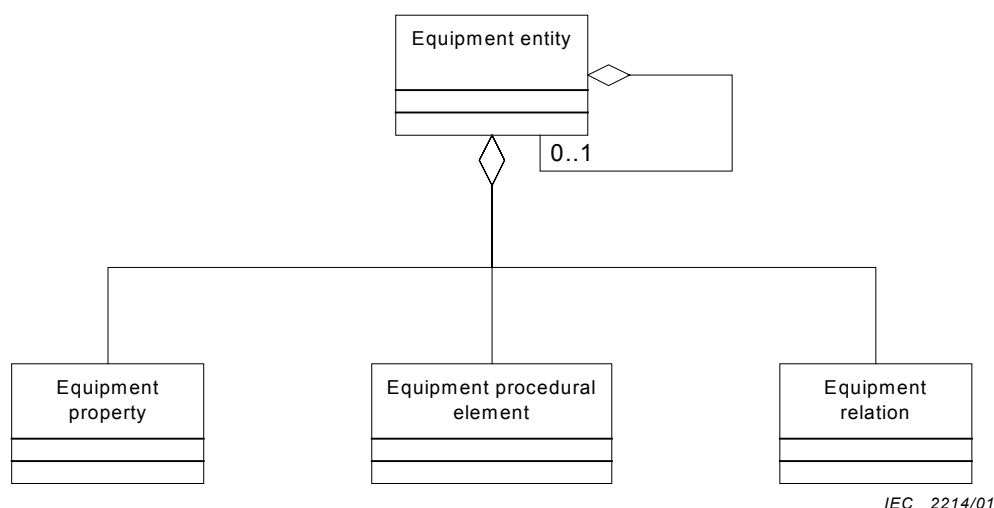


Figure 8 – Equipment structure

Table 18 – Equipment relation

| NAME                  | EQUIPMENT RELATION                                                                                                                                                                                                          |
|-----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | A representation of the connections between equipment (e.g., pipes, conveyors, flexible connections), but may also be used to represent other kinds of relations between equipment (e.g., relation to shared-use equipment) |
| ATTRIBUTES            |                                                                                                                                                                                                                             |
| RelationID            | Provides unique identification                                                                                                                                                                                              |

The equipment in, for example, a process cell (i.e., units, equipment modules, control modules) is normally interrelated by pipes or other connections. The connections may be modelled as equipment relations (see figure 9), optionally with a direction (for example, a flow direction). The relations (for example, pipes) are part of the higher-level equipment entity. The connections may conveniently be categorized in relation classes, and this ensures a consistent evaluation. Equipment relations include:

- permanent connection;
- temporary connection;
- may be used as resource for;
- always runs the same product as.

Note that relations other than connections may be possible.

The equipment may have properties. The properties are specific to each user implementation. Equipment properties may be used for examining equipment characteristics and matching recipe equipment requirements. See 4.3.5.

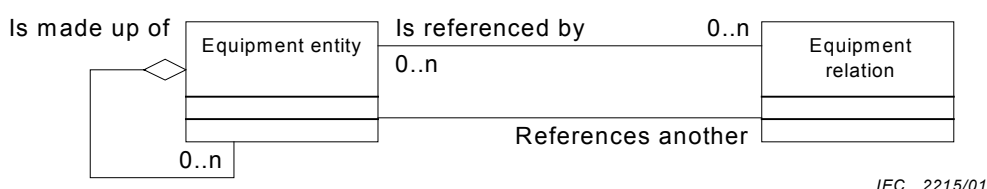


Figure 9 – Equipment entity relations

Equipment classes (see figure 10 and table 19) provide a means of grouping equipment entities by common characteristics. Equipment entities may be a member of one or more equipment classes, or they may not belong to a class at all. Equipment classes may be used to specify groups of units, and they may be used as alternatives during equipment selection. For example, a recipe may require a reactor for a unit procedure: its equipment requirements may specify a specific reactor (for example, R-101), a set of reactor units (for example, R-101, R-103) or the reactor class (for example, the class "reactor" that contains reactors R-101, R-102 and R-103).

*Equipment entities* may be members of an *equipment class*, and the class determines some of the properties of the class members. As an example, certain equipment properties (for example, glass lining) are shared with the class.

*Equipment entities* may belong to zero or more *equipment classes* (for example, vessel BV1 may be both a reactor and a holding tank).

Equipment classes may determine some or all *equipment properties*, *equipment procedural elements* and *equipment relations* of the referencing equipment entities.

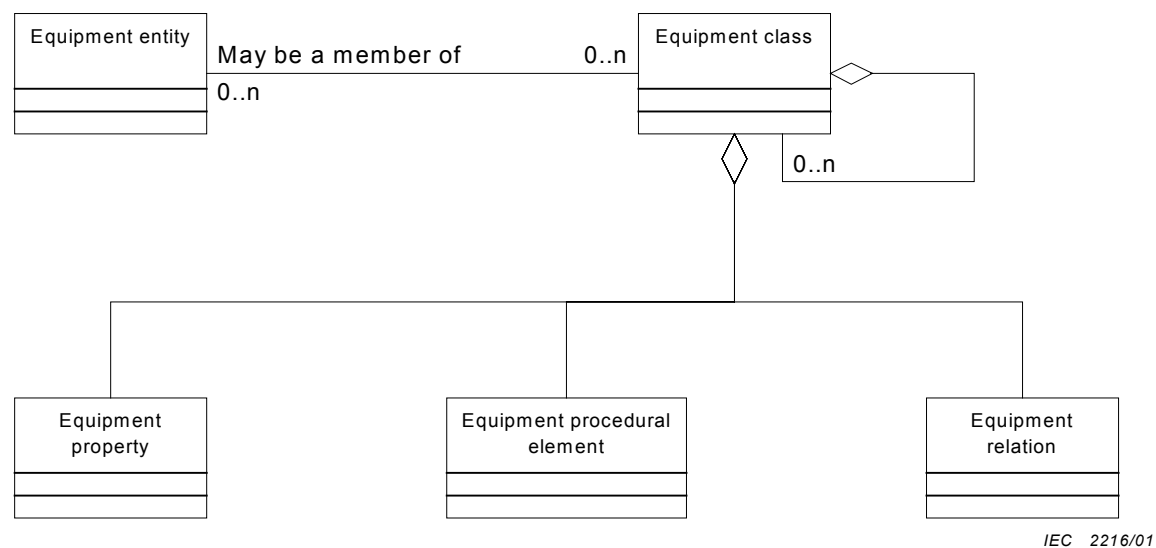


**Figure 10 – Equipment classes**

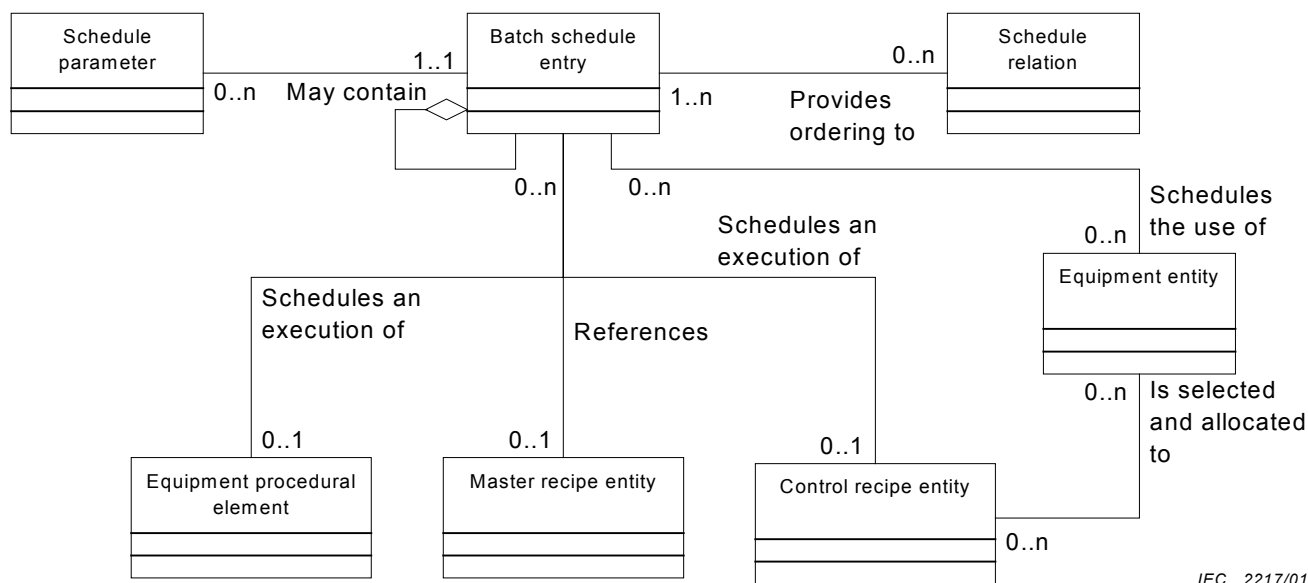
**Table 19 – Equipment class**

| NAME                  | EQUIPMENT CLASS                                                                                     |
|-----------------------|-----------------------------------------------------------------------------------------------------|
| FunctionalDescription | An equipment entity class                                                                           |
| ATTRIBUTES            |                                                                                                     |
| EquipmentClass        | Provides unique identification                                                                      |
| EquipmentLevel        | Specifies the physical hierarchy level (e.g., process cell, unit, equipment module, control module) |

### 4.5 Production planning and scheduling

The central entity in a schedule (see figure 11) is the batch schedule entry. This object defines an intended execution of one or more batches/control recipes or other control recipe entities (typically unit procedures) (see table 20). The batch schedule entry may also be used to schedule other activities (for example, equipment downtime). A batch schedule entry may include formula/parameter values that are to be used in a control recipe (see table 21).

The batch schedule entry can be used to represent higher level schedule entities (for example, a production campaign or a production order).



IEC 2217/01

Figure 11 – Batch schedule

Table 20 – Batch schedule entry

| NAME                  | BATCH SCHEDULE ENTRY                                                                                                                |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | A scheduled item that represents a unit procedure in a batch, a complete batch or a set of batches (e.g., a campaign)               |
| ATTRIBUTES            |                                                                                                                                     |
| ID                    | Provides unique identification (e.g., actual campaign, lot, batch ID, procedural entity ID)                                         |
| Level                 | Specifies the hierarchy level (e.g., campaign, batch, unit procedure)                                                               |
| BatchSize             | Defines the requested size, or scale factor, for the batch, based on the scale factor for the batch as defined in the master recipe |
| Schedule              | Defines scheduled execution times (start/stop)                                                                                      |
| ResourceUsage         | Specifies resource usage for this schedule entry                                                                                    |
| Status                | Specifies schedule status (e.g., proposed for evaluation (e.g., what-if analysis), planned, committed, started, completed)          |

Table 21 – Schedule parameter

| NAME                  | SCHEDULE PARAMETER                                                                                                                                                                                                                               |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | Formula values that are to be communicated to and from batch schedule entries                                                                                                                                                                    |
| ATTRIBUTES            |                                                                                                                                                                                                                                                  |
| ParameterID           | Provides unique identification                                                                                                                                                                                                                   |
| ParameterType         | Includes how the value is interpreted (e.g., constant, reference or equation)                                                                                                                                                                    |
| Description           | Describes the parameter or use of the parameter                                                                                                                                                                                                  |
| EngineeringUnits      | Identifies the engineering units of measure for the value (e.g., kg, pounds)                                                                                                                                                                     |
| Value                 | Contains the parameter value. If it is a relation, the value contains the equation, form, deferral rule or whatever ties the related parameters together. If the value is a building block parameter, this attribute will hold the default value |
| Scaled                | Defines the scaling rule. Simplest case: scaled or not scaled with batch reference size                                                                                                                                                          |
| Usage                 | Identifies the parameter as a process input, process output or process parameter                                                                                                                                                                 |

The schedule relations can be used to represent the subset of recipe relations relevant to scheduling (for example, the relations related to batch transfers) (see table 22). At higher levels, they can be used to represent required or desirable relations between schedule entries (for example, batch xx should follow batch yy, or a specific cleaning should take place between the two batches). The specific subclasses and characteristics of schedule entry relations are not modelled here.

A higher-level batch schedule entry will include the lower level schedule entries and relations (for example, a scheduled campaign may include scheduled batches and relations between these batches).

In the simplest case, the batch schedule entry represents a batch in a batch execution list or queue that is expected to be initiated in sequence. Intended starting times and projected duration/ending times may be added. Furthermore, equipment assignments and the use of other resources may be specified by the batch schedule entry. The scheduling may happen at more detailed levels (for example, scheduling of individual unit recipes and their assignment to equipment, and potentially scheduling individual operations or phases, their projected duration, and their consumption of resources – including shared or exclusive use resources that constrain the schedule). Units and equipment modules are allocated or de-allocated as required by the specific control recipe.

The collection of schedule entries may be viewed in different ways:

- as a list or chart of batches in a process cell or part of a process cell, which provides an overview of process cell utilization;
- as a list or chart of resource utilizations, which provides a resource or equipment schedule.

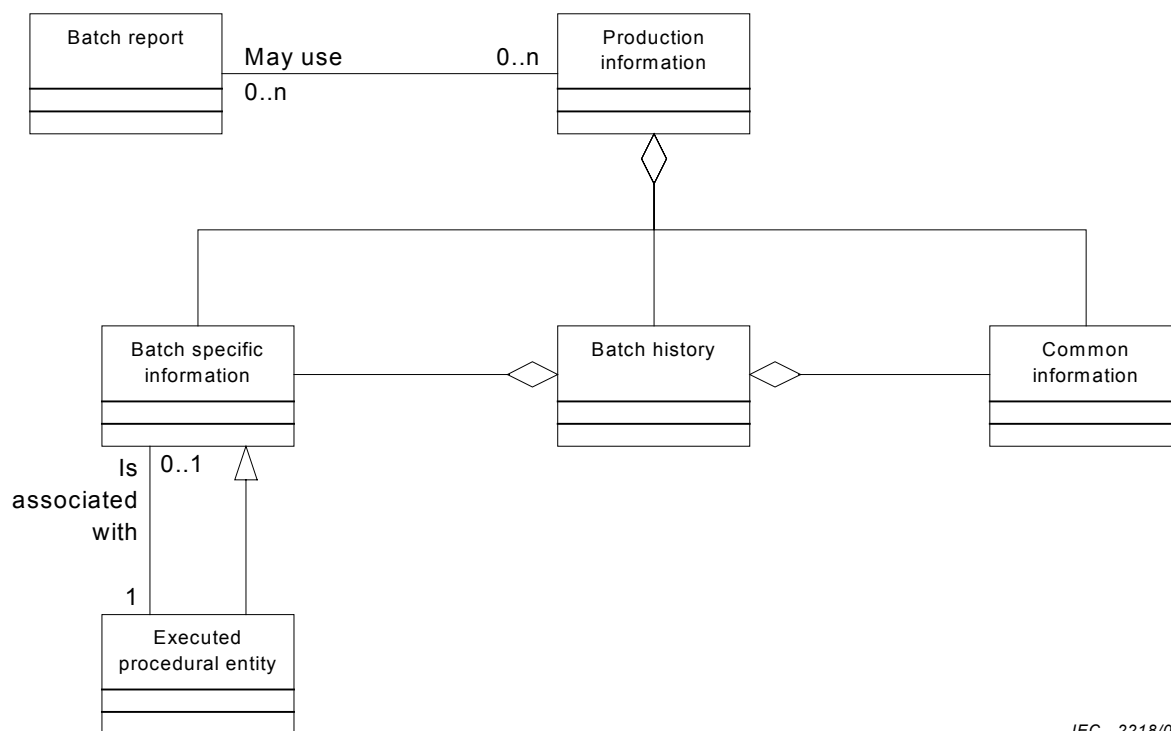
**Table 22 – Schedule relation**

| NAME                  | SCHEDULE RELATION                                                                                                                                                                   |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | A representation of relations between schedule entries (e.g., required line clearance, cleaning between scheduled items, specifications of sequential relations within a procedure) |
| ATTRIBUTES            |                                                                                                                                                                                     |
| ExecuteOrder          | Specifies in what sequence multiple schedule entries should be processed relative to each other                                                                                     |

**4.6    Production information management**

This subclause describes models that define the collection of production information.

Production information, including timely information of how things have progressed, may include both batch-specific information and selected non-batch specific, or common, information (see figure 12 and tables 23 to 28).



IEC 2218/01

Figure 12 – Production information

Table 23 – Production information

| NAME                  | PRODUCTION INFORMATION                                 |
|-----------------------|--------------------------------------------------------|
| FunctionalDescription | Information generated during the production of a batch |
| ATTRIBUTES            |                                                        |
|                       |                                                        |

Table 24 – Batch specific information

| NAME                  | BATCH SPECIFIC INFORMATION                                                      |
|-----------------------|---------------------------------------------------------------------------------|
| FunctionalDescription | Data that relates to one batch history entry                                    |
| ATTRIBUTES            |                                                                                 |
| BatchID               | Defines the actual batch ID                                                     |
| EntryID               | Provides unique identification                                                  |
| NewValue              | Indicates the current actual value                                              |
| EngineeringUnits      | Defines the engineering units, if any, that are appropriate for the NewValue    |
| EquipmentID           | Identifies an equipment element that may be associated with the entry           |
| UTC                   | Identifies the universal co-ordinated time (UTC) and date of the recorded entry |
| UserID                | Identifies the user, if any, who is associated with the change                  |

Table 25 – Batch history

| NAME                  | BATCH HISTORY                                          |
|-----------------------|--------------------------------------------------------|
| FunctionalDescription | An item of information that documents batch production |
| ATTRIBUTES            |                                                        |
| BatchID               | Defines the actual batch ID                            |

Table 26 – Common information

| NAME                  | COMMON INFORMATION                                                                                                            |
|-----------------------|-------------------------------------------------------------------------------------------------------------------------------|
| FunctionalDescription | Data that relates to more than one batch history entry (e.g. cooling water temperature, atmospheric pressure, steam capacity) |
| ATTRIBUTES            |                                                                                                                               |
| EntryID               | Provides unique identification                                                                                                |
| NewValue              | Indicates the current actual value                                                                                            |
| EngineeringUnits      | Defines the engineering units, if any, that are appropriate for the NewValue                                                  |
| EquipmentID           | Identifies an equipment element that may be associated with the entry                                                         |
| UTC                   | Identifies the universal co-ordinated time (UTC) and date of the recorded entry                                               |
| UserID                | Identifies the user, if any, who is associated with the change                                                                |

Production information may include some of the following:

- a copy of the control recipe;
- a copy of the master recipe;
- information about materials that are used and produced;
- trend information;
- alarms and messages;
- operator interactions with the batch (for example, overwrites, acknowledgements);
- late records and asynchronous records (for example, lab sample measurements);
- additional information (for example, allocation, start/stop).

An executed procedural entity is a recording of an instance of execution of a recipe entity or an equipment procedural entity (see table 27). Data is associated with the execution instance, and that data is maintained in the related batch history records.

The executed procedural entities that result from the execution of a control recipe will frequently have the same structure as the control recipe entities. The structure of executed procedural elements may, however, deviate from the control recipe in some cases. The following are some typical examples:

- Repeated instances of a recipe entity created through looping in the procedural logic.
- Instances not executed due to branches or GoTos in the procedural logic.
- Recipe entities that are inserted or repeated manually.
- Recipe entities that are activated on the spot in units that are already associated with a batch or that are manually associated with the batch.

The recipe entity relation and the rest of the recipe entity design pattern is not repeated here, because the history is about logging the facts as they were, and not the intended structure.

Table 27 – Executed procedural entity

| NAME                       | EXECUTED PROCEDURAL ENTITY                                                                      |
|----------------------------|-------------------------------------------------------------------------------------------------|
| FunctionalDescription      | A representation of a recipe entity (e.g., equipment procedural element) that has been executed |
| ATTRIBUTES                 |                                                                                                 |
| ExecutedProceduralEntityID | Provides a unique Identification                                                                |
| ProceduralEntityCounter    | Uniquely identifies repeated execution of the same procedural entity                            |

Batch reports (see table 28) are understood to be any extraction of batch data from production information for display on screen or on paper or for transfer to other systems.

Table 28 – Batch report

| NAME                  | BATCH REPORT                   |
|-----------------------|--------------------------------|
| FunctionalDescription | A component of a batch report  |
| ATTRIBUTES            |                                |
| ReportID              | Provides unique identification |

## 5 Relational tables for information exchange

### 5.1 Introduction

This clause defines the structure of SQL relational tables for the exchange of selected batch control related information between systems. It defines an interface specification, meeting the requirements of clause 4, for the exchange of batch information in the following selected categories:

- Master and control recipe information.
- Process cell equipment information.
- Schedule information.
- Production information.

Exchange tables shall be built using the table names, field names and relations that are defined in this clause. Not all tables need to be implemented, but all fields in an implemented table shall be included. Any such implementation shall be consistent with the table definitions presented here and the concepts of part 1 of this standard.

The format for the exchange tables only defines standard information that can be exchanged. The table definitions can be extended through the inclusion of additional attributes, additional related tables and additional enumerations. The extended structures may be used to exchange information among tools that understand the structures, but this information is outside the scope of this standard.

Examples of additional information are:

- The addition of icons that represent different elements of the equipment hierarchy, so that the equipment may be represented consistently by different tools.

- The addition of control system addresses for equipment element procedures, procedure parameters and data elements.

### 5.1.1 Method

The relational table structures are defined using SQL, as specified in ISO/IEC 9075.

The exchange mechanism is based on a common structure for database tables. These tables are defined as a data base schema that can be defined in SQL tables. Annex B contains the SQL table definitions of the exchange tables.

Figure 13 illustrates how the exchange tables would be used to exchange batch information between different tools. Each tool will generally have its own local data stores for batch information, and each tool is responsible for importing from and exporting to the exchange tables.

Most of the remaining models in this clause are represented using entity relationship diagrams (ERs) (see clause A.3).

The type and use of the tools that use the batch information are not specified in this standard. Possible tools include, but are not limited to:

- recipe authoring systems,
- recipe execution systems,
- documentation systems,
- configuration management systems,
- simulation systems,
- batch control systems,
- planning and scheduling systems,
- information management systems.

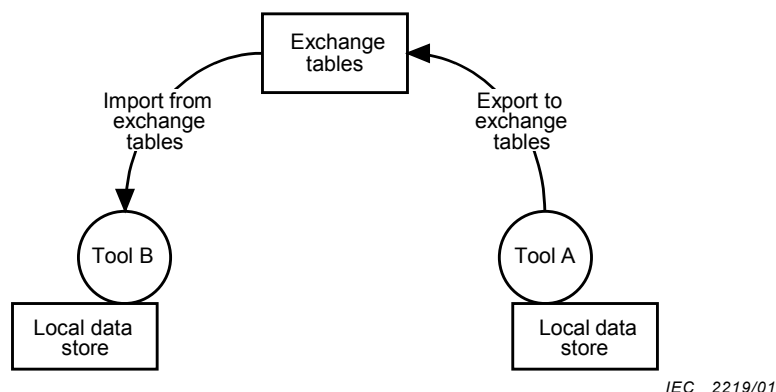


Figure 13 – Data transfer using exchange tables

### 5.1.2 Exchange tables

This standard does not specify which tools create and maintain the exchange tables. This standard only defines the structure of the tables. Tools could be designed such that they can only read from pre-existing exchange tables, only write to pre-existing exchange tables, read from and write to pre-existing tables or create, read, and write to exchange tables.

The exchange table structure is designed to allow multiple recipes to be exchanged in the same set of tables, and it allows multiple versions of the same recipe to be exchanged. The exchange table structure also allows the exchange of the equipment capability and specification information about process cells and process cell equipment.

The exchange table structure also allows the transfer of either complete or incomplete subsets of a master recipe, equipment descriptions, schedule information or batch history.

The syntax of data strings in the exchange tables (for example, computed formula items, transition conditions) is not defined in this standard. Tools that read and write the SQL exchange tables should resolve syntax differences.

The field lengths that are defined in the SQL definition of the exchange tables represent default values, and they are not intended to enforce a minimum or maximum field length standard. Tools that read and write the SQL exchange tables shall resolve field length differences.

### 5.1.3 Common exchange information

A set of tables are defined to contain information that describes the exchange format and that can be commonly used in the different exchange table sets. Figure 14 shows the tables that are involved in the common exchange information.

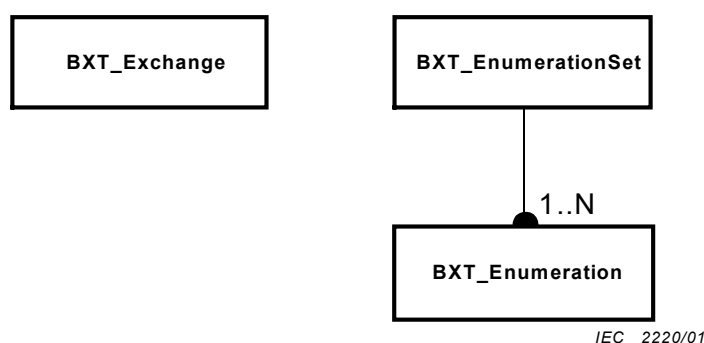


Figure 14 – Common information exchange tables

#### 5.1.3.1 Exchange information

The common exchange information table, BXT\_Exchange, contains all of the information that is needed only once in the exchange of data (see table 29).

The table, BXT\_Exchange table contents, (see table 30) contains one record for each of the defined items (for example, SCHEMA and the DELIMITER characters). It may also contain other user-defined information.

Table 29 – BXT\_Exchange

| Attribute         | Description                                        |
|-------------------|----------------------------------------------------|
| <i>ExchangeID</i> | Identifies the exchange element                    |
| ExchangeValue     | Identifies the value for the exchanged information |