AMERICAN NATIONAL STANDARD

ANSI/ISA-95.00.02-ed3 CVD04 (ISA 95.00.02 ed2 Mod)

Enterprise-Control System Integration

− Part 2: Objects and attributes for enterprise-control system integration

ANSI/ISA-95.00.02-ed3 CVD04 (ISA-95.00.02 ed2Mod)

Enterprise-Control System Integration − Part 2: Objects and attributes for enterprise-control system integration

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ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 2: Objects and attributes for enterprise-control system integration

FOREWORD

This standard is Part 2 of a multi-part set of standards that defines the interfaces between enterprise activities and control activities. It follows ANSI/ISA-95.00.01-2010 (ISA-95.00.01 Mod), Enterprise-Control System Integration - Part 1: Models and Terminology.

The scope of this Part 2 standard is limited to defining the details of the interface content between manufacturing control functions and other enterprise functions. The scope of this Part 2 standard is limited to the definition of object models and attributes for the information defined in Part 1. The goal is to reduce the effort, cost, and errors associated with implementing these interfaces.

The standard may be used to reduce the effort associated with implementing new product offerings. The goal is to have enterprise systems and control systems that interoperate and easily integrate.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2. Therefore, the first three clauses present the scope of the standard, normative references, and definitions, in that order.

Clause 4 is informative. It describes the general information about the object models and examples defined in later clauses.

Clause 5 is normative. It defines the object models, relationships, and attributes of common information defined in Part 1.

Clause 6 is normative. It defines the object models, relationships, and attributes of operations management information defined in Part 1.

Clause 7 is informative. It defines the inter-relationships between the object models.

Clause 8 is informative. It lists the objects defined in the standard as an aid to documenting conformance and compliance.

Clause 9 is normative. It defines completeness, conformance and compliance criteria associated with the objects and attributes.

Annex A is informative. It defines implementation naming convention for object relationships.

Annex B is informative. It defines a value syntax best practice. The format for values in a value attribute of an object is not defined in this part of the standard and are defined by implementations of the standard.

Annex C is informative. It provides examples to illustrate how the models, relationships, and attributes may be used.

Annex D is informative. It illustrates some example data sets for exchange.

Annex E is informative. It contains questions and answers on the use and reason for elements in the standard.

Annex F is informative. It discusses how the standard relates to logical information flows.

Annex G is informative. It discusses how the standard relates to abstract to implementation models.

Annex H is informative. It discusses how the standard relates to abstract to implementation examples.

INTRODUCTION

This clause of this part of this standard further defines formal object models for exchange information described in Part 1 using UML object models, tables of attributes, and examples. The models and terminology defined in this part of this standard

1. emphasize good integration practices of control systems with enterprise systems during the entire life cycle of the systems;
2. can be used to improve existing integration capability of manufacturing control systems with enterprise systems; and
3. can be applied regardless of the degree of automation.

Specifically, this part of this standard provides a standard terminology and a consistent set of concepts and models for integrating control systems with enterprise systems that will improve communications between all parties involved. Benefits produced will

1. reduce the user’s time to reach full production levels for new products;
2. enable vendors to supply appropriate tools for implementing integration of control systems to enterprise systems;
3. enable users to better identify their needs;
4. reduce the cost of automating manufacturing processes;
5. optimize supply chains; and
6. reduce life-cycle engineering efforts.

This standard may be used to reduce the effort associated with implementing new product offerings. The goal is to have enterprise systems and control systems that interoperate and easily integrate.

It is not the intent of the standards to

* 1. suggest that there is only one way of implementing integration of control systems to enterprise systems;
  2. force users to abandon their current way of handling integration; or
  3. restrict development in the area of integration of control systems to enterprise systems.

ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 2: Objects and attributes for enterprise-control system integration

# Scope

Part 2 of this standard specifies conceptual interface content exchanged between manufacturing control functions and other enterprise functions. The interface considered is between Level 3 manufacturing systems and Level 4 business systems in the hierarchical model defined in Part 1 of this standard. The goal is to reduce the risk, cost, and errors associated with implementing the interface.

Since this standard covers many domains and there are many different standards for those domains, the semantics of this standard are described at a level intended to enable the other standards to be mapped to these semantics. To this end, this standard defines a set of elements contained in the conceptual interface, together with a mechanism for extending the interface content for implementations.

The scope of Part 2 of this standard is limited to the definition of object models and attributes of the exchanged information defined in Part 1 of this standard.

# Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, latest edition of referenced document (including any amendments) applies.

ANSI/ISA-95.00.01-2010 (IEC 62264-1 Mod), Enterprise-Control System Integration – Part 1: Models and Terminology

ANSI/ISA-95.00.03-2013, Enterprise-Control System Integration - Part 3: Activity Models of Manufacturing Operations Management

ANSI/ISA-95.00.04-2012, Enterprise-Control System Integration – Part 4: Objects and attributes for manufacturing operations management integration

ANSI/ISA-95.00.05-2013, Enterprise-Control System Integration – Part 5: Business-to-Manufacturing Transactions

ANSI/ISA-88.00.01-2010, Batch Control – Part 1: Models and Terminology

IEC 62264-1, Enterprise-control system integration – Part 1: Models and terminology

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

ANSI/ISA-18.2-2009, Management of Alarm Systems for the Process Industries

ISO/IEC 19501, Information technology – Open Distributed Processing – Unified Modeling Language (UML) Version 1.4.2

ISO/IEC 19505-1, Information technology -- OMG Unified modeling language (OMG UML) Version 2.5 -- Part 1: Infrastructure

ISO/IEC 19505-2, Information technology -- OMG Unified modeling language (OMG UML) Version 2.5 -- Part 2: Superstructure

ISO 15000-5, Core Components Technical Specification

# Terms, definitions, abbreviations and conventions

## Terms and definitions

For the purposes of this document, the terms and definitions given in Part 1 of this standard, as well as the following apply.

by-product

A secondary material, produced as a residual of, or incidental to the production of the primary product.

co-product

a material usually manufactured together or sequentially with the primary product because of product or process similarities.

equipment class

grouping of role based equipment with similar characteristics.

event

representation of a solicited or unsolicited fact indicating a change of relevance to Level 3 activities or Level 4 activities.

material class

grouping of materials with similar characteristics

material definition

definition of a material type and type properties

NOTE 1 The *material definition* applies to *material lot* that can be identified as raw, intermediate, byproduct, finished, or consumable *material*.

material lot

uniquely identifiable amount of a material

NOTE 2 The *material lot* describes the actual or planned total quantity or amount of *material* available, its current state, and its specific property values.

material sublot

uniquely identifiable subset of a material lot

NOTE 3 The *material sublot* can be a single item.

personnel class

grouping of persons with similar characteristics

product

desired output of an operations process

NOTE 4 A product can be an intermediate product or end product from a business perspective.

NOTE 5 Product also defined in ISO 10303-1 as: a substance produced by a natural or artificial process.

property

implementation specific characteristic of an entity

## Abbreviations

For purposes of this standard, the following abbreviations apply.

**B2MML** business to manufacturing markup language

**BOR** bill of resources

**CE** common era

**EBNF** extended Backus-Naur form

**EPSG** European Petroleum Survey Group

**FQN** fully qualified name

**GUID** globally unique identifier

**IEC** International Electrotechnical Commission

**ISO** International Organization for Standardization

**MIMOSA** machinery information management open systems alliance (original) or operations and maintenance information open system alliance (current)

**MOM** manufacturing operations management

**SOC** standard operating conditions

**SOP** standard operating procedure

**SRID** spatial reference identifier

**UML** unified modeling language

**XML** extensible markup language

**XSD**  XML schema definition

## Conventions

### General

Italics are used for the use cases of names of objects used in exchanged data, beyond the use defined in ISO/IEC Directives Part 2, to emphasize the specific meaning of terminology of this standard.

The information object models are depicted using a simplified application of the Unified Modeling Language (UML) notational methodology, as defined in ISO/IEC 19501.

### UML notation in information object models

Table 1 defines the UML notations used in the simplified information object diagrams.

In this standard, the word “class” used as part of an object definition name is to be considered as a category, not as a “class” in the UML specification.

EXAMPLE 1 “Personnel class” is to be considered a “personnel category” in the sense of distinguishing between the kinds of personnel in the real world.

Table 1 – UML notation used

| Symbol | Definition |
| --- | --- |
|  | Defines a package, a collection of object models, state models, use cases, and other UML models. Packages are general-purpose grouping mechanisms used to organize semantically related model elements. In this document, a package is used to specify an external model, such as operations definition model, or a reference to another part of the model. |
|  | Represents a UML class of objects, each with the same types of attributes. Each object is uniquely identifiable or enumerable. No operations or methods are listed for the classes. |
|  | An association between elements of a class and elements of another or the same class. Each association is identified. Can have the expected number or range of members of the subclass, when ‘*\**’ indicates an indeterminate number.  EXAMPLE 2  0..*\** means that zero or more members of the subclass can exist.  The semantics of the association are defined in the object relationship table of each object participating in the relationship. |
|  | Generalization (arrow points to the super class) shows that an element of the class is a specialized type of the super class. |
|  | Dependence is a weak association that shows that a modeling element depends on another modeling element. The item at the tail depends on the item at the head of the relationship.  The semantics of the association are defined in the object relationship table of each object participating in the relationship. |
|  | Aggregation shows an element of the class (whole element) is made up of elements of other classes (part elements).  EXAMPLE 3    The aggregation notation identifies that the lifetime of the part element is independent of the whole element. The part element is able to be a part of multiple parent elements. When a whole element is deleted, the part elements are not deleted.  The parts’ physical relationship is independent of its lifetime relationship. A part can be represented directly in the whole or referenced from the whole. |
|  | A composition relationship represents a whole–part relationship and is a type of aggregation. A composition relationship specifies that the lifetime of the part classifier is dependent on the lifetime of the whole classifier. Composition shows a strong form of aggregation, which requires 1) a part instance is included in only one composition at a time and 2) the composition object has sole responsibility for disposition of its parts.  EXAMPLE 4    The composition notation identifies that the lifetime of the part elements is dependent on the whole element. When a whole element is deleted, the part elements are deleted.  The parts’ physical relationship is independent of its lifetime relationship as a part represented directly in the whole or referenced from the whole. |
|  | Three or more elements are strongly associated. If three elements are associated, the term ‘ternary’ association may be used.  The association object (diamond shape) may be an object, which can support attributes relevant to the association.  There is no lifetime dependency between the associated objects. |
|  | The association of A and B are refined by the class C, which is referred to as the association class.  If A and B are the same class, A and B are part elements with no distinctions made between the A and B. A and B are referred to as source and target to allow distinction of parts. |

NOTE UML lifecycles are not applicable to individual information exchanges. The relationships in the UML diagram provides a view into object lifecycles at the time of an information exchange. The navigation shown in the UML diagram is the most commonly applied; however, some implementation methods and technologies can require a bidirectional relationship or need to specify the relationship roles for both ends of the relationship.

The defined relationship in the information object diagrams in combination with the model relationship table and the object relationship tables for each object define the “minimum” compliance requirements. Additional relationship and roles required for an implementation are explicitly defined as non-compliant the implementation documentation.

### Object color convention for object relationship between UML models

Table 2 defines the object color convention used in the UML diagrams of this part and Part 4 of this standard to illustrate the object relationships between information models. The objects defined in the clause containing the UML diagram have a white background; the relationships to objects not defined in the clause shown in the UML diagram have a gray background if defined in another clause of this part or a beige background if defined in Part 4 of this standard. For the objects not defined in the clause, the basic relationships between objects defined in the clause are shown for the complete context of the objects defined in the clause.

Table 2 – Object color convention for object relationship between UML models

| Object type | Color convention |
| --- | --- |
|  | An object with a white background belongs to the information model defined in the clause containing the UML diagram. |
|  | An object with a gray background is not defined in the clause containing the UML diagram and is defined in another information model in this part of this standard. |
|  | An object with a beige background is not defined in the clause containing the UML diagram and is defined in an information model in Part 4 of this standard. |
|  | An object with a dark gray background belongs to an external information model not defined in this standard. |
|  | An object with a pink background belongs to an interface abstract object defined in the clause containing the UML diagram. |

### Relationship types

This subclause explains the use and meaning of the relationship types in relationship table and role table for each object in an information model.

The generic specification can be further qualified within the relationship table entry to clarify the relationship context.

1. Association: the association type represents a general relationship between two objects. A dashed line indicates a weak association between objects.

EXAMPLE 1 A *material definition* defines 0..\* *material lot* objects where, in contrast, a *material lot* is defined by 1..1 *material definition*. A *material lot* contains a relationship to its *material definition*, which is represented as a relationship attribute in the *material lot*. In a data exchange implementation, the *material lot* objects associated with a *material definition* is recorded in the *material definition* occurrence; but in another implementation, the *material lot* objects are recorded in separate systems using link table references.

1. Dependency: the object has a semantic link to the object, which can be required to be satisfied before the object can be created. A relationship signifying that a single model object or a set of model objects require other model objects for their specification or implementation.
2. Aggregation: the view of the UML relationship is qualified by the target end of the relationship link; the terminology used is “aggregation part” for the sub object and “aggregation whole” for the parent object. An aggregation type can be refined with the following keywords:
3. Whole: the object is the whole object in the aggregation.
4. Part: the object is the part object in the aggregation.
5. Hierarchy: the object can be both a whole and part object.

EXAMPLE 2 Equipment hierarchy.

This infers that implementations can utilize parent and child prefixes or link tables if navigation of the hierarchy is required. In an aggregation hierarchy when a parent object is deleted, the relationships to other child objects are removed if specified in link tables but the child objects are not deleted.

1. Composition: the relationship view is qualified by the target end of the relationship; the terminology used is ‘composition part’ for the sub object and ‘composition whole’ for the parent object. A composition type can be refined with the following keywords:
2. Whole: the object is the whole object in the composition.
3. Part: the object is the part object in the composition.
4. Composition hierarchy: the objects can be both a whole and part object.

EXAMPLE 3 Material lot hierarchy.

A composition hierarchy can use parent and child prefixes or link tables if navigation of the hierarchy is required. If the root parent object is deleted, all child objects and their child objects are deleted. Objects can be both a whole and part object.

### Relationship table

Each information model’s UML diagram is explicitly defined by the simplified UML model in combination with a relationship table. The relationship table lists each relationship and a role table for each object in UML model that lists the role of the object in its relationships.

The object relationship tables indicate an object name for the both end points, a type of relationship and name of relationship for each relationship between objects in an information model. The object relationship table uses the following UML object relationship types to identify the relationship between objects. In the object relationship table, the object relationship is defined specifically from each object’s perspective.

EXAMPLE 1 The UML diagram of personnel model in Figure 1 below in combination with the associated relationship table in Table 3 shows the *personnel class* object’s relationships as an example of how the standard represents each object’s relationships in the context of the information model.

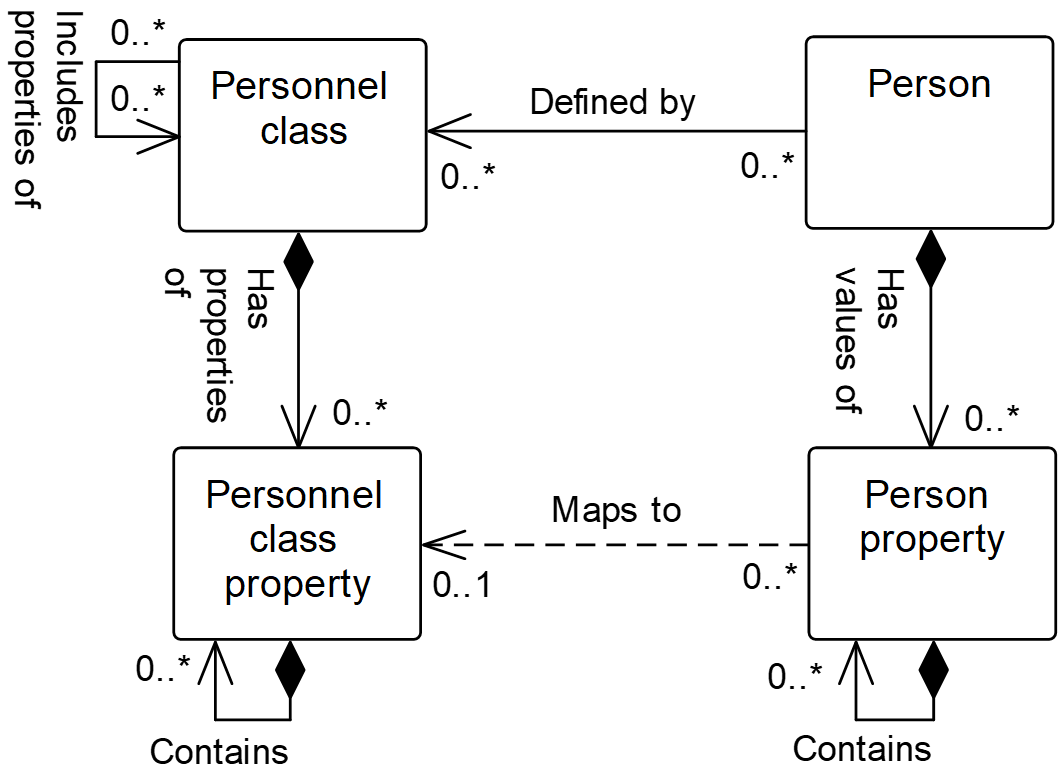


Figure 1 – Example: UML Diagram for an information model, personnel model

Table 3 – Example: Relationship table for an information model, personnel model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Personnel class | Personnel class property | Composition | Has properties of |
| Personnel class | Personnel class | Association | Includes properties of |
| Person property | Personnel class property | Dependency | Maps to |
| Person property | Person property | Composition hierarchy | Contains |
| … | … | … | … |

### Relationship role table

To explicitly define object’s relationships in an information model’s UML diagram, each object’s definition uses a relationship role table to lists role of the related object in each predominate relationship.

The column headers for the object relationship table are

1. related object: for a given object, each row in the relationship role table defines a relationship of the object to another object in the information model;
2. role: the relationship role of the related object in relationship to the given object (what the given object can use to identify the related object);
3. multiplicity: the multiplicity in UML diagram that specifies cardinality of some collection of elements;

EXAMPLE 1 The number of elements.

Multiplicity element defines some collection of elements and includes both multiplicity as well as specification of order and uniqueness of the collection elements:

1. description: the description of the object’s relationship.

EXAMPLE 2 The example for role table for the personnel class object in the example of the UML diagram of personnel model is shown in Table 4.

Table 4 – Example: Relationship role table, Personnel class relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Personnel class | Personnel class parent type | 0..\* | Includes properties of | This *personnel class(s)* include properties of the *personnel class*. |
| Personnel class property | Personnel class property | 0..\* | Has properties of | The *personnel class properties* of this *personnel class*. |
| Person | NA | 0..\* | Defined by | The *person* supports this *personnel class.*  The *person* objects support the *personnel class property(s)* associated with this *personnel class.* |

### Object attribute tables

#### Object attribute tables

This subclause gives the meaning of the object attribute tables. This includes a listing of the object identification, presentation of the examples in the tables, references to resources, object relationships, related object naming convention, and object relationship implementations.

All attributes in the tables are be considered optional, except where specified as required in the attribute description.

#### Presentation of examples

Examples are included with each attribute given in object attribute tables. Examples are presented for each of the four main operation management categories (i.e. production, maintenance, quality and inventory operations) defined in Part 1 of this standard. Table 5 shows how the attribute example rows and columns are used.

Table 5 – Example: Object attribute table

| Attribute name | Description | Production example | Maintenance example | Quality example | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Name of first attribute | Description of first attribute | Production example | Maintenance example | Quality example | Inventory example |
| Name of second attribute | Description of second attribute | Production example | Maintenance example | Quality example | Inventory example |
| Name of third attribute | Description of third attribute | Production example | Maintenance example | Quality example | Inventory example |

When an example value is a set of values, or a member of a set of values, the set of values is given within a set of braces, {}.

The examples are purely fictional. They are provided to further describe attributes in the model. It is not intended to make the examples complete or representative of any manufacturing enterprise.

NOTE 1 Within a table the columns for Production, Maintenance, Quality and Inventory can be examples where the four operations management categories are coordinated, or they can be separate examples.

EXAMPLE 1 When one system is coordinating multiple operations management categories, the IDs used in each column can be the same. When different systems coordinate multiple operations management categories, the IDs can be different.

Example values of attribute are meant to be illustrative and do not imply requirements.

NOTE 2 Time and date attributes can illustrate a general or specific time horizon.

EXAMPLE 2 A yearly or quarterly plan can use general dates with no specific time, while a detailed schedule can include a specific time stamp down to the minute.

EXAMPLE 3 Data resolution used in the examples are typical examples.

Specific implementations of this part may specify the data resolution required for each attribute.

When <NA> (not applicable) is used as an example, this is only illustrative that there is not a value for this attribute in this example. It does not imply there can never be a value. This is also true when all four columns contain <NA>.

### Relationships between information models and resource models

The inforamtion models in this standard use a simplified method to reference resource model. In order to make the UML diagrams less complex, the simplified UML model does not fully document the possible four cross-model relationships or paired relationships between a specific object (specification, requirement, actual, capability) in an information model and an associated object(s) in the resource information model. The UML models are not fully conformant to the Unified Modeling Language (UML) notational methodology as defined in ISO/IEC 19501.

The simplified UML techniques in this standard are intended as a visualization method that must be used in combination the object attribute tables, object model relationship table, and object role tables for an explicit definition of the abstract information exchanges supported by compliant integration implementations.

Figure 2 illustrates resource model referencing method in the simplified UML model in this standard in the left column to compare the detailed relationships per the ISO/IEC 19501 compliant UML model in the right column.

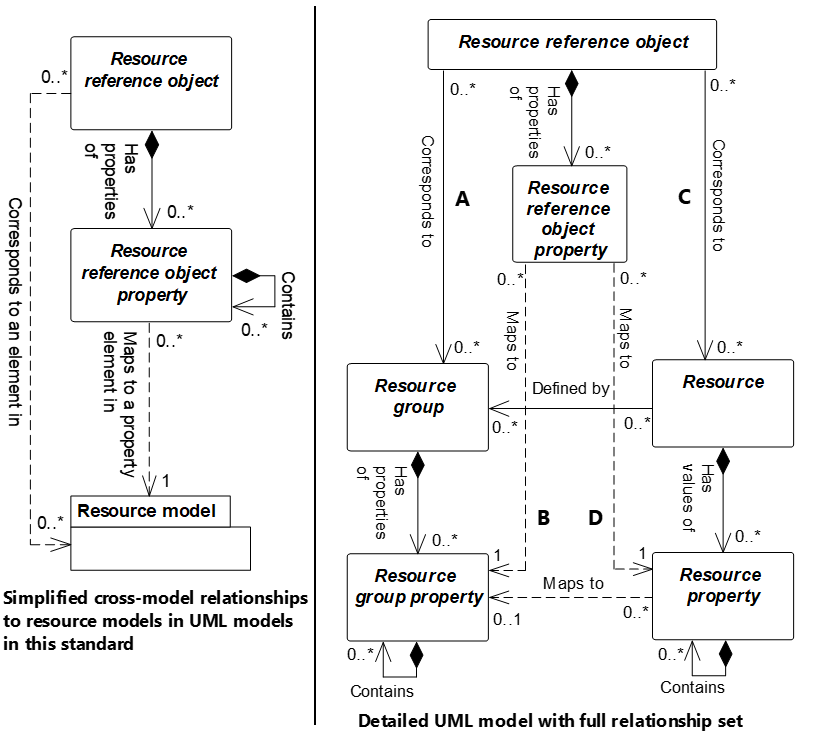


Figure 2 – Convention for simplified cross-model relationships to resource models

The implemented association relationship of the detailed UML model for a *resource reference object* is defined through only one of the following four relationships or paired relationships shown in Figure 2:

1. A,
2. A and B,
3. C, and
4. C and D.

Reference terms for resource objects in Figure 2 are

1. *resource reference object* includes the *resource reference object* objects listed in Table 249**,**
2. *resource group* includes *personnel class, equipment class, physical asset class, material class, and material definition objects, and*
3. *resource* includes *person, equipment, physical asset, material lot and material sublot objects.*

Table 6 lists the object relationships in the detailed UML model example in Figure 2.

Table 6 – Detailed UML model relationships in Figure 2

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Resource reference object | Resource group | Association (A) | Corresponds to |
| Resource reference object | Resource | Association (C) | Corresponds to |
| Resource reference object property | Resource group property | Dependency (B) | Maps to |
| Resource reference object property | Resource property | Dependency (D) | Maps to |
| Resource reference object | Resource reference object property | Composition | Has properties of |
| Resource | Resource group | Association | Defined by` |
| Resource | Resource property | Composition | Has values of |
| Resource group | Resource group property | Composition | Has properties of |
| Resource property | Resource group property | Dependency | Maps to |
| Resource property | Resource property | Composition hierarchy | Contains |
| Resource group property | Resource group property | Composition hierarchy | Contains |

Table 7 provides the reference labels for each of the possible four cross-model relationships or paired relationships for referencing resource objects shown in Figure 2 for an implemented *resource reference object* instance such as Mixer 101 as an *equipment* object*.* The following conventions apply.

1. Only one of the four possible relationships or paired relationships are allowed for a given *resource reference object* instance.
2. The paired relationships, Label A with B and Label C with D, shows that a *resource reference object* cannot be represented by a single dependency relationship to either a *resource class property* (B) or to a *resource property* (D) since the properties are in a composition relationship;
3. Consequently, the *resource reference object* only references a resource model property if the property's parent object has an association relationship (A or D) with the *resource reference object*.

Table 7 – Four possible cross-model relationships or paired relationships for a *resource reference object* instance

|  |  |
| --- | --- |
| Figure 3 relationship label | Possible cross-model relationships for a *resource reference object* instance |
| A | An association between the *resource reference object* and *resource group* |
| A with B | An association between the *resource reference object* and *resource group* and  A dependency between the *resource reference object property* and *resource group property* |
| C | An association between the *resource reference object* and resource |
| C with D | An association between the *resource reference object* and resource and  A dependency between the *resource reference object property* and *resource property* |

Table 249 lists the information models of this part that apply the simplified resource models to reference the resource models and defines the set of possible relationships to the specific resource group and resource objects within each model.

Table 8 to Table 13 provide the role table for the following reference objects contained in the detailed UML model in Figure 2: *resource reference object, resource reference object property, resource group, resource group property, resource,* and *resource property*.

Table 8 – Resource reference object cross-model relationship roles

| Related Object (Figure 2 relationship label) | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Resource group (A) | Resource group | 0..\* | Corresponds to | The *resource group(s)* support this resource reference object.  The *resource group(s)* support the *resource reference object property(s)* associated with this *resource reference object*. |
| Resource (C) | Resource | 0..\* | Corresponds to | The *resource(s)* support this *resource reference object*.  The *resource(s)* support the *resource reference object property(s)* associated with this *resource reference object.* |
| Resource reference object property | Resource reference object property | 0..\* | Has properties of | The *resource reference object property(s)* defining in part this *resource reference object.* |
| EXAMPLE 1 *Personnel segment specification* cross-model relationships to personnel model | | | | |
| Personnel class (A) | Personnel class | 0..\* | Corresponds to | The *personnel class(s)* support this *personnel segment specification.*  The *personnel class(s)* support the *personnel segment specification property(s)* associated with this *personnel segment specification*. |
| Person (C) | Person | 0..\* | Corresponds to | The *personnel class(s)* support this *person.*  The *personnel class(s)* support the *person property(s)* associated with this *person.* |

Table 9 – Resource reference object property cross-model relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Related Object (Figure 2 relationship label) | Role | Multiplicity | Relationship Name | Description |
| Resource group property (B) | Resource group property | 1 | Maps to | This *resource reference object property* defined by the *resource group property*. |
| Resource property (D) | Resource property | 1 | Maps to | This *resource reference object property* defined by the *resource property*. |
| Resource reference object | NA | 1 | Composition | This *resource reference object property(s)* of the *resource reference object.* |
| EXAMPLE 2 *Personnel segment specification* cross-model relationships to *personnel model property(s)* | | | | |
| Personnel class property (B) | Personnel class property | 1 | Maps to | The *personnel class(s)* support this *personnel segment specification*.  The *personnel class property(s)* support the *personnel segment specification* *property(s)* associated with this *personnel segment specification*. |
| Person property (D) | Person property | 1 | Maps to | The *person(s)* support this *personnel segment specification.* The *person property(s)* support the *personnel segment specification property(s)* associated with this *personnel segment specification.* |

Table 10 – Resource group cross-model relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Related Object  (Figure 2 relationship label) | Role | Multiplicity | Relationship Name | Description |
| Resource reference object (A) | NA | 0..\* | Corresponds to | The *resource reference object* related to this *resource group*. |
| Resource | NA | 0..\* | Defined by | The *resource* defined by this *resource group.* |
| Resource group property | Resource group property | 0..\* | Has properties of | The *resource group property(s)* of this *resource group property.* |
| EXAMPLE 3 *Personnel segment specification* cross-model relationships with *personnel class* | | | | |
| Personnel segment specification (A) | NA | 0..\* | Corresponds to | The *personnel class(s)* support this *personnel segment specification*.  The *personnel class property(s)* support the *personnel segment specification* *property(s)* associated with this *personnel segment specification*. |
| Personnel class property | Personnel class property | 0..\* | Has properties of | The *personnel class(s)* support this *personnel segment specification.*  The *personnel class property(s)* support *the personnel segment specification property(s)* associated with this *personnel segment specification*. |

Table 11 – Resource group property cross-model relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Related Object  (Figure 2 relationship label) | Role | Multiplicity | Relationship Name | Description |
| Resource reference object property (B) | NA | 0..\* | Maps to | The *resource reference object property* related to this *resource group property*. |
| Resource group | NA | 1 | Has properties of | The *resource group* defined in part by this *resource property*. |
| Resource property | NA | 0..\* | Maps to | The *resource property* defined by this *resource group property.* |
| Resource group property | Resource group property | 0..\* | Contains | The *resource group property(s)* of this *resource group property.* |
| EXAMPLE 4 *Personnel class property* cross-model relationships with a *personnel segment specification property* | | | | |
| Personnel segment specification property (B) | NA | 1 | Maps to | The *personnel class(s)* support the *personnel segment specification*.  This *personnel class property(s)* support the *personnel segment specification* *property(s)* associated with the *personnel segment specification*. |
| Personnel class property | Personnel class property | 0..\* | Contains | The *personnel class(s)* support this *personnel segment specification.*  The *personnel class property(s)* support *the personnel segment specification property(s)* associated with this *personnel segment specification*. |

Table 12 – Resource cross-model relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Related Object  (Figure 2 relationship label) | Role | Multiplicity | Relationship Name | Description |
| Resource reference object (C) | NA | 0..\* | Corresponds to | This *resource* related to the *resource reference object*. |
| Resource group | Resource group | 0..\* | Defined by | This *resource* defined by the resource group |
| Resource property | Resource property | 0..\* | Has values of | The *resource property(s)* containing the values of this *resource.* |
| EXAMPLE 5  *Personnel segment specification* cross-model relationships with a *person* | | | | |
| Personnel segment specification (C) | NA | 0..\* | Corresponds to | This *person(s)* support the *personnel segment specification*.  This *person property(s)* support the *personnel segment specification* *property(s)* associated with the *personnel segment specification*. |
| Person property | Person property | 0..\* | Has values of | This *person(s)* support the *personnel segment specification.*  This *person property(s)* support *the personnel segment specification property(s)* associated with this *personnel segment specification*. |

Table 13 – Resource property cross-model relationship roles

| Related Object  (Figure 2 relationship label) | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Resource reference object property (D) | NA | 0..\* | Maps to | The *resource reference object property* related to this *resource group property*. |
| Resource | NA | 1 | Has values of | The *resource* contains the values of this *resource property(s)*. |
| Resource group property | Resource group property | 0..1 | Maps to | This *resource property* defined by the *resource group*. |
| Resource property | Resource property | 0..\* | Contains | The *resource property(s)* of this *resource property.* |
| EXAMPLE 6  *Person property* cross-model relationships with a *personnel segment specification property* | | | | |
| Personnel segment specification property (D) | NA | 0..\* | Maps to | This *person(s)* support the *personnel segment specification*.  This *person property(s)* support the *personnel segment specification* *property(s)* associated with the *personnel segment specification*. |
| Personnel class property | Personnel class property | 0..1 | Maps to | This *person(s)* support the *personnel segment specification.*  This *person property(s)* support *the personnel segment specification property(s)* associated with this *personnel segment specification*. This *person property* is defined in part by the *personnel class property*. |

# Manufacturing operations information models

## Information models

Information models in Figure 3 define a common way of representing information that can be exchanged between different manufacturing operations activities. They define the objects that can be used to represent information, attributes of the objects, and relationships of objects in the exchange models.

A generic operations management information model is used to represent the information that can be exchanged between manufacturing operations activities and business activities. This is illustrated in Figure 3 to indicate the 4 common types of exchanged information, operations schedule information, operations performance information, operations definition information, and operations capability information. The specific object models for exchanged information are defined in Clause 6.



Figure 3 – Operations information models for operations management

## Relationship of exchange information models to operations management activity categories

The common information models in Clause 5 describe the different types of resources and their uses in describing a (business) *process segment*. The Clause 5 common information models are also used to describe the other manufacturing operations management information models in Clauses 6 and to describe the information models defined by the Part 4 of this standard.

NOTE 1 The operations management information object models described in this part of this standard can be used for any manufacturing operations category, such as, production, maintenance, quality, inventory, and inventory handling as defined in Part 1 of this standard.

NOTE 2 Although the generic information model can also be used to describe operations management information models for user-defined operations categories, conformance can be evaluated only if user-specific conformance testing scenarios are available.

Additional explanations are provided in Annex C to assist in applying these object definitions to describe the structure for the exchange information among the following operations management categories:

* production operations;
* maintenance operations;
* quality operations;
* inventory (handling) operations;
* mixed operations; and
* user-defined operations.

NOTE 3 Where Part 3 of this standard provide reference explanation for quality test operations, this standard applies across all Level 3 quality operations.

## Cross model relationships for MOM activity context in exchanges

The Part 2 operations information models and Part 4 work information models are aligned through defined cross-model relationships to provide the context of MOM activity or workflow for schedules/requirements, definitions, and performance/response exchanges. These cross-model relationships provide an integration framework for interactive manufacturing operations in the plant and between the plant and enterprise functions, Figure 4 and Table 14 shows the supported relationships between MOM objects that provide data references for schedule/request/requirement; *job order*, definitions; and responses/actuals objects in Part 2 and Part 4 of this standard.

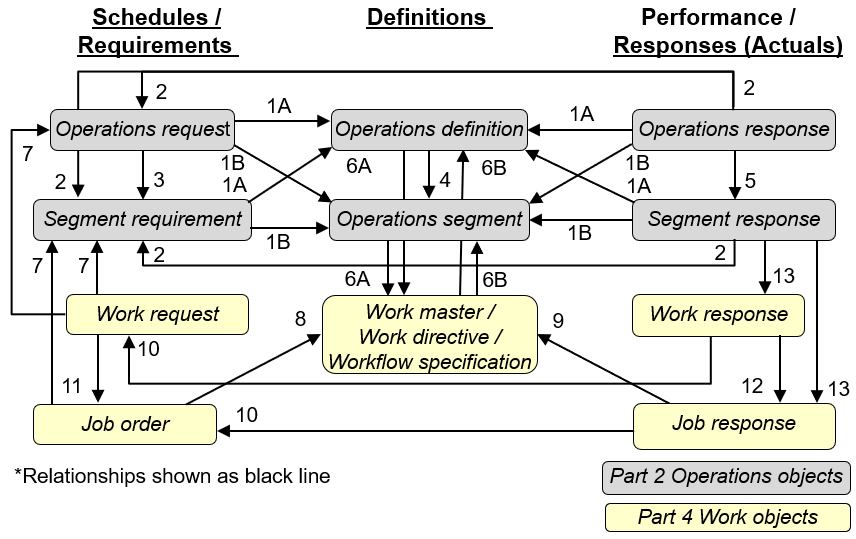


Figure 4 – Defined cross-model MOM relationships between operations & work models

Table 14 – Cross-model MOM relationship description

| Reference  No. | MOM context relationship description | |
| --- | --- | --- |
| From *object* | To *object* |
| 1A | Part 2 schedule: *operations request*  Part 2 requirement: *segment requirement*  Part 2 response: *operations response, segment response* | Part 2 definition: *operations definition* |
| 1B | Part 2 schedule: *operations request*  Part 2 requirement: *segment requirement*  Part 2 response: *operations response, segment response* | Part 2 definition: *operations segment* |
| 2 | Part 2 response: *operations response, segment response* | Part 2 schedule: *operations request*  Part 2 requirement*: segment requirement*. |
| 3 | Part 2 schedule: *operations request* | Part 2 requirement: *segment requirement* |
| 4 | Part 2 definition: *operations definition* | Part 2 definition: *operation segment* |
| 5 | Part 2 response: *operations response* | Part 2 response: *segment response* |
| 6A | Part 2 definition: *operations definition, operations segment* | L3 definition: work master |
| 6B | Part 4 definition: *work directive* | Part 2 definition: *operations definition, operations segment* |
| 7 | Part 4 schedule: *job order, work request* | Part 2 requirement: *segment requirement*  Part 2 schedule: *operations request* |
| 8 | Part 4 schedule: *job order* | Part 4 definition: *work master* |
| 9 | Part 4 response: *job response* | Part 4 definition: *work masters, work directives* |
| 10 | Part 4 response: *job response, work response* | Part 4 schedule: *job order, work request* |
| 11 | Part 4 schedule: *work request* | Part 4 requirement: *job order* |
| 12 | Part 4 response: *work response* | Part 4 response: *job response* |
| 13 | Part 2 response: *segment response* | Part 4 response: work responses, job responses |

## Abstract UML model information

The information models of this part and Part 4 of this standard represent exchanged data in an abstract UML model using

1. objects,
2. attributes of objects, and
3. relationships and roles between objects.

Abstract UML model is a conceptual abstract overview of the structure of data. An abstract UML model does not provide information related to how the structure is to be implemented or the means (rules, technologies) that are needed to implement the structure shown.

NOTE 1 Abstract UML models can be represented as a logical model schema for the specific purpose to formally documents the contents of the abstract UML models.

NOTE 2 UML lifecycles are not applicable to individual information exchanges. The relationships in the UML model provides a view into object lifecycles at the time of an information exchange

Abstract UML models differ from the logical models typically used by IT groups in application development. Logical models in application development focus on a specific target. Abstract UML models are generic models, so they can be applied across many industries and applications. As such the abstract information models are focused on being abstract and generic with limited constraints on the representation. Constraints are applied during the transformation from abstract to implementation model.

NOTE 3 Implementation models are an interpretation / instance of the abstract UML model relevant as specific implementation scope. An implementation model can apply rules and requirements to the abstract model to develop a model implemented with a specific exchange technology.

## Attributes of an object in an information model

### General

Clause 4.5 describes the methods used to define object models and attributes for information exchanged between Level 3 and Level 4 activities and associated functions. The attributes are part of the definition of object models for exchanged information and terms.

### Minimum object attribute sets

A minimum set of industry-independent information has been defined as attributes. However, values for all attributes are not be required depending on the actual usage of the models. If additional information, including industry- and application-specific information, is needed, it is presented as property objects. This mechanism is the extension capability referenced in the scope of this standard. This method increases the usability through the use of standard attributes and allows flexibility and extensibility through the use of properties. The use of properties is included to make the standard as widely applicable as practical.

### Data types of object attributes

The attributes presented are abstract representations without any specific data type specified.

NOTE Specific implementations of this part can specify how the information is represented.

EXAMPLE 1 An attribute can be represented as a string in one implementation and as a numeric value in another implementation.

EXAMPLE 2 A date/time value can be represented in ISO standard format in one implementation and in Julian calendar format in another. Attributes for date or time can contain values for a date, a date and time or a time value, the standard does not enforce the value semantics. Each implementation will have to negotiate the value semantics.

EXAMPLE 3 An object or attribute relationship can be represented by key fields in data base tables, or by parent/child elements in an XML by nested hierarchy.

### Object attribute extensibility

Accordingly, this standard provides mechanisms so that application or industry specific attributes can be modeled in terms of object properties and represented in object property classes in the model.

EXAMPLE The *personnel class property* can define application- or industry-specific attributes for *personnel classes* and *person property* can contain values for the properties.

NOTE The use of extensions through the addition of attributes can negate the advantage of using this standard.

### Common object attributes

#### Object identification

Objects in the information model which require unique identifications contain an ID attribute, which are unique within the scope of the exchanged information.

NOTE 1 Translation of the ID attributes is possibly necessary for implementations

* from the internal ID of the source system to the interface content ID and
* from the interface content ID to the internal ID of the target system.

EXAMPLE 1 A unit can be identified as “X6777” in the interface content, as resource “R100011” in the business system, and as “East Side Reactor” in the control system.

A unique identification set should be agreed to support an information exchange.

The object IDs are used only to identify objects within related exchanged information sets.

EXAMPLE 2 Object ID values can be GUIDs or database index values.

NOTE 2 Generally, objects that are elements of composite aggregations or shared aggregation that are not referenced elsewhere in the model, does not require unique IDs.

#### Value type and use

##### General

Value attributes are used in properties, parameters, and data to exchange actual values.

Value attributes are also used to exchange the allowed or expected values in properties and parameters for *material definitions, material classes, equipment classes, personnel classes, physical asset classes, process segments,* and *operations definitions*. Value types thus represent actual single values, actual arrays of values, ranges of possible values, series values, and structured values, either as numerical or textual ranges or as sets of values.

##### Simple value types

Simple value types in Table 15 – Commonly used CCTS types for exchange should be derived from core component types that are compatible with the ISO-15000-5 Core Component Technical Specification (CCTS). The CCTS types are a common set of types that define specific terms with semantic meaning.

EXAMPLE 1 The meaning of a quantity, currency, amount, and identifier.

Table 15 – Commonly used CCTS types for exchange

|  |  |
| --- | --- |
| AmountType | Used to define a number of monetary units specified in a currency where the unit of currency is explicit or implied. |
| BinaryObjectType | Used to define a data types representing graphics, pictures, sound, video, or other forms of data that can be represented as a finite length sequence of binary octets. |
| CodeType | Used to define a character string that is used to represent an entry from a fixed set of enumerations. |
| DateTimeType | Used to define a particular point in time together with the relevant supplementary information to identify the time zone information. This is a specific instance on time using the ISO 8601 CE (Common Era) calendar extended format and abbreviated versions. |
| IdentifierType | Used to define a character string to identify and distinguish uniquely, one instance of an object in an identification scheme from all other objects in the same scheme. |
| IndicatorType | Used to define a list of two mutually exclusive Boolean values that express the only possible states of a Property.  EXAMPLE 2 “True” or “False”. |
| MeasureType | Used to define a numeric value determined by measuring an object along with the specified unit of measure. |
| NumericType | Numeric information that is assigned or is determined by calculation, counting, or sequencing. It does not require a unit of quantity or unit of measure. |
| QuantityType | Used to define a counted number of non-monetary units, possibly including fractions. |
| TextType | Used to define a character string generally in the form of words of a language.  EXAMPLE 3 A finite set of characters. |

##### Array value types

Arrays of values may be represented following the syntax defined in Annex B.

EXAMPLE 1 A set of values for a single dimension array with 6 values would be represented as:

[ 1 , 2 , 3 , 4 , 5 , 6]

EXAMPLE 2 A set of values for a two-dimension array of size 2x3 would be represented as:

[ [ 1 , 2] , [ 3 , 4 ] , [ 5 , 6 ] ]

##### Range value types

Range specifications may be represented following the syntax defined in the EBNF above.

EXAMPLE 1 A simple range of values can be represented as:

{ 0 .. 100 }

EXAMPLE 2 A non-continuous range of values can be represented as:

{ a .. z , A .. Z }

{ 0 .. 100 , 200 .. 300 , 500 , 600 .. 650 }

##### Series value types

A specification defined as a set of allowed values may be represented following the syntax defined in Annex B.

EXAMPLE 1 A series of values that define colors can be represented as:

< Red, Green, Yellow, Blue>

EXAMPLE 2 A series of values that define equipment hierarchy levels can be represented as:

<Enterprise, Site, Area, WorkCenter, WorkUnit>

##### Structured value types

Structured data elements may be represented in this standard as properties, data and parameters as structured objects by

1. the property model by representing the atomic elements of the structure in a flattened name space,
2. using nested properties to represent the data structure, and
3. a single value like arrays, ranges and series which are specific cases of structured data.

NOTE 1 The decision to use a flattened name space, nested properties, or a combination can be determined by the specific implementation.

A structure may be modeled by flattening the name space and having a single property for each structure element or by embedding a data structure within a single value attribute using EBNF notation.

EXAMPLE 1 To summarize, structured data can be represented in 3 different ways:

1. EBNF notation,

(ABC(DEF(GHI = “x”)))

1. Using properties/parameters in the same namespace,

ABC

*ABC.DEF*

ABC.DEF.GHI value = “x”

1. Using fully qualified nested properties, and

ABC

*DEF*

GHI value = “x”

NOTE 2   This standard specifies how to exchange information without regard to the specific exchange element’s mapping. With structured elements, there can be no guarantee that the communicating entities would have the same structure for the data. Therefore, flattening the structure to its individual elements provides a transportable format for structured data.

EXAMPLE 2 A structured element of data can be mapped to a flat name space as follows:

**Structure Definition** **Flattened Property Name**

Struct ABC {

Integer DEF; ABC.DEF

Float GHI; ABC.GHI

Array [3] of Integer JKI ABC.JKI

}

A structured data element may be represented by creating a property with no data value or unit of measure and with nested child properties and an identification of the element.

EXAMPLE 3 A structured data element can be mapped as follows:

**C# Structure Definition Equivalent Property**

struct **Simple** { Property [ID=”**Simple**”]

public int **Position**; Property [ID=”**Simple**”] \ Property [ID=”**Position**”]

public bool **Exists**; Property [ID=”**Simple**”] \ Property [ID=”**Exists**”]

public double **LastValue**; Property [ID=”**Simple**”] \ Property [ID=”**LastValue**”]

};

A grouping or collection of related properties may be represented by creating a property with nested child properties.

EXAMPLE 4 A collection of related nominal properties can be mapped as follows:

**Collection of Properties Property Structure**

Property [ID=”**Nominal**”]

**NominalRate** Property [ID=”**Nominal**”] \ Property [ID=”**NominalRate**”]

**ExpectedRate** Property [ID=”**Nominal**”] \ Property [ID=”**ExpectedRate**”]

**LabelCode** Property [ID=”**Nominal**”] \ Property [ID=”**LabelCode**”]

Nested property objects are only shown in the personnel, equipment, physical asset, and material models. All property objects are also nested, as defined in the appropriate section in the text, but are not shown in the model figures in order to reduce the complexity of the figures.

#### Measurement uncertainty sub-attributes in value and quantity attributes

The exchange of measured quantity values, y, are supported in this standard using value, quantity, and duration attributes of objects within the information models. All value, quantity, and duration attributes defined in this standard may be subject to measurement uncertainty. When measurement uncertainty is required in the exchange, value, quantity, and duration attributes may contain the following sub-attributes:

* level of confidence;
* expanded uncertainty, U;
* coverage factor, k;
* precision of level of confidence; and
* accuracy of level of confidence.

NOTE 1 When a level of confidence attribute is required in the exchange, implementations can support the inclusion of one or more sets of values for the sub-attributes so that multiple levels of confidence can be exchanged for any given value, quantity, or duration attribute.

EXAMPLE Total capability of a piece of *equipment* has a y value of 100 widgets/hour. Two sets of uncertainty data are included in the exchange for each capability property value. One set has a level of confidence value of 95%, U value of 10 widgets/hour and k value of 2. The second set has a level of confidence value of 68%, U value of 5 widgets/hour and k value of 1. This information could be used in planning and scheduling in the development of possible and alternate schedules based on risk levels of 50%, 68% and 95%.

Measurement uncertainty for a measurand Y, can be expressed for a specified level of confidence in the following manner:

Y=y ±U

where

y is the measured quantity value

U is the expanded uncertainty

U=ku\_c (y)

where

k is the coverage factor

u\_c (y) is the combined standard uncertainty

NOTE 2 Metrology, the science of measurement and its application, recognizes that all values which are obtained via a process of measurement are subject to measurement uncertainty. Measurement in this context refers broadly to the method by which quantities are obtained that represent the properties of a phenomenon, body or substance, where the properties have a magnitude that can be expressed as a number and a reference.

NOTE 3 Definitions pertaining to the measurement uncertainty explanation:

1. measurand: quantity intended to be measured. [Source: ISO/IEC Guide 99, 2.3];
2. measured quantity value: value of a measured quantity. [Source: ISO/IEC Guide 99, 2.10];
3. measured value: quantity value representing a measurement result. [Source: ISO/IEC Guide 99, 2.10];
4. standard uncertainty: uncertainty of the result of a measurement expressed as a standard deviation. [Source: ISO/IEC Guide 99, 2.3];
5. measurement uncertainty: non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used. [Source: ISO/IEC Guide 99, 2.26];
6. combined standard uncertainty: standard uncertainty that is obtained using the individual standard measurement uncertainties associated with the input quantities in a measurement model. [Source: ISO/IEC Guide 99, 2.31];
7. expanded uncertainty: quantity defining an interval about the result of a measurement that can be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand. The fraction can be viewed as the coverage probability or level of confidence of the interval. [Source: ISO/IEC Guide 98-3, 2.3.5];
8. coverage probability: level of confidence probability that the set of true quantity values of a measurand is contained within a specified coverage interval. [Source: ISO/IEC Guide 99, 2.37]; and
9. coverage factor: numerical factor used as a multiplier of the combined standard uncertainty in order to obtain an expanded uncertainty. A coverage factor, k, is typically in the range 2 to 3. [Source: ISO/IEC Guide 98-3, 2.3.6].

NOTE 4 As specified in ISO/IEC Guide 98-3, the intended purpose of expanded uncertainty, U, is to provide an interval about the result of a measurement that can be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand. The choice of coverage factor k, which is usually in the range 2 to 3, is based on the coverage probability or level of confidence required of the interval.

NOTE 5 Practical methods for the expression of measurement uncertainty where the probability distribution function is asymmetric are provided in ISO/IEC Guide 98-3.

#### Unit of measure

This standard defines attributes for value, quantity, and duration where each has corresponding unit of measure attribute. The unit of measure is explicitly specified to ensure that it is not missed in information exchanges. Implementations of this standard can represent the unit of measure in the manner appropriate for the implementation.

# Common object models

## Hierarchy scope

The *hierarchy scope* identifies where the exchanged information fits within the role based equipment hierarchy. It defines the scope of the exchanged information, such as a site or area for which the information is relevant. The *hierarchy scope* identifies the associated instance in the role based equipment hierarchy.

The hierarchy scope as an object attribute is not needed if the context of the exchanged information can be determined based on the exchange mechanism used.

EXAMPLE 1 A *hierarchy scope* *c*an identify a Site, such as WEST-END. A *operations performance* can have a hierarchy scope attribute that identifies the WEST-END site.

EXAMPLE 2 A *hierarchy scope* can identify an Area within a Site, such as WEST-END/HOLDING-AREA. An *operations capability* can have a hierarchy scope attribute that identifies the area.

EXAMPLE 3 A *hierarchy scope* *c*an identify a WORK CENTER within an Area or Site, such as WEST-END/HOLDING-AREA/CHIPPING-BIN #1.

EXAMPLE 4 A *hierarchy scope c*an identify a WORK CENTER without an Area or Site identification because these are already known due to the exchange mechanism, such as CHIPPING-BIN #1.

EXAMPLE 5 *A* *hierarchy scope* can identify a complete hierarchy of Enterprise, Site, Area, Work Center.

Each *hierarchy scope* object defines one element in the equipment hierarchy. The *hierarchy scope* may be modeled using the model illustrated in Figure 5 in combination with Table 16 listing the relationships for *hierarchy scope*.

Table 17 listing the relationship roles for the *hierarchy scope* object.

Table 18 listing the attributes for the *hierarchy scope* object.

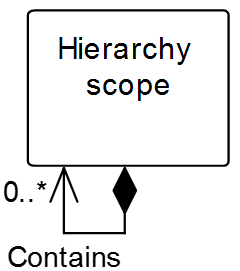


Figure 5 – Hierarchy scope model

Table 16 – Hierarchy scope relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Hierarchy scope | Hierarchy scope | Composition hierarchy | Contains |

Table 17 – Hierarchy scope relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Hierarchy scope | Hierarchy scope child | 0..\* | Contains | The child *hierarchy scope(s)* contained within this *hierarchy scope*. |

Table 18 – Hierarchy scope attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Equipment ID | A unique identification of an *equipment* element | WorkCenter23 | West End | Ajax | North Size |
| Equipment level | Identification of the *equipment level* if the *equipment* element is defined | Work Center | Site | Enterprise | Area |

## Spatial definition

The spatial definition provides a means of communicating 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid geospatial location data for planning/scheduling, actuals, resources, and analytics. Spatial definition identifies a value and the pre-defined coordinate reference system using following attributes:

1. value;
2. format;
3. spatial reference identifier (SRID); and
4. SRID authority.

A fully qualified spatial definition exchange has all 4 attributes as a minimum. In some information exchanges, sending and receiving applications may have a specified agreement on format, SRID, and SRID authority.

Spatial definition is distinct from and separate to storage location and physical location. Storage location attribute is defined for *material lots* and *material sublots* as a non-spatial definition of location. The physical location attribute logically identifies a “place” which is actual physical location of the *physical asset*.

NOTE The spatial definition attribute is not needed if there is no requirement for exchanging geospatial location information.

Table 19 lists the attributes for the spatial definition object.

Table 19 – Attributes of spatial definition

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Value | A string to uniquely identify a spatial definition.  EXAMPLE 1  UN/CEFACT CCTS: TextType) of the geospatial information in the format indicated in the format attribute. | lat="45.35" lon="24.15" | POINT (-1000 463 ) | POINT (3848472 96789 ) | POLYGON ( (-2594646.99104 11815676.18456, -2594645.14848 11815683.08856, -2594646.99104 11815676.18456 ) ) |
| Format | An enumerator that determines the format of the value attribute. | GPX | WKT | WKT | WKT |
| SRID | SRID is the Spatial Reference Identifier which identifies the coordinate reference system to identify a pre-defined coordinate reference system (pre-configured into communication systems).  An identifier from the SRID Authority. | 4326  (WGS84) | 5800  (Astra Minas) | 4269  (North American Datum 1983) | 6283  (Geocentric Datum of Australia 1994) |
| SRID authority | The *SRID authority* identifies the authority that defines the coordinate reference system identified by the *SRID*.  EXAMPLE 2  EPSG (see <http://www.epsg-registry.org/>).  An organization can choose to define its own SRIDs.  EXAMPLE 3  Reference its own authority. | EPSG | EPSG | EPSG | EPSG |

EXAMPLE 4 Format attribute options can include but are not limited to.

1. WKT (Well-known text): a text mark-up language defined by the open geospatial consortium (OGC) and used to represent vector geometry objects. WKT is defined in the ISO/IEC 13249-3:2011 standard, "Information technology – Database languages – SQL multimedia and application packages – Part 3: Spatial" (SQL/MM);
2. WKB (Well-known binary): a binary representation of WKT defined in the ISO/IEC 13249-3:2011 standard, "Information technology – Database languages – SQL multimedia and application packages – Part 3: Spatial" (SQL/MM);
3. GML (Geography markup language): GML defined by the Open Geospatial Consortium (OGC) and used to express geographical features. ISO 19136:2007 defines the OpenGIS® Geography Mark-up Language Encoding Standard (GML) or the Geography Markup Language (GML), version OGC 10-129r1;
4. KML (Keyhole markup language): KML Version 2.2 is defined by the Open Geospatial Consortium (OGC) and used for the visualization of geographic information;
5. GPX (GPS Exchange Format): GPX,1.1 schema is the primary format for working with GPS data from mobile devices. GPX was released on August 9, 2004;
6. GeoJSON: designed for representing simple geographical features based on JavaScript Object Notation (JSON). The current version is GeoJSON 1.0, 2008; and
7. SVG (Scalable Vector Graphics): SVG is an XML-based vector image format for two-dimensional graphics with support for interactivity and animation. The SVG specification is an open standard developed by the World Wide Web Consortium (W3C) since 1999. The current version is SVG 2.0;

The spatial definition attribute can represent a point, line, 2D or 3D polygon or 2D or 3D solid for any resource. The value attribute is used to uniquely identify a point, line, polygon or solid. The advantage over other more complex spatial definition approaches is that the spatial definition attribute relies on an external format.

EXAMPLE 5 Figure 6 is example of WKT in 2D (3D is equally supported). WKT is defined in the ISO/IEC 13249-3:2011 standard, "Information technology – Database languages – SQL multimedia and application packages – Part 3: Spatial" (SQL/MM).

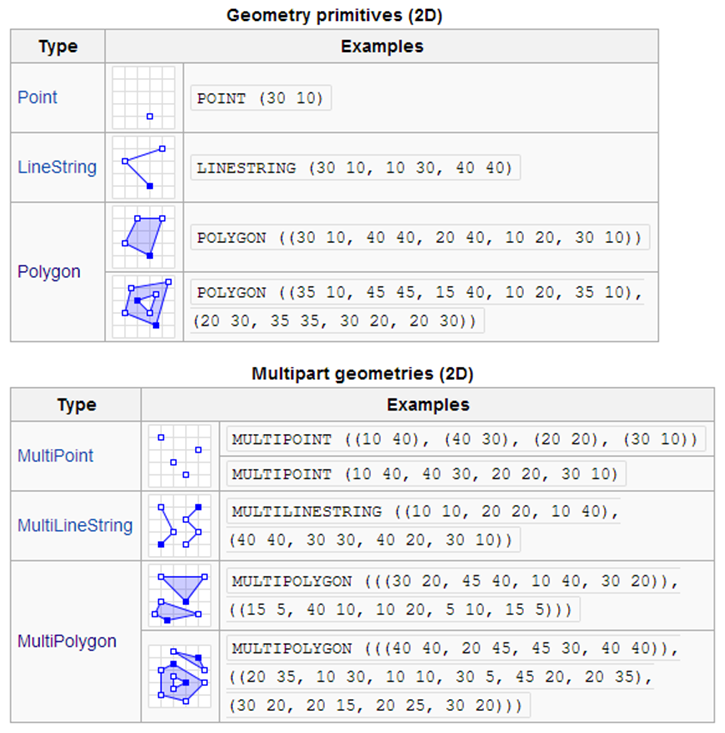


Figure 6 – Example, WKT in 2D (3D is equally supported)

## Operational location information

### Operational location model

*Operational locations* define the logical or physical places in which resources are located or are expected to be located within a plant. *Operational* *locations* may be made up of smaller *operational* *locations*. An *operational location* may belong to one or more *operational location classes*. An *operational* *location class* may be a specialization of one or more *operational* *location classes*.

The operational location model shown in Figure 7 contains the information about specific *operational* *locations* and classes of *operational* *locations*. Table 20 lists the relationships of the objects in the operational location model.

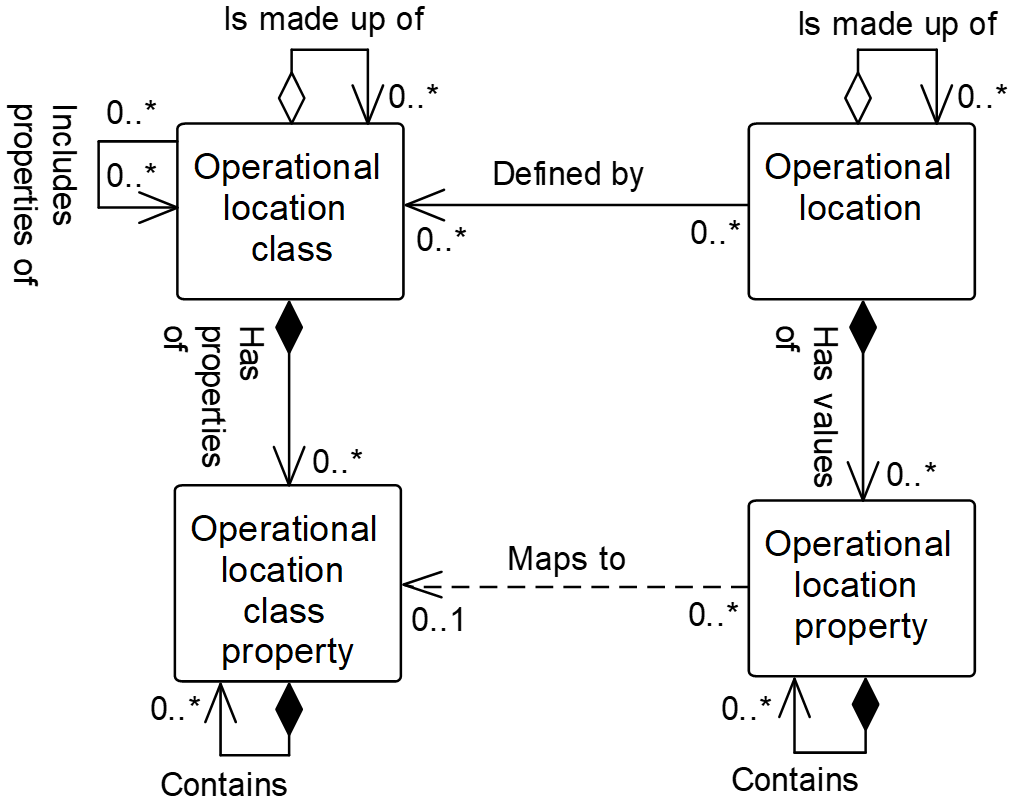


Figure 7 – Operational location model

Table 20 – Operational location model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operational location class | Operational location class | Aggregation hierarchy | Is made up of |
| Operational location class | Operational location class | Association | Includes properties of |
| Operational location class | Operational location class property | Composition whole | Has properties of |
| Operational location | Operational location class | Association | Defined by |
| Operational location | Operational location | Aggregation hierarchy | Is made up of |
| Operational location | Operational location property | Composition whole | Has values of |
| Operational location class property | Operational location class property | Composition hierarchy | Contains |
| Operational location property | Operational location property | Composition hierarchy | Contains |
| Operational location property | Operational location class property | Dependency | Maps to |

An *operational location* may specify a spatial definition attribute, which defines the position (0D) and/or boundaries (1D, 2D or 3D) of the *operational location*. A *material lot*, *material sublot*, *equipment*, *physical asset* or *person* may directly specify a spatial definition attribute, and/or it may have a corresponding *operational location*, which in turn may specify a spatial definition attribute.

Alternatively, a *material lot*, *material sublot, equipment*, *physical asset* or *person* may directly describe a location such as a street address instead of referencing an *operational location* object where it is not appropriate or required to define the location as an *operational location*.

A *material lot* or *material sublot* may specify an *equipment* or physical asset as its location instead of an *operational location*.

EXAMPLE 1 A *material lot* or *sublot* can be stored in a wagon, represented as a *physical asset*.

EXAMPLE 2 A *material lot* or *sublot* can be stored in a tank, represented as an element of *equipment*.

EXAMPLE 3 A *material lot* or *sublot* can be stored in a sample pickup location, represented as an *operational location*.

EXAMPLE 4 A *material lot* or *sublot* can have a storage location attribute containing a street address.

A resource capability, specification, segment specification, requirement or actual may reference an *operational location*, or may directly describe a location such as a street address for example. A *material capability*, *material* *specification*, *material* *segment specification*, *material* *requirement* or *material* *actual* may reference an *equipment* or *physical asset* instead of an *operational location* as a container per Clause 5.6.1 Containers.

### Operational location class

A representation of a grouping of *operational locations* with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability and performance shall be presented as an *operational location class*. Any *operational location* may be a member of zero or more *operational location classes*.

EXAMPLE *Operational location classes* can be a bin, hatch and stockpile footprint.

An *operational location class* may be defined as a specialization of zero or more *operational location classes*.

An *operational location class* may be made up of zero or more *operational location classes*.

Table 21 lists the relationship roles of the *operational location class*.

Table 22 lists the attributes of the *operational location class.*

Table 21 – Operational location class relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operational location class | Operational location class parent type | 0..\* | Includes properties of | This o*perational location class(s)* include properties of the *operational location class*. |
| Operational location class | Operational location class child | 0..\* | Is made up of | This parent *operational location class* is whole of the child *operational location class(s)* as the part. |
| Operational location class property | Operational location class property | 0..\* | Has properties of | The *operational location class property(s)* of this *operational location class.* |
| Operational location | NA | 0..\* | Defined by | The *operational location(s)* defined by this *operational location class.* |

Table 22 – Operational location class attributes

| Attribute Name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *location class*, within the *hierarchy scope* of the *operational location class*.  Required attribute. | SST | Shed.Maint | 3822 | WH |
| Description | Additional information about the *operational location class*. | Stainless Steel Tote | Maintenance Shed | Work Bench Shelf | Warehouse |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarch scope may define the scope of the *operational location class*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |

### Operational location class property

Properties of an *operational location class* shall be defined as *operational location class property(s)*. An *operational location class property* may contain nested *operational location class property(s).* An *operational location class property* may have zero or more *operational location property(s)* mapping to it.

Table 23 lists the relationship roles of the *operational location class property*.

Table 24 lists the attributes of the *operational location class property.*

Table 23 – Operational location class property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operational location class property | Operational location class property child | 0..\* | Contains | The child *operational location class property(s)* of this *operational location class property*. |
| Operational location class property | NA | 1 | Has properties of | The *operational location class property(s)* of this *operational location class.* |
| Operational location property | NA | 0..\* | Maps to | The *operational location property(s)* mapping to this *operational location class property*. |

Table 24 – Location class property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *operational location class property* within the operational location class.  Required attribute. | Capacity | Accessibility | Usage | Default Material |
| Description | Additional information about the *operational location class property*. | The storage capacity of the operational location | The accessibility of the operational location | How the operational location is used | Default material stored at the operational location |
| Value | The value, set of values, or range of the property. | n/a | n/a | n/a | n/a |
| Value unit of measure | The unit of measure of the associated property value. | n/a | n/a | n/a | n/a |
| Property type | Defines the type of the property. Defined types are   * class type: the property value is defined for the class and there is no value associated with an instance; * instance type: the property value of the class is undefined; and * default type: the property value is defined for the class as the default instance value, but individual instances of the class may redefine specific values. | Instance Type | Instance Type | Class Type | Default Type |

### Operational location

A logical or physical location where a *material lot*, *material sublot*, *equipment*, *physical asset* or *person* is located or expected to be located shall be presented as an *operational location*. *Operational locations* may be made up of other *operational locations*.

EXAMPLE O*perational locations* can include bin 28, hatch 3 and stockpile footprint A1.

Table 25 lists the relationships roles of an *operational location*.

Table 26 lists the attributes of an *operational location*.

Table 25 – Operational location relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operational location class | Operational location class | 0..\* | Defined by | The *operational location class(s)* to which this *operational location* belongs. |
| Operational location | Operational location child | 0..\* | Is made up of | The child *operational location(s)* contained within this *operational location*. |
| Operational location property | Operational location property | 0..\* | Has values of | The *operational location property(s)* of this *operational location.* |

Table 26 – Operational location attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *operational* *location*, within the *hierarchy scope* of the *operational location*.  Required attribute. | SST57 | Shed4S-8 | 3822 | WH1 |
| Description | Contains additional information and descriptions of the *operational location*. | Stainless Steel Tote #57 | Maintenance Shed 4S, Top Shelf | Work Bench 10, Top Shelf | Rake 23842A |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *operational location*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Spatial definition | Spatially defines the *operational location* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |

### Operational location property

Properties of *operational locations* shall be presented as *operational location properties.* An *operational location* shall have zero or more *operational location properties*. These specify the current property values of the *operational location* for the associated *operational location class property*. *Operational location properties* may include a unit of measure.

*Operational location properties* may contain nested o*perational location properties*.

Table 27 lists the relationship roles of an *operational location property*.

Table 28 lists the attributes of an *operational location property*.

Table 27 – Operational location property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operational location property | Operational location property child | 0..\* | Contains | The child *operational location property(s)* of this *operational location property*. |
| Operational location | NA | 1 | Has values of | This *operational location property(s)* of the *operational location.* |
| Operational location class property | Operational location class property | 0..1 | Maps to | The *operational location class property* to which this *operational location class property* maps. |

Table 28 – Operational location property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *operational location property* within the *operational location*.  Required attribute. | Capacity | Accessibility | Usage | Default Material |
| Description | Additional information about the *operational location property*. | The storage capacity of the operational location | The accessibility of the operational location | How the operational location is used | Default material stored at the operational location |
| Value | The value, set of values, or range of the property. | 180 | Unrestricted | Sample storage | Coarse ore |
| Value unit of measure | The unit of measure of the associated property value. | kT | n/a | n/a | n/a |

## Personnel information

### Personnel model

The personnel model shown in Figure 8 contains the information about specific p*ersonnel, classes* of *personne*l, and qualifications of *personnel*. Table 29 lists the relationships of the objects in the personnel model.

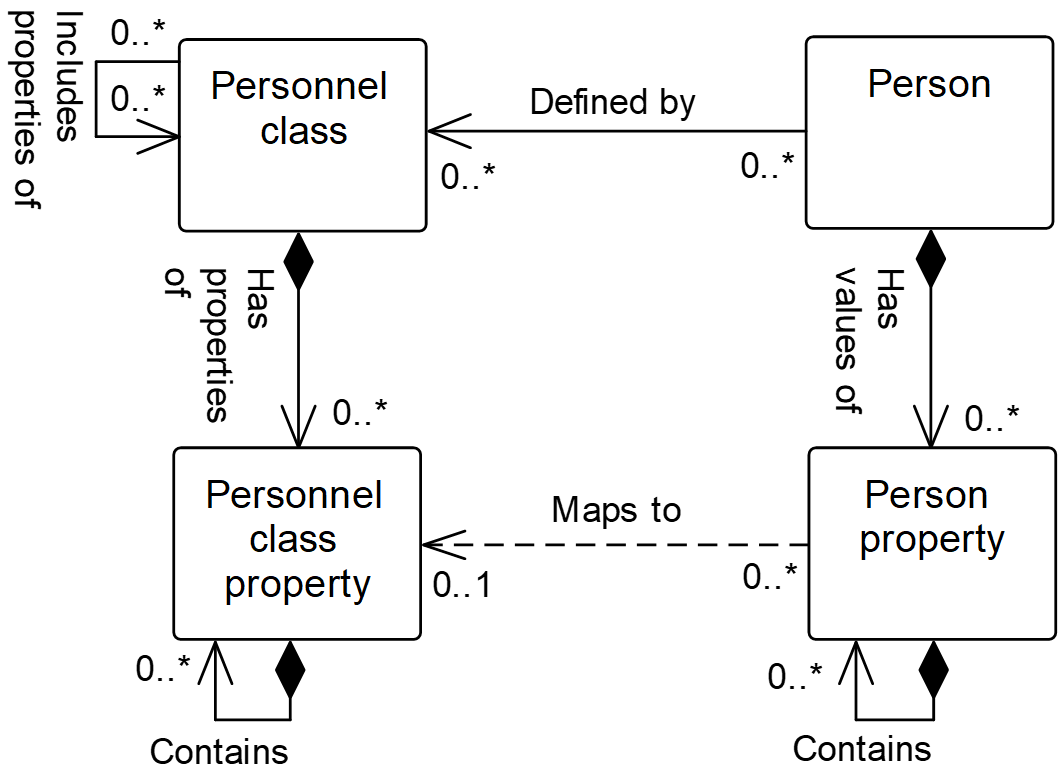


Figure 8 – Personnel model

To simplify Figure 8, the relationships between model objects and the *test specification, evaluated property,* *test result*, and *property measurement* objects are shown in Figure 16 – Operations test model and listed in Table 99 – Operations test requirement relationship roles.

Table 29 lists the model object relationships to *test specification, evaluated property,* *test result*, and *property measurement* objects. These relationships are shown in Figure 16 – Operations test model.

Table 29 – Personnel model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Personnel class | Personnel class property | Composition | Has properties of |
| Personnel class | Personnel class | Association | Includes properties of |
| Person | Personnel class | Association | Defined by |
| Person | Person property | Composition | Has values of |
| Person property | Personnel class property | Dependency | Maps to |
| Person property | Person property | Composition hierarchy | Contains |
| Personnel class property | Personnel class property | Composition hierarchy | Contains |
| Personnel class,  Person | Test specification | Association | Specifies |
| Test specification  Refer to Figure 16. | Personnel class,  person | Association | Specifies test for |
| Test result  Refer to Figure 16. | Personnel class,  person | Association | Records test results for |
| Evaluated property  Refer to Figure 16. | Personnel class property,  person property | Association | Corresponds to |
| Property measurement  Refer to Figure 16. | Personnel class,  person property | Association | Records measurement of |

### Personnel class

A representation of a grouping of persons with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability and performance shall be presented as a *personnel class*. Any *person* may be a member of zero or more *personnel classes*. A *personnel class* may be defined as a specialization of zero or more *personnel class*. A *personnel class* may be made up of zero or more *personnel class(s)*.

A *personnel class* may be tested by the evaluation of the *test specification criteria* in the *test specification* that references the *evaluated property* and may be recorded in an evaluated criterion result attribute in the *test result.*

Table 30 lists the relationship roles of the *personnel class*.

Table 31 lists the attributes of the *personnel class.*

EXAMPLE *Personnel classes* are cook machine mechanics, slicing machine operators, cat-cracker operator, and zipper line inspectors.

Table 30 – Personnel class relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Personnel class | Personnel class parent type | 0..\* | Includes properties of | This *personnel class(s)* include properties of the *personnel class*. |
| Personnel class property | Personnel class property | 0..\* | Has properties of | The *personnel class property(s)* of this *personnel class*. |
| Person | NA | 0..\* | Defined by | The *person* supports this *personnel class.*  The *person* objects support the *personnel class property(s)* associated with this *personnel class.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 31 – Personnel class attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| ID | A unique identification of a specific *personnel class*.  These are not necessarily job titles, but identify classes that are referenced in other parts of the model.  Required attribute. | Widget assembly operator | Maintenance Technician Grade 1 | Senior Lab Assistant | Warehouse Manager |
| Description | Additional information and description about the *personnel class*. | General information about widget assembly operators. | Highest grade for maintenance technician | Highest level of lab assistants | Person responsible for the warehouse |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *personnel class* definition, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |

### Personnel class property

Properties of a *personnel class* shall be presented as *personnel class properties.* Each *personnel class* shall have zero or more recognized properties.

EXAMPLE 1 *Personnel class properties* for the *personnel class* operators canbe a class 1 certified, class 2 certified, night shift, and exposure hours.

*Operations requests* may specify required *personnel class property* requirements for an *operations segment*.

A *personnel class property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may also be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.*

*Personnel class property(s)* may contain nested personnel class property(s).

Table 32 lists the relationship roles of the *person class property.*

Table 33 lists the attributes of the *personnel class property.*

Table 32 – Personnel class property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Descriptions |
| --- | --- | --- | --- | --- |
| Personnel class | NA | 1 | Has properties of | The *personnel class* defined in part by this *personnel class property.* |
| Personnel class property | Personnel class property child | 0..\* | Contains | The nested *personnel class property(s)* makes up part of this *personnel class property* as the whole. |
| Person property | NA | 0..\* | Maps to | If the *person s*upports a personnel class, this *personnel class property(s)* is applied in the *person property(s)*.  The *person property* maps to this corresponding *personnel class property.* |
| Evaluated property | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing the *evaluated property*. |
| Property measurement | NA | 0..\* | Records measurement of | The *property measurement* records the measurement result for this *testable object property*. |

Table 33 – Personnel class property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property, unique under the scope of the parent *personnel class* object.  Required attribute.  EXAMPLE 2  The property “*Has Class 1 Safety Training*” (with values of *Yes* or *No*) can be defined under several different *personnel class* definitions, such as fork lift operatorand pipe fitter classes, but has a different meaning for each class. | Class 1 Certified | Electrician Skills Class | LGC Model 1003 Certified Operator | Lift Truck Driver |
| Description | Additional information and description about the *personnel class property.* | Indicates the certification level of the operator. | Level of Skill Attained | Indicates if qualified to run equipment | Indicates if allowed to drive lift trucks |
| Property type | Defines the type of the property.  Defined types are   * class type: the property value is defined for the class and there is no value associated with an instance; * instance type: the property value of the class is undefined; and * default type: the property value is defined for the class as the default instance value, but individual instances of the class may redefine specific values. | Instance Type | Instance Type | Class Type | Default Type |
| Value | The value, set of values, or range of the property.  This presents a range of possible numeric values, a list of possible *values,* or it can be empty if any *value* is valid. | <True, False> | <Master, Journeyman, Apprentice> | <True, False> | <True, False> |
| Value unit of measure | The unit of measure of the associated property values. | Boolean | String | Boolean | Boolean |

### Person

A representation of a specifically identified individual shall be presented as a *person*. A *person* may be a member of zero or more *personnel classes*.

A *person* may be tested by the evaluation of the *test specification criteria* in the *test specification* that references the *evaluated property* and may be recorded in an evaluated criterion result attribute in the *test result.*

*Person* shall include a unique identification of the individual.

Table 34 lists the relationship roles of *person.*

Table 35 lists the attributes of *person.*

Table 34 – Person relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Related Object | Role | Multiplicity | Relationship Name | Description |
| Personnel class | Personnel class | 0..\* | Defined by | *Personnel classes* supported by this *person.*  This *person* supports the *personnel class property(s)* associated with the *personnel class.* |
| Person property | Person property | 0..\* | Has values of | The *person property* values of this *person.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 35 – Person attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *person*, within the scope of the information exchanged (*operations capability, operations schedule, operations performance*, …).  Required attribute.  The ID is used in other parts of the model when the *person* needs to be identified, such as the *operations capability* for this person, or a *operations response* identifying the person. | Employee 23 | 22828 | 999-123-4567 | 007 |
| Description | Additional information about the resource. | Person Information | Maintenance Tech | Lab Tech | Driver |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *person* definition. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Name | The name of the individual.  This is meant as an additional identification of the resource, but only as information and not as a unique value. | Jane | Jim | John | James |
| Spatial definition | Spatially defines the *person* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid, | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the *person*. | SST57 | Maintenance Shed 4S | Sample Pickup 3 | Waypoint 7 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |

NOTE A *person* can specify both a spatial definition and an operational location attribute where it is necessary to specify the spatial definition of a *person* within a given *operational location*.

### Person property

Properties of a *person* shall be presented as *person properties.* Each *person* shall have zero or more *person properties*. These specify the current property values of the *person* for the associated *personnel class property*.

EXAMPLE A *person property* can be night shift and its value would be available, and a *person property* can be exposure hours available and its value would be 4.

*Person properties* may include the current availability of a *person* and other current information, such as location and assigned activity, and the unit of measure of the current information.

A *person property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may also be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.* *Person properties* may contain nested *person properties*.

Table 36 lists the relationship roles of the *person property.*

Table 37 lists the attributes of the *person property.*

Table 36 – Person property relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Related Object** | **Role** | **Multiplicity** | **Relationship Name** | **Description** |
| Person | NA | 1 | Has values of | This *person property* values in part for the *person*. |
| Person property | Person property | 0..\* | Contains | This nested *person property(s)* is part of the *person property* as the whole. |
| Personnel class property | Personnel class property | 0..1 | Maps to | If the *person* supports the parent *personnel class*, the *personnel class property(s)* is applied in this *person property(s).*  This *person property* maps to the corresponding *personnel class property.* |
| Evaluated property  Refer to Figure 16. | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing the *evaluated property*. |
| Property measurement  Refer to Figure 16. | NA | 0..\* | Records measurement of | The *property measurement* records the measurement result for this *testable object property*. |

Table 37 – Person property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property.  Required attribute. | Exposure Hours Available | Union ID | LGC Model 1003 Certified Operator | Lift Truck Driver |
| Description | Additional information about the *person property*. | Indicates number of exposure hours available this month | Union ID number | Indicates if qualified to run equipment | Indicates if allowed to drive lift trucks |
| Value | The value, set of values, or range of the property.  The value(s) is assumed to be within the range or set of defined values for the related *personnel class property*. | 4 | CA55363 | True | False |
| Value unit of measure | The unit of measure of the associated property value. | Hours | String | Boolean | Boolean |

## Role based equipment information

### Role based equipment model

The role based equipment model shown in Figure 9 contains the information about specific *equipment*, and the classes of *equipment*. Table 38 lists the relationships of the objects in the role based equipment model.

The formal UML *role based equipment model* object is used to define the role based equipment hierarchy information that is defined in Part 1 of this standard. The model contains the information that may be used to construct the hierarchical models used in manufacturing scenarios. For purposes of corresponding to the Part 1 models, the defined equipment levels, specified in the equipment level attributes, for role based *equipment* are: enterprise, site, area, work center, work unit, process cell, unit, production line, production unit, work cell, storage zone, and storage unit.

NOTE The types of work centers can be extended as needed for application specific role based equipment hierarchies where the defined types do not apply. When a new type is added it usually maintains the same relationship within the hierarchy as the defined work center types (within an area and contains work units).

EXAMPLE 1 A laboratory can be an extended equipment level that defines a Work Center that includes all equipment in a test lab.

EXAMPLE 2 A maintenance storage center can be an extended equipment level that defines a Work Center that includes all *equipment* used by maintenance activities.

EXAMPLE 3 A Mobile Equipment Center can be a work center that includes all mobile *equipment* which can be used at different work centers or areas at different points in time.

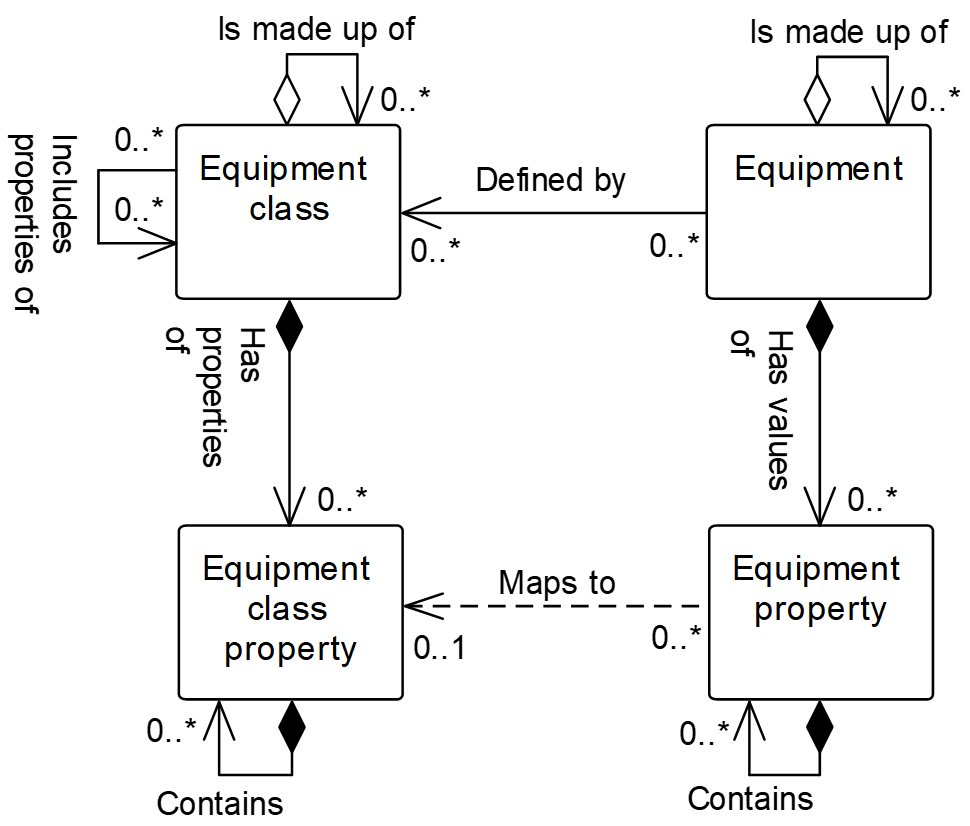


Figure 9 – Role based equipment model

To simplify Figure 9, the relationships between model objects and the *test specification, evaluated property,* *test result*, and *property measurement* objects are shown in Figure 16 – Operations test model and listed in Table 99 – Operations test requirement relationship roles.

Table 38 lists the model object relationships to *test specification, evaluated property,* *test result*, and *property measurement* objects.

Table 38 – Role based equipment model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Equipment class | Equipment class property | Composition | Has properties of |
| Equipment class | Equipment class | Association | Includes properties of |
| Equipment class | Equipment class | Aggregation hierarchy | Is made up of |
| Equipment | Equipment class | Association | Defined by |
| Equipment | Equipment property | Composition | Has values of |
| Equipment | Equipment | Aggregation hierarchy | Is made up of |
| Equipment property | Equipment class property | Dependency | Maps to |
| Equipment property | Equipment property | Composition hierarchy | Contains |
| Equipment class property | Equipment class property | Composition hierarchy | Contains |
| Equipment class,  equipment | Test specification | Association | Specifies |
| Test specification  Refer to Figure 16. | Equipment class,  equipment | Association | Specifies test for |
| Test result  Refer to Figure 16. | Equipment class,  equipment | Association | Records test results for |
| Evaluated property  Refer to Figure 16. | Equipment class property,  equipment property | Association | Corresponds to |
| Property measurement  Refer to Figure 16. | Equipment class property,  equipment property | Association | Records measurement of |

### Equipment class

A representation of a grouping of *equipment* with similar characteristics for a definite purpose such as manufacturing operations definition, scheduling, capability and performance shall be presented as an *equipment class*. Any piece of *equipment* may be a member of zero or more *equipment classes*. An *equipment class* may be defined as a specialization of zero or more *equipment classes*. An *equipment class* may be made up of zero or more *equipment classes*.

An e*quipment class* may be tested by the evaluation of the *test specification criteria* in the *test specification* that references the *evaluated property* and may be recorded in an evaluated criterion result attribute in the *test result.*

EXAMPLE *Equipment classes* can be a reactor unit, bottling line, and horizontal drill press.

Table 39 lists the relationship roles of the *equipment class.*

Table 40 lists the attributes of the *equipment class.*

Table 39 – Equipment class relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Equipment class | Equipment class parent type | 0..\* | Includes properties of | This *equipment class(s)* include properties of the *equipment class*. |
| Equipment class | Equipment class child | 0..\* | Is made up of | This parent *equipment class* is whole of the child *equipment class(s)* as the part. |
| Equipment class property | Equipment class property | 0..\* | Has properties of | The *equipment class property(s)* of this *equipment class*. |
| Equipment | NA | 0..\* | Defined by | The *equipment* objects support this *equipment class.*  The *equipment* objects support the *equipment class property(s)* associated with this *equipment class.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 40 – Equipment class attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *equipment class*, within the scope of the information exchanged (*operations capability*, *operations schedule*, *operations performance*, …)  Required attribute.  The ID is used in other parts of the model when the *equipment class* needs to be identified, such as the *production capability* for this *equipment class*, or a *operations response* identifying the *equipment class* used. | WJ6672892 | Welder | 5662AT | DR-FLT |
| Description | Additional information about the *equipment class*. | Jigs used to assemble widgets. | Welder to be signed out | Auto Titration Tester | Deep Reach Fork Truck |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *equipment class*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Equipment level | An identification of the level in the role based equipment hierarchy. | Production Line | Work Center | Site | Area |

### Equipment class property

Properties of an *equipment class* shall be presented as *equipment class properties.* Each may have zero or more recognized properties.

An *equipment class property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may also be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.* *Equipment class properties* may contain nested *equipment class properties*.

EXAMPLE *Equipment class properties* for the *equipment class* reactor unit can be lining material, BTU extraction rate, and volume.

Table 41 lists the relationship roles of the *equipment class property.*

Table 42 lists the attributes of the *equipment class property.*

Table 41 – Equipment class property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Descriptions |
| --- | --- | --- | --- | --- |
| Equipment class | NA | 1 | Has properties of | The *equipment class* defined in part by this *equipment class property*. |
| Equipment class property | Equipment class property child | 0..\* | Contains | The nested *equipment class property(s)* makes up part of this *equipment class property* as the whole. |
| Equipment property | NA | 0..\* | Maps to | If the parent *equipment* supports a *equipment class*, this *equipment class property(s)* is applied in the *equipment property(s).*  The *equipment property* maps to this corresponding *equipment class property.* |
| Evaluated property  Refer to Figure 16. | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing the *evaluated property*. |
| Property measurement  Refer to Figure 16. | NA | 0..\* | Records measurement of | The *property measurement* records the measurement result for this *testable object property*. |

Table 42 – Equipment class property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property.  Required attribute. | Template Size | Capacity | Resolution | Max Weight |
| Description | Additional information about the *equipment class property*. | Range of template sizes for widget machines. | Capacity of the welder | Minimum peak resolution | Maximum carrying weight for the truck |
| Property type | Defines the type of the property.  Defined types are   * class type: the property value is defined for the class and there is no value associated with an instance; * instance type: the property value of the class is undefined; and * default type: the property value is defined for the class as the default instance value, but individual instances of the class may redefine specific values. | Instance Type | Instance Type | Class Type | Default Type |
| Value | The value, set of values, or range of the property. | {10,20,30,40, 100,200,300} | {10..400} | {1 ..10} | {2 000 .. 36 000} |
| Value unit of measure | The unit of measure of the associated property value. | Cm | Amperes | ppm | Kg |

### Equipment

A representation of the elements of the equipment hierarchy model shown in ISA 95.00.01 shall be presented as *equipment*. *Equipment* may be a listing of any of the following: enterprise, site, area, work center, work unit, process cell, unit, production line, production unit, work cell, storage zone, and storage unit.

*Equipment* may be tested by the execution of the *test specification criteria* in the *test specification* that references the *evaluated property* and may be recorded in an evaluated criterion result attribute in the *test result.*

*Equipment* may be made up of other *equipment*, as presented in the equipment hierarchy model.

EXAMPLE 1 A production line can be made up of work cells.

EXAMPLE 2 A reactor can be made up of sensors, valves, an agitator, and level switches.

Table 43 lists the relationship roles of the *equipment.*

Table 44lists the attributes of the *equipment.*

Table 43 – Equipment relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Related Object | Role | Multiplicity | Relationship Name | Description |
| Equipment class | Equipment class | 0..\* | Defined by | *Equipment classes* supported by this *equipment.*  This *equipment* supports the *equipment class property(s)* associated with the *equipment class.* |
| Equipment property | Equipment property | 0..\* | Has values of | The *equipment property* values of this *equipment.* |
| Equipment | Equipment child | 0..\* | Is made up of | The related object(s) makes up part of this *equipment* as the whole. |
| Equipment asset mapping | NA | 0..\* | Records use of | The *equipment asset mapping* records the uses of the *equipment* that is associated with the *physical asset* if the *equipment* associated with a manufacturing function. |
| Physical asset | NA | 0..1 | Implemented by | This *equipment* as role in a *process segment* is implemented by the *physical asset.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 44 – Equipment attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific piece of *equipment*, within the scope of the information exchanged (manufacturing operations definition, scheduling, capability and performance).  Required attribute.  The equipment ID is used in other parts of the model when the *equipment* needs to be identified, such as the *operations capability* for a piece of equipment, or a *operations response* identifying the *equipment* used. | Jig 347 | Wldr445 | SN3883AT | VIN28203 |
| Description | Additional information about the *equipment.* | This is the east side, north building, widget jig. | Welder for north building | Floor 2 lab auto titrator | Shipping dock lift truck |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *equipment* definition, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Equipment level | An identification of the level in the role based equipment hierarchy. | Production Line | Work Center | Site | Area |
| Spatial definition | Spatially defines the *equipment* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the *equipment*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |

NOTE *Equipment* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of *equipment* within a given *operational location*.

### Equipment property

Properties of *equipment* shall be presented as *equipment properties.* An *equipment* shall have zero or more *equipment properties*. These specify the current property values of the *equipment* for the associated *equipment class property*.

*Equipment properties* may include a unit of measure.

An *equipment property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may also be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.* *Equipment property(s)* may contain nested *equipment properties*.

NOTE An *equipment property* can exist without an associated *equipment class property*, however all parties in an exchange will have to have a common understanding of the *equipment property*.

EXAMPLE 1 An *equipment class property* can be volume with a value of {10 000 – 50 000} with a unit of measure of liters, an *equipment property* can be volume with a value of 30 000 and a unit of measure of liters.

EXAMPLE 2 *Equipment properties* are

* other current information, such as when calibration is needed;
* maintenance status;
* the current state of the *equipment;* and
* performance values.

Table 45 lists the relationship roles of an *equipment property*.

Table 46 lists the attributes of an *equipment property.*

Table 45 – Equipment property relationships

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Equipment | NA | 1 | Has values of | These *equipment property* values in part for the *equipment.* |
| Equipment property | Equipment property child | 0..\* | Contains | The nested *equipment property(s)* makes up part of this *equipment property* as the whole. |
| Equipment class property | Equipment class property | 0..\* | Maps to | If the parent *equipment* supports an *equipment class*, the *equipment class property(s)* is applied in this *equipment property(s).*  This *equipment property* maps to the corresponding *equipment class property.* |
| Evaluated property  Refer to Figure 16. | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing the *evaluated property*. |
| Property measurement  Refer to Figure 16. | NA | 0..\* | Records measurement of | The *property measurement* records the measurement result for this *testable object property*. |

Table 46 – Equipment property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property.  Required attribute. | Run Rate | Capacity | Resolution | Max Weight |
| Description | Additional information about the *equipment property*. | Widget making average run rate | Capacity of the welder | Minimum peak resolution | Maximum carrying weight for the truck |
| Value | The value, set of values, or range of the property.  The *value(s*) is assumed to be within the range or set of defined values for the related *equipment property*. | 59 | {10-200} | 0,05 | 1 |
| Value unit of measure | The unit of measure of the associated property value. | Widgets/Hour | Amperes | % | Tons |

## Physical asset information

### Physical asset model

The physical asset model contains information about the physical piece of *equipment*, usually managed as a *physical asset* within the enterprise often utilizing a specific serial number. An object in the equipment model defines a role for the *equipment*, and object in the physical asset model defines the physical asset ID and properties of a piece of *equipment*.

EXAMPLE Equipment IDs can be represented as tag, which define a role such as TC184 for a temperature controller, while the temperature controller is an asset and has a serial number (TC\_WED\_9982002922).

NOTE 1 The *physical asset* can be replaced and in that case the tag will not change, but a new *physical asset* with a unique serial number will take the place of the old *physical asset*. Therefore, two separate ID’s would be used one for the role (equipment ID) and one for the *physical asset* (physical asset ID).

While assets have Level 4 significance, usually because they have an economic value, Part 2 of the standard focuses on the Level 3 significance of the asset. The physical asset model defines a *physical asset* as a representation of a physical piece of *equipment*.

Hierarchy levels in the physical asset hierarchy are not defined in Part 2 of the standard; however, the role-based equipment hierarchy names should be used if they are equivalent.

A representation of physical asset model is illustrated in Figure 10. Table 47 lists the relationships of the objects in the physical asset model.



Figure 10 – Physical asset model

To simplify Figure 10, the relationships between model objects and the *test specification, evaluated property,* *test result*, and *property measurement* objects are shown in Figure 16 – Operations test model and listed in Table 99 – Operations test requirement relationship roles.

Table 47 lists the model object relationships to *test specification, evaluated property,* *test result*, and *property measurement* objects.

Table 47 – Physical asset model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Physical asset class | Physical asset class | Aggregation hierarchy | Is made up of |
| Physical asset class | Physical asset class property | Composition | Has properties of |
| Physical asset class | Physical asset class | Association | Includes properties of |
| Physical asset | Physical asset | Aggregation hierarchy | Is made up of |
| Physical asset | Physical asset class | Association | Defined by |
| Physical asset | Physical asset property | Composition | Has values of |
| Physical asset property | Physical asset class property | Dependency | Maps to |
| Physical asset property | Physical asset property | Composition hierarchy | Contains |
| Physical asset class property | Physical asset class property | Composition hierarchy | Contains |
| Physical asset class,  Physical asset | Test specification | Association | Specifies |
| Test specification  Refer to Figure 16. | Physical asset class,  physical asset | Association | Specifies test for |
| Test result  Refer to Figure 16. | Physical asset class,  physical asset | Association | Records test results for |
| Evaluated property  Refer to Figure 16. | Physical asset class property,  physical asset property | Association | Corresponds to |
| Property measurement  Refer to Figure 16. | Physical asset class property,  physical asset property | Association | Records measurement of |

The relationship between the *physical asset* information and the *equipment* information is shown in Figure 11. Table 48 lists the relationships of the objects in the physical asset and equipment relationships model. There is a temporal relationship between the role of the *equipment* and the *physical asset*. The *physical asset* performing the role may change over time and the e*quipment asset mapping* maintains the association.

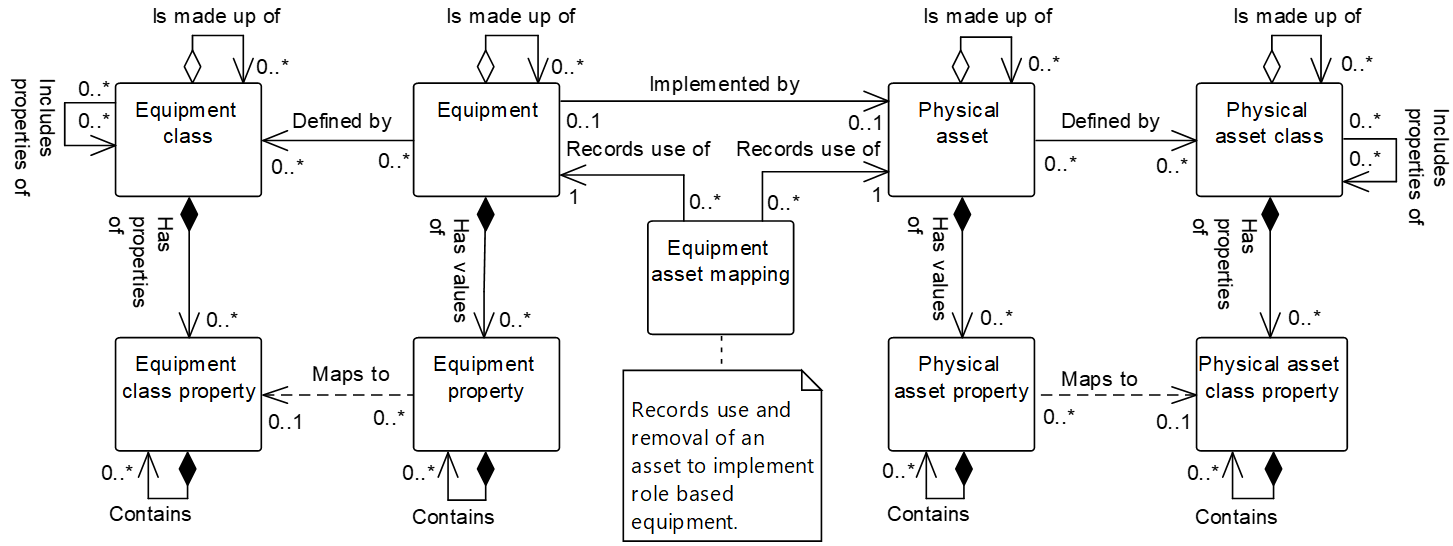


Figure 11 – Physical asset and equipment relationships

NOTE 2 This model shown in Figure 11 is consistent with the MIMOSA data models, but with various name differences due to their development history.

1. A MIMOSA asset element maps to a *physical asset* object.
2. A MIMOSA asset utilization history element maps to an *equipment asset mapping* object.
3. A MIMOSA segment element maps to an *equipment* object.
4. A MIMOSA model element maps to a *physical asset class* object.
5. A MIMOSA agent element would map to an attribute or property, where needed.

Table 48 – Physical asset and equipment relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Equipment asset mapping | Equipment | Association | Records use of |
| Equipment asset mapping | Physical asset | Association | Records use of |
| Equipment | Physical asset | Association | Implemented by |

### Physical asset class

A representation of a grouping of *physical assets* with similar characteristics for purposes of repair and replacement shall be presented as a *physical asset class*. Any *physical asset* shall be a member of one *physical asset class*. A *physical asset class* may be defined as a specialization of zero or more *physical asset classes*. A *physical asset class* may be made up of zero or more *physical asset classes*.

A *physical asset class* may be tested by evaluating the *test specification criteria* in the *test specification* that references the *evaluated property* and may be recorded in an evaluated criterion result attribute in the *test result.*

Table 49 lists the relationship roles of a *physical asset class*.

Table 50 lists the attributes of a *physical asset class*.

Table 49 – Physical asset class relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset class | Physical asset class parent type | 0..\* | Includes properties of | This *physical asset class(s)* include properties of the *physical asset class*. |
| Physical asset class | Physical asset class child | 0..\* | Is made up of | This parent *physical asset class* is whole of the child *physical asset class(s)* as the part. |
| Physical asset class property | Physical asset class property | 0..\* | Has properties of | The *physical asset class property(s)* of this *physical asset class.* |
| Physical asset | NA | 0..\* | Defined by | The *physical asset* objects support this *physical asset class.*  The *physical asset* objects support the *physical asset class property(s)* associated with this *physical asset class.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 50 – Physical asset class attributes

| Attribute Name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Manufacturer | An identification of the manufacturer. | Smith Pumps. | Jones Welders | Franz Testers | Chrysler Fleet Car |
| ID | The manufacture’s identification of the specific *physical asset class*.  Required attribute.  EXAMPLE  Model number | 2HPWP | HPWLDR 103 | ATT 99 | Series K |
| Description | Additional information about the *physical asset class*. | Pump | Welder | Instruments | Automobile |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *physical asset class*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |

### Physical asset class property

Properties of a *physical asset class* shall be presented as *physical asset class properties.* Each may have zero or more recognized properties.

A *physical asset class property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may also be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.*

*Physical asset class property(s)* may contain nested *physical asset class property(s)*.

Table 51 lists the relationship roles of a *physical asset class property*.

Table 52 lists the attributes of a *physical asset class property*.

Table 51 – Physical asset class property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset class | NA | 1 | Has values of | These *physical asset class property* values in part define the *physical asset class.* |
| Physical asset class property | Physical asset property class child | 0..\* | Contains | The nested *physical asset class property(s)* makes up part of this *physical asset class property* as the whole. |
| Physical asset property | NA | 0..\* | Maps to | If the parent *physical asset* supports a *physical asset class,* this *physical asset class property(s)* is applied in the *physical asset property(s).*  The *physical asset property* maps to the corresponding this *physical asset class property.* |
| Evaluated property  Refer to Figure 16. | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing the *evaluated property*. |
| Property measurement  Refer to Figure 16. | NA | 0..\* | Records measurement of | The *property measurement* records the measurement result for this *testable object property*. |

Table 52 – Physical asset class property attributes

| Attribute Name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property.  Required attribute. | Throughput | Weld Rate | Test Speed | Charge Time |
| Description | Additional information about the property. | Pump throughput | Maximum speed of welder | Average test rate | Hours to recharge truck |
| Property type | Defines the type of the property.  Defined types are   * class type: the property value is defined for the class and there is no value associated with an instance; * instance type: the property value of the class is undefined; and * default type: the property value is defined for the class as the default instance value, but individual instances of the class may redefine specific values. | Instance Type | Instance Type | Class Type | Default Type |
| Value | The value, set of values, or range of the property.  The value(s) is assumed to be within the range or set of defined values for the related *asset property*. | 400 | 5 | 1 315 | 5 |
| Value unit of measure | The unit of measure of the associated property value. | L / min | cm/s | Samples / Hour | Hours |

### Physical asset

A physical piece of equipment shall be presented as a *physical asset*.

A *physical asset* may be tested by the evaluation of the *test specification criteria* in the *test specification* that references the *evaluated property* and may be recorded in an evaluated criterion result attribute in the *test result.*

*Physical assets* may be made up of other *physical assets*.

EXAMPLE 1 A packaging line can be made up of conveyor sections, motors, and sensors.

Table 53 lists the relationship roles of a *physical asset*.

Table 54 lists the attributes of a *physical asset*.

Table 53 – Physical asset relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset class | Physical asset class | 0..\* | Defined by | *Physical asset classes* supported by this *physical asset.*  This *physical asset* supports the *physical asset class property(s)* associated with the *physical asset class.* |
| Physical asset property | Physical asset property | 0..\* | Has values of | The *physical asset property* values of this *physical asset*. |
| Physical asset | Physical asset | 0..\* | Is made up of | The related object(s) makes up part of this *physical asset* as the whole. |
| Equipment asset mapping | NA | 0..\* | Record use of | The *equipment asset mapping* records the uses of the *physical asset* that is associated with the *equipment* if the *physical asset* associated with a manufacturing function. |
| Equipment | NA | 0..1 | Implemented by | This *equipment* as role in a *process segment* is implemented by the *physical asset.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 54 – Physical asset attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a *physical asset*.  Required attribute. | SN5246$9 | SN68928#1 | SN5247$3 | VIN 55262528 |
| Description | Contains additional information and descriptions of the *physical asset*. | 2 HP Pump | High Performance Welder | Auto titration tester | Fork truck |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *physical asset* definition, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Fixed asset ID | Contains a unique identification for financial tracking as required by laws or regulations | 2000291 | 2000292 | 2000293 | 2000294 |
| Vendor ID | Contains a vendor’s serial number | AT55628 | 667y62 | W78GJ77 | H2228 |
| Spatial definition | Spatially defines the *physical asset* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Physical location | Identifies the physical location of the *physical asset*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Physical location type | Indicates whether the physical location attribute refers to an *operational* *location* object or contains a description of the physical location.  Mandatory where a physical location attribute is specified.  Defined values are   * operational location: physical location attribute references an *operational* *location*; * description: physical location attribute contains a description of the physical location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |

NOTE 1 A *physical asset* can specify both a spatial definition and a physical location attribute where it is necessary to specify the spatial definition of a *physical asset* within a given *physical location*.

EXAMPLE 2 Implementations can consider the following rules concerning the use of IDs:

1. The physical asset ID could be an enterprise wide identification.
2. If an information exchange is needed to handle assets across enterprises, then the ID could be a GUID (Globally Unique ID).
3. Common local practices can have other identifications of *physical assets* and additional correlated identifications represented as properties.

NOTE 2 Materials used in maintenance operations can be represented either in the *physical asset* model, in the material model, or in both. When represented in both models, the *IDs* used to identify the material in both models (material lot ID and physical asset ID) can be the same.

### Physical asset property

Properties of *physical assets* shall be presented as *physical asset properties.* A *physical asset* shall have zero or more *physical asset properties*. These specify the current property values of the *physical asset* for the associated *physical asset class property*. *Physical asset properties* may include a unit of measure.

A *physical asset property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may also be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.*

*Physical asset property(s)* may contain nested *physical asset property(s)*.

Table 55 lists the relationship roles of a *physical asset property*.

Table 56 lists the attributes of a *physical asset property*.

Table 55 – Physical asset property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset | NA | 1 | Has values of | These *physical asset property* values in part for the *physical asset.* |
| Physical asset property | Physical asset property child | 0..\* | Contains | The nested *physical asset property(s)* makes up part of this *physical asset property* as the whole. |
| Physical asset class property | Physical asset class property | 0..\* | Maps to | If the parent *physical asset* supports a *physical asset class,* the *physical asset class property(s)* is applied in this *physical asset property(s).*  This *physical asset property* maps to the corresponding *physical asset class property.* |
| Evaluated property  Refer to Figure 16. | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing the *evaluated property*. |
| Property measurement  Refer to Figure 16. | NA | 0..\* | Records measurement of | The *property measurement* records the measurement result for this *testable object property*. |

Table 56 – Physical asset property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property.  Required attribute. | Date of Manufacture | Assembly Drawing | Tracked Physical Asset | Tracked Physical Asset |
| Description | Additional information about the *asset property*. | Name plate date of production | Vendor assembly drawing ID | Indicates that the physical asset shall be signed out and tracked | Indicates the state of the physical asset |
| Value | The value, set of values, or range of the property.  The value(s) is assumed to be within the range or set of defined values for the related *asset property*. | 2008 10 | ACC08-55642 | <Tracked, Not Tracked,> | <Assigned, Issued, Available> |
| Value unit of measure | The unit of measure of the associated property value. | Date | String | Boolean | Boolean |

### Equipment asset mapping

The relationship between a *physical asset* and an *equipment* shall be presented as an *equipment asset mapping*.

The *equipment asset mapping* records the time period when one *equipment* object and one *physical asset* object were associated.

Table 57 lists the relationship roles of an *equipment asset mapping*.

Table 58 lists the attributes of an *equipment asset mapping*.

Table 57 – Equipment asset mapping relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Related Object | Role | Multiplicity | Relationship Name | Description |
| Equipment | Equipment | 1 | Records use of | The *equipment* performing the manufacturing function. |
| Physical asset | Physical asset | 1 | Records use of | The *physical asset* that is associated with the *equipment* if the *physical asset* associated with a manufacturing function. |

Table 58 – Equipment asset mapping attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *equipment asset mapping*.  Required attribute. | 111 | 112 | 113 | 114 |
| Description | Additional information about the *mapping* element. | (not applicable) | Installed under work order 48423.  Removed under work order 93823 | (not applicable) | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *physical asset class*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Start time | The starting time of the association. | 1997-02-10 | 1997-02-10 | 2004-04-23 | 2005-04-30 |
| End time | The ending time of the association. | 2004-12-10 | 2004-12-10 | (not applicable) | (not applicable) |

## Material information

### Material model

The material model shown in Figure 12 defines the *actual materials, material definitions*, and information about classes of *material definitions*. Material information includes the inventory of raw, finished, intermediate materials, and consumables. The information about planned or actual material is contained in the *material lot* and *material sublot* information. *Material classe*s are defined to organize materials. Table 59 lists the relationships of the objects in the material model.

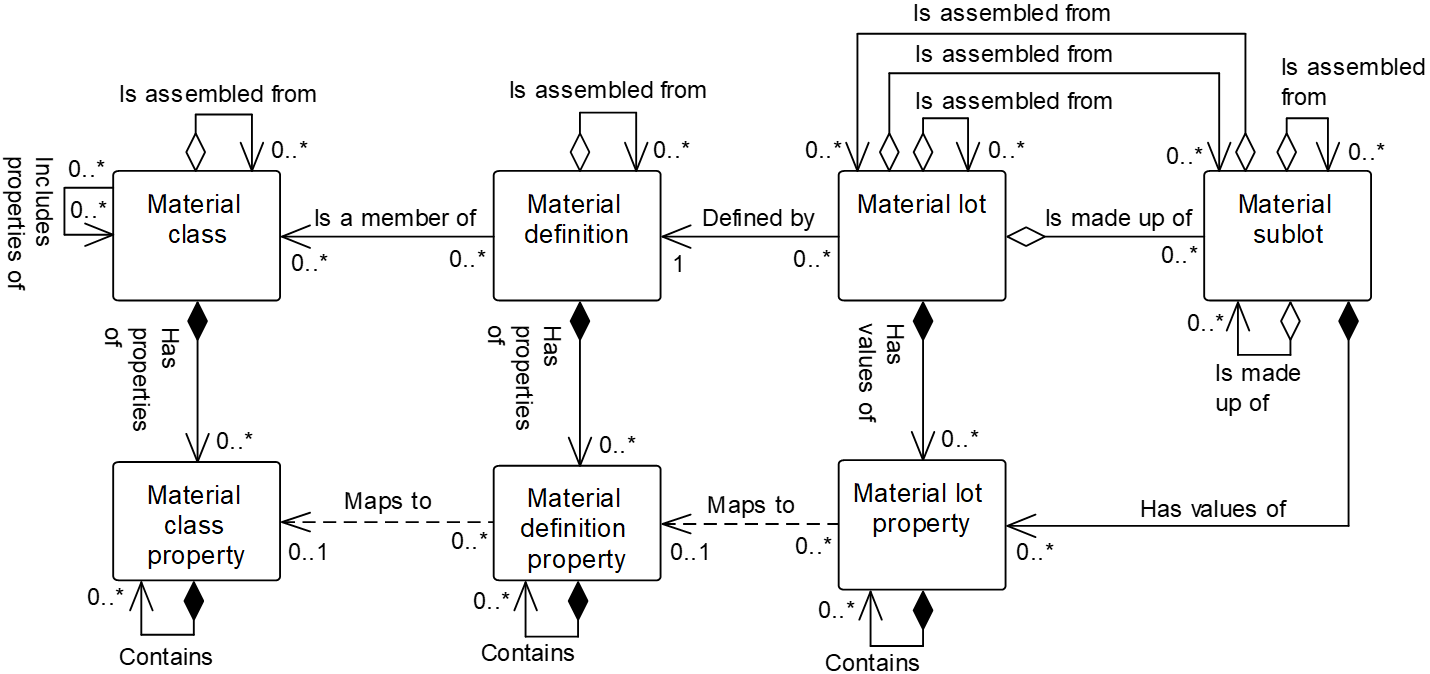


Figure 12 – Material model

NOTE 1 The material model corresponds to a resource model for *material*, as defined in ISO 10303.

To simplify Figure 12, the relationships between model objects and the *test specification, evaluated property,* *test result*, and *property measurement* objects are shown in Figure 16 – Operations test model and listed in Table 99 – Operations test requirement relationship roles.

Table 59 lists the model object relationships to *test specification, evaluated property,* *test result*, and *property measurement* objects.

Table 59 – Material model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Material class | Material class | Aggregation hierarchy | Is assembled from |
| Material class | Material class | Association | Includes properties of |
| Material class | Material class property | Composition | Has properties of |
| Material definition | Material definition | Aggregation hierarchy | Is assembled from |
| Material definition | Material class | Association | Is a member of |
| Material definition | Material definition property | Composition | Has properties of |
| Material lot | Material definition | Association | Defined by |
| Material lot | Material lot property | Composition | Has values of |
| Material lot | Material lot | Aggregation hierarchy | Is assembled from |
| Material lot | Material sublot | Aggregation hierarchy | Is assembled from |
| Material lot | Material sublot | Aggregation hierarchy | Is made up of |
| Material sublot | Material sublot | Aggregation hierarchy | Is assembled from |
| Material sublot | Material lot | Aggregation hierarchy | Is assembled from |
| Material sublot | Material sublot | Aggregation hierarchy | Is made up of |
| Material sublot | Material lot property | Composition | Has values of |
| Material definition property | Material class property | Dependency | Maps to |
| Material lot property | Material definition property | Dependency | Maps to |
| Material class property | Material class property | Composition hierarchy | Contains |
| Material definition property | Material definition property | Composition hierarchy | Contains |
| Material lot property | Material lot property | Composition hierarchy | Contains |
| Material class,  material definition,  material lot, and  material sublot. | Test specification | Association | Specifies |
| Test specification  Refer to Figure 16. | Material class,  material definition,  material lot, and  material sublot. | Association | Specifies test for |
| Test result  Refer to Figure 16. | Material class,  material definition,  material lot, and  material sublot. | Association | Records test results for |
| Evaluated property  Refer to Figure 16. | Material class property  material definition property,  material lot property, and  material sublot property. | Association | Corresponds to |
| Property measurement  Refer to Figure 16. | Material class property  material definition property,  material lot property, and  material sublot property. | Association | Records measurement of |

### Material class

A representation of groupings of *material definitions* for a definite purpose such as manufacturing operations definition, scheduling, capability and performance shall be presented as a *material class*. A *material definition* shall belong to zero or more *material classes*.

A *material class* may be defined as a specialization of zero or more material classes. A *material class* may be made up of zero or more *material classes*. A *material class* may be defined as follows by containing an assembly of *material classes* and as part of an assembly of *material classes*.

1. A *material class* may define an assembly of zero or more *material classes*.
2. A *material class* may be an assembly element of zero or more *material classes*.
3. An assembly may be defined as a permanent or transient assembly of *material classes*.
4. An assembly may be defined as physical or a logical assembly of *material classes*.

A *material class* may be tested by the evaluation of the *test specification criteria* in the *test specification* that references the *evaluated property* and may be recorded in an evaluated criterion result attribute in the *test result.*

EXAMPLE 1 A *material class* can be sweetener with members of fructose, corn syrup, and sugar cane syrup.

EXAMPLE 2 A *material class* can be water with members of city water, recycled water, and spring water.

Table 60 lists the relationship roles of a *material class*.

Table 61 lists the attributes of a *material class*.

Table 60 – Material class relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material class | Material class parent type | 0..\* | Includes properties of | This *material class(s)* include properties of the *material class*. |
| Material class | Material class child | 0..\* | Is assembled from | This parent *material class* is whole of the child *material class(s)* as the part. |
| Material class property | Material class property | 0..\* | Has properties of | The *material class property(s)* of this *material class*. |
| Material definition | NA | 0..\* | Is a member of | The *material definition* objects support this *material class.*  The *material definition* objects support the *material class property(s)* associated with this *material class.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 61 – Material class attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *material class*, within the scope of the information exchanged (*operations capability, operations schedule, operations performance*, …)  Required attribute.  The ID is used in other parts of the model when the *material class* needs to be identified, such as the *operations capability* for this *material class*, or a *operations response* identifying the *material class* used. | Polymer sheet stock 1001A | 200 cP Oil  (SAE 90) | RH5510 | 20 mil Wrap |
| Description | Additional information about the *material class*. | Solid polymer resin | Very High Viscosity Lubricating Oil | Oxidizing Agent | Wrap used to wrap pallets |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *material class*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Assembly type | Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area; * logical: the components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process; * transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit. | Permanent | Transient | Permanent | Transient |

A *material class* may be defined as follows by containing an assembly of *material classes* and as part of an assembly of *material classes*.

* 1. A *material class* may define an assembly of zero or more *material classes*.
  2. A *material class* may be an assembly element of zero or more *material classes*.
  3. An assembly may be defined as a permanent or transient assembly of *material classes*.
  4. An assembly may be defined as physical or a logical assembly of *material classes*.

### Material class property

Properties of a *material class* shall be presented as *material class properties.* A *material class* may define zero or more *material class properties*.

A *material class property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may also be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.*

*Material class property(s)* may contain nested *material class property(s)*.

EXAMPLE M*aterial class properties* include density, pH factor, and material strength.

The *material class properties* often list the nominal or standard values for the *material*. A *material property* value does not have to match the value of the corresponding *material class property*.

Table 62 lists the relationship roles of a *material class property* object.

Table 63 lists the attributes of a *material class property* object.

Table 62 – Material class property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Descriptions |
| --- | --- | --- | --- | --- |
| Material class | NA | 1 | Has properties of | The *material class* defined in part by this *material class property.* |
| Material class property | Class material class property | 0..\* | Contains | The nested *material class property(s)* makes up part of this *material class property* as the whole. |
| Material definition property | NA | 0..\* | Maps to | If the parent *material definition* supports a *material class,* this *material class property(s)* is applied in the *material definition property(s).*  The *material definition property* maps to this corresponding *material class property*. |
| Evaluated property  Refer to Figure 16. | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing the *evaluated property*. |
| Property measurement  Refer to Figure 16. | NA | 0..\* | Records measurement of | The *property measurement* records the measurement resultfor this *testable object property*. |

Table 63 – Material class property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a specific *material class property*.  Required attribute. | Polyethylene sheet thickness | Oil Viscosity | pH | Weight |
| Description | Additional information about the *material class property*. | Sheet Thickness | Coefficient of viscosity | Acidity | Weight to be added to shipping label |
| Property type | Defines the type of the property.  Defined types are   * class type: the property value is defined for the class and there is no value associated with an instance; * instance type: the property value of the class is undefined; and * default type; the property value is defined for the class as the default instance value, but individual instances of the class may redefine specific values. | Instance Type | Instance Type | Class Type | Default Type |
| Value | The value, set of values, or range of the property. | {5, 10, 25} | (not applicable) | {0..7} | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | mm | Pa-s | pH | g / m2 |

### Material definition

A representation of a material with similar characteristics for the purpose of manufacturing operations definition, scheduling, capability and performance shall be presented as a *material definition*.

A *material definition* may be tested by the evaluation of the *test specification criteria* in the *test specification* that references the *evaluated property* and may be recorded in an evaluated criterion result attribute in the *test result.*

EXAMPLE M*aterial definitions* can include city water, hydrochloric acid from Vendor A, and grade B aluminum.

Any *material lot* shall be associated with one *material definition*.

Table 64 lists the relationship roles of a *material definition.*

Table 65 lists the attributes of a *material definition.*

Table 64 – Material definition relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material definition | Material definition child | 0..\* | Is assembled from | This *material definition* is part of the related object as the whole. |
| Material definition property | Material definition property | 0..\* | Has properties of | The *material definition property(s)* of this *material definition.* |
| Material class | Material class | 0..\* | Is a member of | This *material definition* objects support this *material class*.  This *material definition* objects support the *material class property(s)* associated with the *material class.* |
| Material lot | NA | 0..\* | Defined by | The *material lot* occurrences that are constructed based on this *material definition.* The *material lot property(s)* map to a corresponding *material definition property*. |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 65 – Material definition attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *material definition*, within the scope of the information exchanged (*operations capability*, *operations schedule*, *operations performance*, …)  Required attribute.  The ID is used in other parts of the model when the *material definition* needs to be identified, such as the *operations capability* for this *material definition*, or a *operations response* identifying the *material definition* used. | Sheet stock 1443a | DO200cpO | OA9929 | PW882929 |
| Description | Additional information about the *material definition*. | General purpose sheet stock | 200 cP Oil from Dino Oil | Oxidizing Agent from RustItAll | General purpose 20 mil wrap |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *material definition*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Spatial definition | Spatially defines the *material definition* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid, | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Assembly type | Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area; * logical: the components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process; * transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit. | Permanent | Transient | Permanent | Transient |

A *material definition* may be defined as follows by containing an assembly of *material definitions* and as part of an assembly of *material definitions.*

1. A *material definition* may define an assembly of zero or more *material definitions*.
2. A *material definition* may be an assembly element of zero or more *material definitions*.
3. An assembly may be defined as a permanent or transient assembly of *material definitions*.
4. An assembly may be defined as physical or a logical assembly of *material definitions*.

### Material definition property

Properties of a *material definition* shall be presented as *material definition properties*. A *material definition* may define zero or more *material definition properties*.

A *material definition property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may also be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.*

*Material definition property(s)* may contain nested *material definition property(s)*.

EXAMPLE M*aterial definition property* can include density, pH factor, or material strength.

Properties may present the nominal or standard values for the material.

Table 66 lists the relationship roles of a *material definition property* object*.*

Table 67 lists the attributes of a *material definition property* object*.*

Table 66 – Material definition property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Descriptions |
| --- | --- | --- | --- | --- |
| Material definition | NA | 1 | Has properties of | The *material definition* defined in part by this *material definition property.* |
| Material definition property | Material definition property child | 0..\* | Contains | The nested *material definition property(s)* makes up part of this *material definition property* as the whole. |
| Material class property | Material class property | 0..1 | Maps to | If the parent *material definition* supports a *material class,* the *material class property(s)* is applied in the *material definition property(s).*  This *material definition property* maps to the corresponding *material class property.* |
| Material lot property | NA | 0..\* | Maps to | If the parent *material lot* supports a *material definition,* this *material definition property(s)* is applied in the *material lot property(s).*  The *material lot property* maps to this corresponding *material definition property*. |
| Evaluated property  Refer to Figure 16. | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing the *evaluated property*. |
| Property measurement  Refer to Figure 16. | NA | 0..\* | Records measurement of | The *property measurement* records the measurement result for this *testable object property*. |

Table 67 – Material definition property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *material definition property*.  Required attribute. | 1443a5mm | Oil viscosity | pH | Weight |
| Description | Additional information about the *material definition property*. | 5 mm sheet | Coefficient of viscosity | Acidity | Weight to be added to shipping label |
| Property type | Defines the type of the property.  Defined types are   * class type: the property value is defined for the material definition and there is no value associated with an instance; * instance type: the property value of the *material definition* is undefined; and * default type: the property value is defined for the *material definition* as the default instance value, but individual instances of the class may redefine specific values. | Instance Type | Instance Type | Class Type | Default Type |
| Value | The value, set of values, or range of the property. | {4,85 .. 5,15} | {250 × 10-3 .. 255 × 10-3} | {3.99 .. 4.01} | 20 .. 21 |
| Value unit of measure | The unit of measure of the associated property value. | Mm | Pa-s | pH | g / m2 |

### Material lot

A uniquely identified specific amount of *material*, either countable or weighable shall be presented as a *material lot*. A *material lot* describes the planned or actual total quantity or amount of material available, its current state, and its specific property values.

A *material lot* may be tested by the evaluation of a *test specification*.

A *material lot* shall include

1. the unique identification of the lot;
2. the amount of *material;*

EXAMPLE 1 Count, volume, weight, etc.

1. the unit of measure of the *material;*

EXAMPLE 2 Parts, liters, kg, etc.

1. the storage location for the *material*; and
2. any status of the lot.

A *material lot* may be made up of *material sublots*. *Material lots* and *material sublots* may be used for traceability when they contain unique identifications.

Table 68 lists the relationship roles of a *material lot.*

Table 69 lists the attributes of the *material lot.*

Table 68 – Material lot relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material lot | Material lot | 0..\* | Is assembled from | This *material lot* is part of the related object as the whole. |
| Material lot property | Material lot property | 0..\* | Has values of | The *material lot property(s)* of this *material lot*. |
| Material definition | Material definition | 1 | Defined by | The *material definition* that defines this *material lot.*  This *material lot* objects support the *material definition property(s)* associated with the *material definition.*  The *material lot* can act as a container for other objects where it does not have *material definition* association. |
| Material sublot | NA | 0..1 | Is made up of | The *material sublot* occurrences that are constructed based on this *material lot*. The *material sublot property(s)* map to a corresponding *material lot property*. |
| Material sublot | Material sublot | 0..\* | Is assembled from | This *material lot* is part of the related object as the whole. |
| Material sublot | NA | 0..1 | Is assembled from | *The related object(s)* makes up part of this *material lot* as the whole. |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 69 – Material lot attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *material lot*, within the scope of the information exchanged (*operations capability*, *operations schedule*, *operations performance*, …)  Required attribute.  The ID is used in other parts of the model when the *material lot* needs to be identified, such as the *operations capability* for this *material lot* or an *operations response* identifying the *material lot* used. | L66738-99 | L8828-81 | L53920-02 | L8626-33 |
| Description | Additional information about the *material lot.* | PlastiFab 10/31 shipment | Oil | Reagent | Wrapping material |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *material lot*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Spatial definition | Spatially defines the *material lot* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Storage location | Identifies the storage location of the *material lot*. | Work Center 1 | Maintenance Shed 4S | Work Bench 10, Top Shelf | Rake 23842A |
| Storage location type | Indicates whether the storage location attribute refers to an *operational location*, *equipment* or *physical asset* object, or contains a description of the storage location.  Mandatory where a storage location is specified.  Defined values are   * operational location: storage location attribute references an *operational location*; * equipment: storage location attribute references an *equipment* object; * physical asset; storage location attribute references a *physical asset*; and * description: storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Assembly type | Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area; * logical: the components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process; * transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit.   If *material lots* (or *sublots*) are merged or absorbed, then this is a new *material lot*.  EXAMPLE 3  A blended material lot. | Permanent | Transient | Permanent | Transient |
| Status | Status of the *material lot* in manufacturing operations. Values defined by implementation.  EXAMPLE 4  Released, approved, blocked, in process, and in quality check. | In process | approved | blocked | approved |
| Disposition | Planning and logistics disposition of a *material lot* or assembly of *material lots*.  Defined values for the *disposition* of a *material lot are*   * + - planned: a *material lot* that does not yet physically exist, is assigned to an *operations request* (*segment requirement*) or *work request* (Part 4 object) *or job order* (Part 4 object);     - in process: the *material lot* is in the process of being worked on;     - restricted: a *material lot* is not permitted for normal use due to a restriction condition.   EXAMPLE 5  A *material lot* can be awaiting a quality decision or a *material lot* can be physically inaccessible.   * + - unrestricted: *material lot* is permitted for normal use without restriction; and     - closed: *material lot* has been reconciled as completely consumed, sold or disposed of. | Planned | Unrestricted | Restricted | Closed |
| Quantity | The quantity of the *material lot.* | 1 200 | 20 | 1 | 41 |
| Quantity unit of measure | The unit of measure of the associated quantity. | sheets | Cans | Liter | Rolls |

NOTE 1 Representation of non-lot controlled items (e.g. Consumable *materials* or bulk *materials*) can be represented in the material lot model through the use of a unique IDs for each different *material definition*.

EXAMPLE 6 Material definition ID or a system assigned ID.

NOTE 2 If non-lot controlled items are maintained in multiple locations then the information can be represented in the material sublot model through the use of unique sublot IDs for each different location and *material definition*.

NOTE 3 A *material lot* can specify a spatial definition attribute in addition to a storage location attribute where it is necessary to specify the spatial definition of the *material lot* within the given storage location.

A *material lot* or a *material sublot* may be defined as follows by containing an assembly of *material lots* or *material sublots* and as part of an assembly of *material lots* or *material sublots*.

1. A *material lot* or a *material sublot* may define an assembly of zero or more *material lots* or *material sublots*.
2. A *material lot* or a *material sublot* may be an assembly element of zero or more *material lots* or a *material sublots*.
3. An assembly may be defined as a permanent or transient assembly of *material lots* or *material sublots*.

EXAMPLE 7 A transient assembly could be a temporary collection of *material* maintained as a batch kit on a pallet, the batch kit is identified with a unique identification and can contain specific properties, such as a pallet identification, location, and related batch ID.

EXAMPLE 8 A permanent assembly of *material* can be an automobile. The automobile has a unique vehicle identification number (VIN) and other properties. The automobile can contain an assembly of an engine, transmission, chassis, and wheels, each with their own unique identification and properties.

1. An assembly may be defined as physical or a logical assembly of *material lots* or *material sublots*. Assemblies of *materials* do not imply a manufacturing status.

EXAMPLE 9 A finished tractor is a physical assembly of *materials.*

EXAMPLE 10 An unassembled collection of tractor components that are separately shipped is a logical assembly of *materials.*

### Material lot property

Properties of a *material lot* shall be presented as *material lot properties*. Each *material* can have unique values for zero or more *material lot properties*, such as a specific pH value for the specific *material lot*, or a specific density for the *material lot*.

A *material lot property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.*

*Material lot property(s)* may contain nested *material lot property(s)*.

A *material lot property* is associated with either a *material lot* or a *material sublot*. When associated with a *material lot* it specifies a property value for all *material sublots*, when associated with a *material sublot* it specifies a property value for a single *material sublot*.

Table 70 lists the relationship roles of a *material lot property.*

Table 71 lists the attributes of *material lot property.*

Table 70 – Material lot property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Descriptions |
| --- | --- | --- | --- | --- |
| Material lot | NA | 1 | Has values of | The *material lot* defined in part by this *material lot property.* |
| Material sublot | NA | 1 | Has values of | The *material sublot* defined in part by this *material lot property.*  If this *material lot property* is part of a *material lot,* this value is not used. |
| Material lot property | Material lot property child | 0..\* | Contains | The nested *material lot property(s)* makes up part of this *material* *lot property* as the whole. |
| Material definition property | Material definition property | 0..1 | Maps to | If the parent *material lot* supports a *material definition*, the *material definition property(s)* is applied in the *material lot property(s).*  This *material lot property* maps to the corresponding *material definition property.* |
| Evaluated property  Refer to Figure 16. | NA | 1 | Corresponds to | This *testable object property* is measured to the *test specification* containing this *evaluated property*. |
| Property measurement  Refer to Figure 16. | NA | 0..\* | Records measurement of | The *property measurement* records the measurement result for this *testable object property*. |

Table 71 – Material lot property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *material lot property*.  Required attribute. | Average sheet thickness | Oil Viscosity | pH | Weight |
| Description | Additional information about the *material lot property*. | Measured thickness | Coefficient of viscosity | Acidity | Weight to be added to shipping label |
| Value | The value, set of values, or range of the property. | 5,002 | 250 × 10-3 | 4,01 | 20,3 |
| Value unit of measure | The unit of measure of the associated property value. | mm | Pa-s | pH | g / m2 |

### Material sublot

Each separately identifiable quantity of the same *material lot* shall be presented as a *material sublot*. A *material lot* may be stored in separately identifiable quantities. All *material sublots* are part of the same *material lot*, so they have the *material lot’s* property values. A *material sublot* may be just a single item.

*Material sublots* may have sublot specific properties.

A *material sublot property* may be tested to the *evaluated property* in a *test specification* where the measured results may be recorded in a *property measurement* attribute in a *test result*. The measured results may be evaluated to the *test specification criteria* in the *test specification* that references the *evaluated property* where they may be recorded in an evaluated criterion result attribute in the *test result.*

*Material sublot property(s)* may contain nested *material sublot property(s)*.

EXAMPLE 1 *Material sublot properties* can be RFID tag IDs or other identification properties, such that each *material sublot* has a different property value.

Each *material sublot* shall contain the location of the *material sublot* and the quantity or amount of *material* available in the *material sublot*.

*Material sublots* may contain other *material sublots*.

EXAMPLE 2 A *material sublot* can be a pallet, each box on the pallet can also be a sublot, and each *material* blister pack in the box can also be a *material sublot*.

A *material sublot* shall include

1. a unique identification of the *material sublot*,
2. the storage location of the *material sublot*,
3. the unit of measure of the material, and

EXAMPLE 3 Parts, kg, tons, etc.

1. any status of the *material sublot*.

Table 72 lists the relationship roles of the *material sublot*.

Table 73 lists the attributes of a *material sublot*.

Table 72 – Material sublot relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material sublot | Material sublot child | 0..\* | Is made up of | This *material sublot* is part of the related object as the whole. |
| Material lot property | Material lot property | 0..\* | Has values of | The *material lot property(s)* of this *material sublot.* |
| Material sublot | Material sublot | 0..\* | Is assembled from | The *material sublot* occurrences that are constructed based on this *material sublot*. The *material sublot properties* map to a corresponding *material lot property*. |
| Material lot | NA | 0..1 | Is assembled from | This *material lot* is part of the related object as the whole. |
| Material lot | Material lot | 0..\* | Is assembled from | The related object(s) makes up part of this *material sublot* as the whole. |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Test result  Refer to Figure 16. | NA | 0..\* | Records test results for | The *test result* records the evaluated criterion result attributeand *property measurement* for this *testable object*. |

Table 73 – Material sublot attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *material sublot,* within the scope of the information exchanged (*operations capability, operations schedule, operations performance* …)  Required attribute.  The ID is used in other parts of the model when the *material sublot* needs to be identified, such as the *operations capability* for this *material sublot*, or an *operations response* identifying the *material sublot* used. | 1999-10-27-a67-B6653 | L8828-81-S1 | L53920-02-A554 | L8626-33-2 |
| Description | Additional information about the *material sublot*. | Pallet 2 of 6 | Oil | Reagent | Wrapping material |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *material sublot*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Spatial definition | Spatially defines the *material sublot* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. 1 | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Storage location | Identifies the storage location of the *material sublot*. | Stainless Steel Tote #57 | Maintenance Shed 4S, Top Shelf | Work Bench 10, Top Shelf | Warehouse 1 |
| Storage location type | Indicates whether the storage location attribute refers to an *operational location*, *equipment* or *physical asset* object, or contains a description of the storage location.  Mandatory where a storage location is specified.  Defined values are   * operational location: storage location attribute references an *operational location*; * *equipment:* storage location attribute references an *equipment* object; * *physical asset:* storage location attribute references a *physical asset*; and * description: storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Assembly type | Defines the type of the assembly.  Defined types are:  Physical – The components of the assembly are physically connected or in the same area.  Logical – The components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process; * transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit.   If *material lots* (or *sublots*) are merged or absorbed, then this is a new *material lot*.  EXAMPLE 4  A blended material lot. | Permanent | Transient | Permanent | Transient |
| Status | Status of the current *material sublot*.  EXAMPLE 5  Released, approved, blocked, in process, and in quality check. | Released | approved | blocked | Approved |
| Disposition | Defines the *material sublot* disposition types of a *material sublot* or assembly of *material sublots*.  Defined values for the disposition of a *material sublot are*   * planned: a *material sublot* that does not yet physically exist, is assigned to an *operations request* *(segment requirement*) or *work request* *(job order*); * in process: the *material sublot* is in the process of being worked on; * restricted: a *material sublot* is not permitted for normal use due to a restriction condition;   EXAMPLE 6  A *material sublot* can be awaiting a quality decision or a *material sublot* can be physically inaccessible.   * unrestricted: a *material sublot* is permitted for normal use without restriction; and * closed: a *material sublot* has been reconciled as completely consumed, sold or disposed of. | Planned | Unrestricted | Restricted | Closed |
| Quantity | The quantity of the *material sublot.* | 40 | 10 | 1 | 41 |
| Quantity unit of measure | The unit of measure of the associated quantity. | sheets | Cans | Liter | Rolls |

NOTE A *material sublot* can specify a spatial definition attribute in addition to a storage location attribute where it is necessary to specify the spatial definition of the *material sublot* within the given storage location.

### Assemblies

Assemblies are collections or sets of related elements. Assemblies are represented as relationships between elements and attributes of the elements. Each assembly element has its own identity and properties, such as a *material lot* which has its own identity and properties. An object with an assembly (*material lot, material sublot*, *material class*, and *material definition*) shall contain the list of other elements that make up the assembly.

NOTE Many assembly type industries, such as automobile manufacturing, airplane assembly, and furniture manufacturing can use the concept of assemblies. A produced *material* with a unique identification and properties can be made up of other *materials* with their own unique identification and properties.

In applying assemblies to resource objects, the associated child objects shall be identified as the values of attributes under the parent resource object.

Assembly relationship applies to the following resource objects: *material lot, material sublot, material definition, material class, material requirement, material actual, material segment specification, operations material bill item,* and *material capability*.

In applying assemblies to resource objects, the assembly type and the assembly relationship attributes for the associated parent resource object shall apply to the parent object and its specified set of children resource objects at the time of the data exchange.

EXAMPLE 1 An “automobile” is a *material lot*, with specific properties (color, VIN #, make, model …) while it also contains other chassis parts (engine, transmission, axles …) that also have their own unique identification and properties.

EXAMPLE 2 A transaxle in an automobile has its own identification and is an assembly of subcomponents, including seals, bearing, axle shaft, etc., as shown in Figure 13. There can be an assembly which defines a specific model of transmission described in a *material definition assembly*, and there can be an assembly that defines a specific transmission described in a *material assembly*.

EXAMPLE 3 A “batch kit” is an assembly that contains a collection of different *materials* that would be used in the production of a batch, e.g. a batch kit for a soup can contain the seasonings that are used in production of a single batch. There can be an assembly which defines the class of materials used in a batch kit described in a *material class assembly*, and there can be a batch specific assembly which defines specific *material lots* or *material sublots* described in a *material assembly*.

EXAMPLE 4 Where production creates a *material lot* that is an assembly of two other *material lots*, the *material actuals* for the produced *material lot* are reported as an assembly of *material lot*s. The *segment response* in the *operations response* message contains three *material actuals*.

1. Produced *material lot* with quantity produced;
2. One each of the two *material lots* consumed with quantity consumed from each lot.



Figure 13 – Example, material with an assembly

## Process segment information

### Process segment model

*Process segments* are the smallest elements of manufacturing activities that are visible to business processes. The process segment model is a hierarchical model, in which multiple levels of abstraction of manufacturing processes may be defined because there can be multiple business processes requiring visibility to manufacturing activities.

NOTE 1 The term, business process segment*,* is a synonym for *process segment* and can be used to reflect the business process aspect of the *process segment.*

*Process segments* are also logical grouping of personnel resources, equipment resources, physical asset resource and material required to perform a manufacturing operations step. A *process segment* defines the needed classes of *personnel, equipment, physical assets*, and *material*, and/or it may define specific resources, such as specific *equipment* needed. A *process segment* may define the quantity of the resource needed.

The manufacturing operations step may be a production operations step, inventory operations step, maintenance operations step, and quality operations step. Figure 14 is the *process segment* model. Table 74 lists the relationships of the objects in the process segment model.

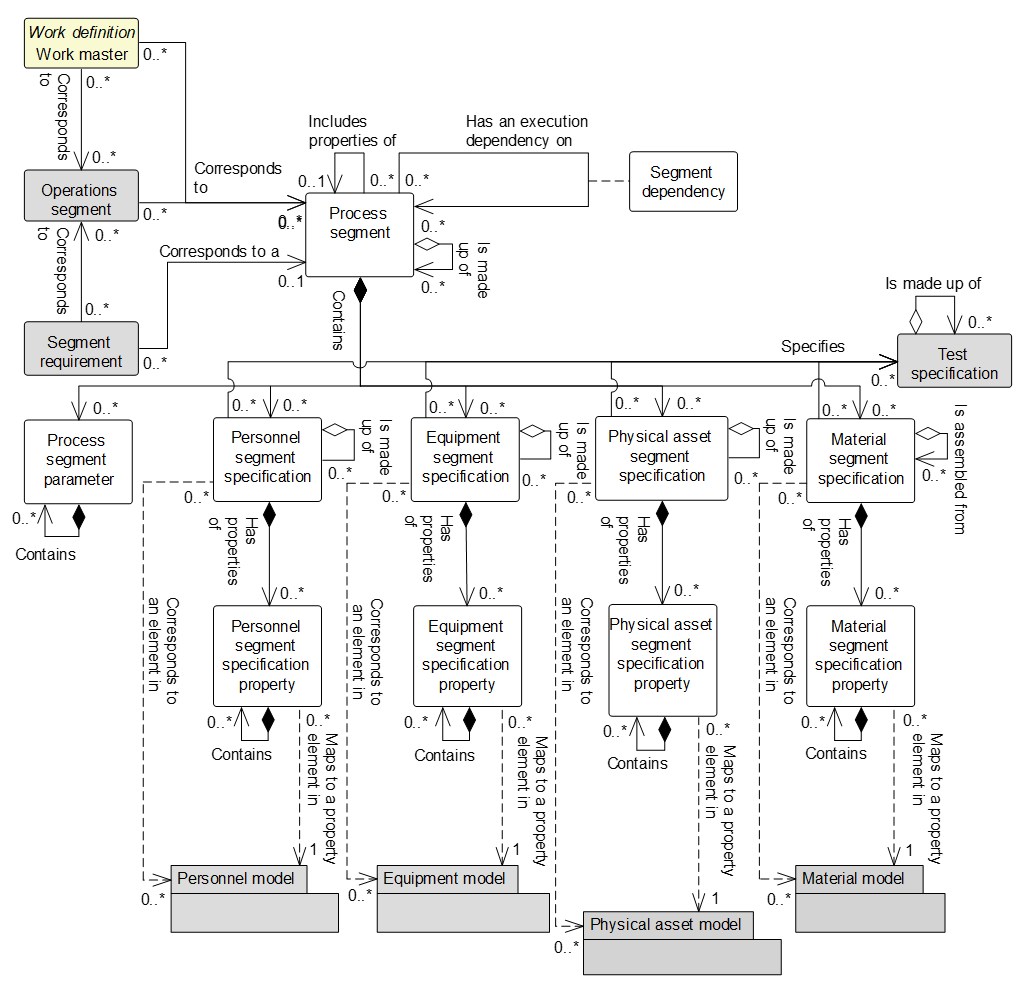


Figure 14 – Process segment model

To simplify Figure 14, the relationships between the resource segment specification objects and *test specification* are shown but not their relationships to the *test result*. For the complete contextual view of the information model, Table 74 lists the all relationships between the resource segment specification objects and *test specification* and *test result* with all relationship roles defined in each object subclause in their relationship role table.

All relationships to *test specification* and *test result* are shown in Figure 16 – Operations test model and listed in Table 99 – Operations test requirement relationship roles.

NOTE 2 The work definition model and its *work master* object are defined in Part 4 of this standard.

NOTE 3 The object color convention used in the Part 2 and Part 4 UML diagrams for this information model is as shown in Clause 3.3.3.

Table 74 – Process segment model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Process segment | Process segment | Aggregation hierarchy | Is made up of |
| Process segment | Process segment | Association | Includes properties of |
| Process segment | Work master | Association | Corresponds to |
| Process segment | Process segment | Association class with *segment dependency* | Has an execution dependency on |
| Segment dependency | Process segment | Association class with *segment dependency* | Has an execution dependency on |
| Operations segment | Process segment | Association | Corresponds to |
| Work master (Defined in Part 4) | Process segment | Association | Corresponds to |
| Process segment | Process segment parameter | Composition whole | Contains |
| Process segment | Personnel segment specification | Composition whole | Contains |
| Process segment | Equipment segment specification | Composition whole | Contains |
| Process segment | Physical asset segment specification | Composition whole | Contains |
| Process segment | Material segment specification | Composition whole | Contains |
| Process segment parameter | Process segment parameter | Composition hierarchy | Contains |
| Personnel segment specification,  equipment segment specification,  physical asset segment specification, and  material segment specification. | Test specification  Refer to Figure 16. | Association | Specifies |
| Test specification  Refer to Figure 16. | Personnel segment specification,  equipment segment specification,  physical asset segment specification, and  material segment specification. | Association | Specifies test for |
| Test result  Refer to Figure 16. | Personnel segment specification,  equipment segment specification,  physical asset segment specification, and  material segment specification. | Association | Generated in context of |
| Personnel segment specification | Personnel segment specification | Aggregation hierarchy | Is made up of |
| Personnel segment specification | Personnel segment specification property | Composition whole | Has properties of |
| Personnel segment specification property | Personnel segment specification property | Composition hierarchy | Contains |
| Personnel segment specification | Personnel class | Association (A) | Corresponds to |
| Personnel segment specification | Person | Association (C) | Corresponds to |
| Personnel segment specification property | Personnel class property | Dependency (B) | Maps to |
| Personnel segment specification property | Person property | Dependency (D) | Maps to |
| Equipment segment specification | Equipment segment specification | Aggregation hierarchy | Is made up of |
| Equipment segment specification | Equipment segment specification property | Composition whole | Has properties of |
| Equipment segment specification property | Equipment segment specification property | Composition hierarchy | Contains |
| Equipment segment specification | Equipment class | Association (A) | Corresponds to |
| Equipment segment specification | Equipment | Association (C) | Corresponds to |
| Equipment segment specification property | Equipment class property | Dependency (B) | Maps to |
| Equipment segment specification property | Equipment property | Dependency (D) | Maps to |
| Physical asset segment specification | Physical asset segment specification | Aggregation hierarchy | Is made up of |
| Physical asset segment specification | Physical asset segment specification property | Composition whole | Has properties of |
| Physical asset segment specification property | Physical asset segment specification property | Composition hierarchy | Contains |
| Physical asset segment specification | Physical asset class | Association (A) | Corresponds to |
| Physical asset segment specification | Physical asset | Association (C) | Corresponds to |
| Physical asset segment specification property | Physical asset class property | Dependency (B) | Maps to |
| Physical asset segment specification property | Physical asset property | Dependency (D) | Maps to |
| Material segment specification | Material segment specification | Aggregation hierarchy | Is assembled from |
| Material segment specification | Material segment specification property | Composition whole | Has properties of |
| Material segment specification property | Material segment specification property | Composition hierarchy | Contains |
| Material segment specification | Material class | Association (A) | Corresponds to |
| Material segment specification | Material definition | Association (A) | Corresponds to |
| Material segment specification | Material lot | Association (C) | Corresponds to |
| Material segment specification | Material sublot | Association (C) | Corresponds to |
| Material segment specification property | Material class property | Dependency (B) | Maps to |
| Material segment specification property | Material definition property | Dependency (B) | Maps to |
| Material segment specification property | Material lot property | Dependency (D) | Maps to |

### Process segment

A *process segment* lists the classes of *personnel, equipment, physical assets*, and *material needed*, and/or it may present specific resources, such as specific *equipment* needed for the *process segment*. A *process segment* may list the quantity of the resource needed.

A *process segment* is something that occurs or can occur during manufacturing operations.

*Process segment* may identify

1. the time duration associated with the resource;

EXAMPLE 1 Five hours or 5 h/100 kg.

1. constraint rules associated with ordering or sequencing of segments; and
2. a *process segment* may be made up of other *process segments*, in a hierarchy of definitions.

*Process segments* may contain specifications of specific resources required by the *process segment*. *Process segments* may contain parameters that can be listed in specific *operations requests*.

A *process segment* may be a specialization of another *process segment*. A *process segment* shall be defined as a “pattern” or an “instance”. A pattern *process segment* defines a ‘template’, upon which other pattern or instance *process segments* may be based. Unlike instance *process segments*, pattern *process segments* shall not be directly scheduled or tracked. Therefore, *segment requirements*, *segment responses* and *process segment capabilities* shall not reference pattern *process segments*.

Where a *process segment* references a *work master*, the definition type (pattern or instance) of the referenced *work master* shall have the same value as that of the *process segment*.

The *parameter, personnel, equipment, physical asset* and *material specifications* of a *process segment* may map to those of any pattern *process segment* upon which the *process segment* is based.

EXAMPLE 2 A pattern *process segment* can contain *material segment specifications* that reference *material classes,* while a instance *process segment* based on this pattern *process segment* can contain *material segment specifications* that reference *material definitions* belonging to the *material classes.*

EXAMPLE 3 A mining organization defines the following pattern and instance *process segments*.

Extraction (pattern):

1. open Cut Extraction (pattern), specialization of Extraction (pattern);
2. underground Extraction (pattern), specialization of Extraction (pattern);
3. Site S1 Open Cut Extraction (instance), specialization of Open Cut Extraction (pattern); and
4. Site S2 Underground Extraction (instance), specialization of Underground Extraction (pattern).

NOTE Pattern *process segments* provide a basis for standardization and reuse of pattern *process segments* across many instance *process segments* across and between plants.

Table 75 defines the relationship roles for the *process segment*.

Table 76 defines the attributes for the *process segment*.

Table 75 – Process segment relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Process segment | Process segment child | 0..\* | Is made up of | This parent *process segment* is whole of the child *process segment(s)* as the part. |
| Process segment | Process segment parent type | 0..1 | Includes properties of | This *process segment class(s)* include properties of the *process segment class*. |
| Work master (Defined in Part 4) | NA | 0..\* | Corresponds to | This *process segment(s)* is applied in zero to many *work master(s)*. |
| Process segment | Process segment | 0..\* | Has an execution dependency on | *Process segment* has an association class relationship with *segment dependency.*  The *process segment(s)* applying the ordering / sequencing rules from the *segment dependency* related to the *process segment* execution. |
| Segment dependency | Segment dependency | 0..\* | Has an execution dependency on | *Process segment* has an association class relationship with *segment dependency.*  The ordering / sequencing rules related to the *process segment* execution. |
| Operations segment | NA | 0..^ | Association | The *operations segment(s)* applying this *process segment(s)* in the *segment requirement* for an *operations request.* |
| Process segment parameter | Process segment parameter | 0..\* | Contains | The *process parameter specifications* related to this *process segment.* |
| Personnel segment specification | Personnel segment specification | 0..\* | Contains | The *personnel specification(s)* defining part of this *process segment.* |
| Equipment segment specification | Equipment segment specification | 0..\* | Contains | The *equipment specification(s)* defining part of this *process segment.* |
| Physical asset segment specification | Physical asset segment specification | 0..\* | Contains | The *physical asset specification(s)* defining part of this *process segment.* |
| Material segment specification | Material segment specification | 0..\* | Contains | The *material specification(s)* defining part of this *process segment.* |

Table 76 – Process segment attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a *process segment*, within the scope of the information exchanged (*operations capability*, *operations schedule*, *operations performance* …)  Required attribute.  The ID is used in other parts of the model when the *process segment* needs to be identified, such as the *operations capability* for this segment, or an operation*s response* identifying the segment. | Widget Frame Milling | Replace Motor | Pull Sample and Run Test | Transfer |
| Description | Additional information about the *process segment*. | Frame milling operation, separately costed operation | Large size motor replacement | Check purity and concentration | Move pallet from truck to conveyor system |
| Operations type | Describes the category of the activity. Required attribute.  Defined values are production, maintenance, quality, inventory, or mixed.  “Mixed” can be used when the activity contains several categories of *process segments*. | Production | Maintenance | Quality | Inventory |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *process segment* definition, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Definition type | Defines the type of the *process segment*.  Defined values are   * pattern: a *process segment* used as a template for other *process segments*; * instance: a *process segment* that may be directly scheduled and tracked. | Pattern | Instance | Instance | Pattern |
| Duration | Duration of *process segment*. | 25 | (not applicable) | 20 | 5 |
| Duration unit of measure | The units of measure of the duration. | Minutes | (not applicable) | minutes | minutes |

### Process segment parameter

Specific parameters required for a *process segment* shall be presented as *process segment parameters*.

*Process segment parameters* may contain nested *process segment parameters*.

Table 77 defines the relationship roles for the *process segment parameter*.

Table 78 defines the attributes for a *process segment parameter*.

Table 77 – Process segment parameter relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Process segment | NA | 1 | Contains | The *process segment* defined in part by this *physical asset segment specification.* |
| Parameter segment parameter | Parameter segment parameter child | 0..\* | Contains | This *parameter segment parameter* is part of the *parameter segment parameter* as the whole. |

Table 78 – Process segment parameter attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the process segment parameter.  Required attribute. | Milling Time | Crane Lead Time | Sample Size | Number of Pallets |
| Description | Contains additional information*.* | Range of acceptable milling times. | Known lead time to get crane available | Size of sample to be pulled | Number of pallets needed for move |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the object, such as the site or area. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Value | The value, set of values, or range of acceptable values | {5.10} | {1.20} | {5-20} | (not applicable) |
| Value unit of measure | Unit of measure of the values. | Minutes | Days | mg | (not applicable) |

### Personnel segment specification

Personnel resources that are required for a *process segment* shall be presented as *personnel segment specifications*.

Table 79 defines the relationship roles for a *personnel segment specification*.

Table 80 defines the attributes for a *personnel segment specification*.

Table 79 – Personnel segment specification relationship roles

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Related Object | Role | Multiplicity | Relationship Name | Description |
| Process segment | NA | 1 | Contains | The *process segment* defined in part by this *personnel segment specification.* |
| Personnel segment specification | Personnel segment specification child | 0..\* | Is made up of | The related object(s) makes up part of this *personnel segment specification* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *personnel segment specification.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *personnel segment specification* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *personnel segment specification* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Personnel segment specification property | Personnel segment specification property | 0..\* | Has properties of | The *personnel segment specification property(s)* of this *personnel segment specification.* |
| Personnel class | Personnel class | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *personnel class* or set of *personnel classes* specified. |
| Person | Person | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *person* or set of *persons* specified.  Typically, either *personnel class* or *person* is specified, but not both. |

Table 80 – Personnel segment specification attributes

| Attribute Name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *personnel segment specification.*  Required attribute. | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Description | Contains additional information and descriptions of the *personnel segment specification* definition. | Defines the time for journeyman milling machine operators for each widget frame milling process segment. | Qualified to replace motor type NEMA 4. | Qualified to operation of reflectometer | Certified lift truck operator |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *personnel segment specification*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Spatial definition | Spatially defines the personnel resource(s)specified by this *personnel segment specification* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the personnel resource(s) specified by this *personnel segment specification.* | SST57 | Maintenance Shed 4S | Sample Pickup 3 | Waypoint 7 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational location | Description | Operational Location | Operational Location |
| Personnel use | Defines the expected use of the *personnel class* or *person* in the context of the *process segment*. | Allocated | Certified | Certified | Allocated |
| Quantity | Specifies the *personnel* resource required for the parent *process segment*. | 1,3 | 2 | 0,5 | 5 |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours / piece | Hours / motor | Hours / sample | minutes / transfer |

NOTE A *personnel segment specification* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified personnel resource(s) within a given *operational location*.

### Personnel segment specification property

Specific properties that are required for *personnel segment specifications* shall be presented as *personnel segment specification properties*.

*Personnel segment specification properties* may contain nested *personnel segment specification properties*.

Table 81 defines the relationship roles for the *personnel segment specification property*.

Table 82 defines the attributes for the *personnel segment specification property*.

Table 81 – Personnel segment specification property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Personnel segment specification property | Personnel segment specification property child | 0..\* | Contains | The *personnel segment specification property(s)* of this *personnel segment specification property.* |
| Personnel segment specification | NA | 1 | Contains | The *personnel segment specification property(s)* of this *personnel segment specification property.* |
| Personnel class property | Personnel class property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |
| Person property | Person property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |

Table 82 – Personnel segment specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *person property* or *personnel class property*.  Required attribute. | Height | Scuba Trained | Color Vision | 2nd Shift |
| Description | Contains additional information and descriptions of the property. | Defines the required minimum height of a milling machine operator. | Class 4 work requires use of scuba underwater | Be able to distinguish red and green | Be able to be able to operate 2nd shift |
| Value | The value, set of values, or range of the property. | 150 | TRUE | TRUE | TRUE |
| Value unit of measure | The unit of measure of the associated property value. | cm | <True, False> | <True, False> | <True, False> |
| Quantity | Specifies the personnel resource required. | 1,3 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours / piece | (not applicable) | (not applicable) | (not applicable) |

### Equipment segment specification

Equipment resources that are required for a *process segment* shall be presented as *equipment segment specifications*.

Table 83 defines the relationship roles for the *equipment segment specification*.

Table 84 defines the attributes for the *equipment segment specification*.

Table 83 – Equipment segment specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Process segment | NA | 1 | Contains | The *process segment* defined in part by this *equipment segment specification.* |
| Equipment segment specification | Equipment segment specification child | 0..\* | Is made up of | The related object(s) makes up part of this *equipment segment specification* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *equipment segment specification.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *equipment personnel segment specification* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *equipment segment specification* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Equipment segment specification property | Equipment segment specification property | 0..\* | Has properties of | The *equipment segment specification property(s)* of this *equipment segment specification.* |
| Equipment class | Equipment class | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment class* or set of *equipment classes* of the specification for a specific *process segment*. |
| Equipment | Equipment | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment* or set of *equipment* of the specification for a specific *process segment*.  Typically, either *equipment class* or *equipment* is defined. |

Table 84 – Equipment segment specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *equipment segment specification.*  Required attribute. | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Description | Contains additional information and descriptions. | Equipment needed for widget milling process segment | Crane required to remove motor | Measures substrate thickness of wafer | Able to lift two standard pallets |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *equipment segment specification*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Spatial definition | Spatially defines the *equipment* specified by this *equipment segment specification* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the *equipment* specified by this *equipment segment specification.* | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Equipment use | Defines the expected use of the *equipment class* or *equipment* in the context of the *process segment*. | Part Milling | Remove and Replace Motor | Run Test | Material Movement |
| Quantity | Specifies the amount of resources required. | 1.3 | 1 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity. | Machine Hours / piece | Day | Test | Move |

NOTE An *equipment segment specification* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified *equipment* within a given *operational location*.

### Equipment segment specification property

Specific properties that are required for *equipment segment specifications* shall be presented as *equipment segment specification properties*.

*Equipment segment specification properties* may contain nested *equipment segment specification properties*.

Table 85 defines the relationship roles for the *equipment segment specification property*.

Table 86 defines the attributes for the *equipment segment specification property*.

Table 85 – Equipment segment specification property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Equipment segment specification property | Equipment segment specification property child | 0..\* | Contains | The *equipment segment specification property(s)* of this *equipment segment specification property.* |
| Equipment segment specification | NA | 1 | Contains | The *equipment segment specification property(s)* of this *equipment segment specification property.* |
| Equipment class property | Equipment class property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |
| Equipment property | Equipment property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |

Table 86 – Equipment segment specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *equipment property* or *equipment class property*.  Required attribute. | Milling Direction | Mobile | Calibrated | Power |
| Description | Contains additional information and descriptions. | Only vertical milling machines are suitable for widget milling. | Mobile crane | Within calibrated date | Type of power |
| Value | The value, set of values, or range of the property.  EXAMPLE  Vertical, horizontal | Vertical | TRUE | TRUE | Electric |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | <True, False> | <True, False> | {Electric, Gas, LP} |
| Quantity | Specifies the amount of resources required. | 1.0 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Machine Hours / piece | (not applicable) | (not applicable) | (not applicable) |

### Physical asset segment specification

Physical asset resources that are required for a *process segment* shall be presented as *physical asset segment specifications*.

Table 87 defines the relationship roles for the *physical asset segment specification*.

Table 88 defines the attributes for the *physical asset segment specification*.

Table 87 – Physical asset segment specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Process segment | NA | 1 | Contains | The *process segment* defined in part by this *physical asset segment specification.* |
| Physical asset segment specification | Physical asset segment specification child | 0..\* | Is made up of | The related object(s) makes up part of this *physical asset* *segment specification* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *physical asset segment specification.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *physical asset personnel segment specification* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *physical asset segment specification* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Physical asset segment specification property | Physical asset segment specification property | 0..\* | Has properties of | The *physical asset segment specification property(s)* of this *physical asset segment specification.* |
| Physical asset class | Physical asset class | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset class* or set of *physical asset classes* of the specification for a specific *process segment*. |
| Physical asset | Physical asset | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset* or set of *physical assets* of the specification for a specific *process segment*.  Typically, either *physical asset class* or *physical asset* is specified, but not both. |

Table 88 – Physical asset segment specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *physical asset segment specification.*  Required attribute. | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Description | Contains additional information and descriptions. | Transmitter with most recent calibration date | Oven with minimum 2000 hours on run clock | Measures substrate thickness of wafer | Able to store 200 vials in 40 x 5 matrix |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarch scope defines the scope of the *physical asset segment specification*, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Spatial definition | Spatially defines the *physical asset(s)* specified by this *physical asset segment specification* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Physical location | Identifies the physical location of the *physical asset(s)* specified by this *physical asset segment specification.* | SST57 | Shed4S-8 | 3822 | WH1 |
| Physical location type | Indicates whether the physical location attribute refers to an *operational* *location* object or contains a description of the physical location.  Mandatory where a physical location attribute is specified.  Defined values are   * operational location: physical location attribute references an *operational* *location*; * description: physical location attribute contains a description of the physical location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Physical asset use | Defines the expected use of the *physical asset class* or *physical asset* in the context of the *process segment*. | Temperature of granulation process | Preventive maintenance | Thickness measure-ment | Storage |
| Quantity | Specifies the amount of resources required. | 1 | 1 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity. | oC, K | hours | micron | Cubic feet |

NOTE A *physical asset segment specification* can specify both a spatial definition and a physical location attributes where it is necessary to specify the spatial definition of the specified *physical asset(s)* within a given physical location.

### Physical asset segment specification property

Specific properties that are required for *physical asset segment specifications* shall be presented as *physical asset segment specification property(s)*.

*Physical asset segment specification* *property(s)* may contain nested *physical asset segment specification property(s)*.

Table 89 defines the relationship roles for the *physical asset segment specification property*.

Table 90 defines the attributes for the *physical asset segment specification property*.

Table 89 – Physical asset segment specification property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset segment specification property | Physical asset segment specification property child | 0..\* | Contains | The *physical asset segment specification property(s)* of this *physical asset segment specification property.* |
| Physical asset segment specification | NA | 1 | Contains | The *physical asset segment specification property(s)* of this *physical asset segment specification property.* |
| Physical asset class property | Physical asset class property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |
| Physical asset property | Physical asset property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8 |

Table 90 – Physical asset segment specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *physical asset property* or *physical asset class property*.  Required attribute. | Temperature calibration date | Run clock | Calibrated | Tote Type |
| Description | Contains additional information and descriptions. | Calibration date no later than 6 months from use | Running time hours from last preventive maintenance | Within calibrated date | Only plastic totes |
| Value | The value, set of values, or range of the property.  EXAMPLE  Vertical, horizontal. | 1999-12-31 | 1200 | True | Plastic |
| Value unit of measure | The unit of measure of the associated property value. | Date | Hours | <True, False> | String |
| Quantity | Specifies the amount of resources required. | (not applicable) | (not applicable) | (not applicable) | 3 |
| Quantity unit of measure | The unit of measure of the associated quantity. | (not applicable) | (not applicable) | (not applicable) | Count |

### Material segment specification

Material resources that are required for a *process segment* shall be presented as *material segment specifications*.

Table 91 defines the relationship roles for *material segment specification*.

Table 92 defines the attributes for the *material segment specification*.

Table 91 – Material segment specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Process segment | NA | 1 | Contains | The *process segment* defined in part by this *material segment specification.* |
| Material segment specification | Material segment specification child | 0..\* | Is assembled from | The related object(s) makes up part of this *material* *segment specification* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *material segment specification.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *material segment specification* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *material segment specification* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Material segment specification property | Material segment specification property | 0..\* | Has properties of | The *material segment specification property(s)* of this *material segment specification.* |
| Material class | Material class | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material class* or set of *material classes* of the specification for a specific *process segment*. |
| Material definition | Material definition | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material definition* or set of *material definition* of the specification for a specific *process segment*. |
| Material lot | Material lot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material lot* or set of *material lot* of the specification for a specific *process segment*.  Typically, either a *material class* or *material definition* is specified. |
| Material sublot | Material sublot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material sublot* or set of *material sublot* of the specification for a specific *process segment*.  Typically, either a *material class* or *material definition* is specified. |

Table 92 – Material segment specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *material segment specification.*  Required attribute. | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Description | Contains additional information and descriptions. | Defines the polymer required for a widget milling process segment. | Brushes required during motor maintenance | Disposable sample holder | Pallet used for storage |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the object, such as the site or area. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Spatial definition | Spatially defines the material resource(s) specified by this *material segment specification* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Storage location | Identifies the storage location of the material resource(s) specified by this *material segment specification*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Storage location type | Indicates whether the storage location attribute refers to an *operational location*, *equipment* or *physical asset* object, or contains a description of the storage location.  Mandatory where a storage location is specified.  Defined values are   * operational location: storage location attribute references an *operational location*; * equipment: storage location attribute references an *equipment* object; * physical asset: storage location attribute references a *physical asset*; and * description: storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Assembly type | Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area; * logical: the components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process; * transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit. | Permanent | Transient | Permanent | Transient |
| Material use | Defines the expected use of the *material class,* *material definition, material lot, or material sublot* in the context of the *process segment*.  Defined values for production operations are  consumable, material consumed, material produced, by-product produced, co-product produced, and yield produced.  Defined values for maintenance operations are  consumable, material consumed, and material produced.  Defined values for quality test operations are  consumable, destructive sample, returned sample, and retained sample.  Defined values for Inventory operations are  consumable, material consumed, material produced, and inventoried. | Material consumed | Material consumed | Material consumed | Material consumed |
| Quantity | Specifies the amount of resources required. | 0.35 | 6 | 1 | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated property value. | Sheets / piece | Units | Units | (not applicable) |

NOTE A *material segment specification* can specify a spatial definition attribute in addition to a storage location attribute where it is necessary to specify the spatial definition of the *material r*esource(s) within the given storage location.

A *material segment specification* may be defined as follows by containing an assembly of *material segment specifications* and as part of an assembly of *material segment specifications*.

1. A *material segment specification* may define an assembly of zero or more *material segment specifications*.
2. A *material segment specification* may be an assembly element of zero or more *material segment specifications*.
3. An assembly may be defined as a permanent or transient assembly of *material segment specifications*.
4. An assembly may be defined as physical or a logical assembly of *material segment specifications*.

Defined values for the material use attribute for production operations are consumable, material consumed, material produced, co-product produced, by-product produced, and yield produced; the definitions of the defined values are

* consumable: resources that are not normally included in bills of material or are not individually accounted for in specific *operations requests* or are not lot tracked(Part 1 definition);
* material consumed: raw and intermediate *material* normally included in bills of material or are individually accounted for in specific *operations requests* or are *material lots* tracked;
* material produced: finished goods material normally included in bills of material or are individually accounted for in specific operations requests or are material lots tracked;
* co-product produced: a planned product typically produced in conjunction with a main planned product per the material master. A product that is usually manufactured together or sequentially because of product or process similarities;
* by-product produced: tracked waste, undesirable *materials*, *material* of value produced as a residual of or incidental to the production process. The ratio of by-product to primary product is usually predictable. By-products may be recycled, sold as-is, or used for other purposes;
* yield produced: a work-in-progress measured *material actual* quantity that is tracked continuously across a long production run or batch. Yield produced is tracked against the amount of planned good or acceptable *material* during and at the completion of a process. Yield produced is typically used to compute a yield value where the amount of yield produced is divided by the measured *material* consumables or inputs per the operations bill of materials and expressed as a decimal or percentage. In manufacturing planning and control systems, the yield value is usually related to a specific process or routing step to determine the required scheduled amount to produce a specific number of finished goods.

EXAMPLE If 50 units of a product are required by a customer and a yield of 70 percent is expected then 72 units (computed as 50 units divided by ,7) should be started in the manufacturing process.”

Defined values for the material use attribute for maintenance operations are consumable, material consumed, and material produced; the definitions of the defined values are

* consumable: ibid;
* material consumed: raw and intermediate *material* normally included in bills of material or are individually accounted for in specific *operations requests* or are *material lots* tracked;
* material produced: finished goods *material* normally included in bills of material or are individually accounted for in specific *operations requests* or are *material lots* tracked.

Defined values for the material use attribute for quality test operations are consumable, destructive sample, returned sample, and retained sample; the definitions of the defined values are

* consumable: ibid
* destructive sample: for a quality test to a *test specification*, a specified amount of consumed or produced *material* is collected during manufacturing operation due being committed to requirement for destructive quality test activities. The *material* sample is normally included in bills of resources, individually accounted for in specific *operations request*, and sample lifecycle (*material lot)* sample tracking;
* returned sample: for a quality test to a *test specification*, a specified amount of *material* is made available for manufacturing operation scheduling and work activities. The available *material* is normally included in bills of resources, individually accounted for in specific *operations request*, and (*material lot*) sample lifecycle tracking;
* retained sample: for a quality test to a *test specification*, a specified amount of *material* is not made available for manufacturing operation scheduling and work activities. The *material* is normally included in bills of resources, individually accounted for in specific *operations request*, and (*material lot*) sample lifecycle tracking;

Defined values for the material use attribute for inventory operations are consumable, material consumed, material produced, and inventoried; the definitions of the defined values are

* consumable: ibid;
* material consumed: raw and intermediate *material* normally included in bills of material or are individually accounted for in specific *operations requests* or are *material lots* tracked;
* material produced: finished goods *material* normally included in bills of material or are individually accounted for in specific operations requests or are *material lots* tracked;
* inventoried: the *material actual* of periodic and/or on-demand inventory cycle counts of each inventory providing material consumables to the process and accumulating *material* produced, co-products produced and by-products produced.

### Material segment specification property

Specific properties that are required for *material segment specifications* shall be presented as *material segment specification properties*.

*Material segment specification properties* may contain nested *material segment specification properties*.

Table 93 defines the relationships for the *material segment specification property*.

Table 94 defines the attributes for the *material segment specification property*.

Table 93 – Material segment specification property relationships

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material segment specification property | Material segment specification property child | 0..\* | Contains | The *material segment specification property(s)* of this *material segment specification property.* |
| Material segment specification | NA | 1 | Contains | The *material segment specification property(s)* of this *material segment specification property.* |
| Material class property | Material class property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material definition property | Material definition property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material lot property | Material lot property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |

Table 94 – Material segment specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *material property* or *equipment class property*.  Required attribute. | Average Surface Roughness | 314 Stainless Steel | Sterilized | RFID |
| Description | Contains additional information and descriptions. | Defines the minimum polyethylene roughness quality. | Required alloy | Sterilized sample holder | Pallet contains an active RFID |
| Value | The value, set of values, or range of the property. | 66,748 | TRUE | TRUE | Active |
| Value unit of measure | The unit of measure of the associated property value. | Angstroms | <True, False> | <True, False> | <Active, Passive, None> |
| Quantity | Specifies the amount of resources required. | 0.10 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated property value. | Sheets / piece | (not applicable) | (not applicable) | (not applicable) |

### Segment dependency

Process dependencies that are independent of any particular product or operations task shall be presented as *segment dependencies*.

EXAMPLE A *segment dependency* can define that a testing segment is required to follow an assembly segment.

Table 95 defines the relationship roles for the *segment dependency*.

Table 96 defines the attributes for the *segment dependency*.

Table 95 – Segment dependency relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Process segment | Process segment from | 0..\* | Has an execution dependency on | The source *process segment(s)* that the target *process segment(s)* are dependent.  *Process segment* has an association class relationship with *segment dependency*. |
| Process segment | Process segment to | 0..\* | Has an execution dependency on | The target *process segment(s)* that are dependent on source *process segment(s).*  *Process segment* has an association class relationship with *segment dependency*. |

Table 96 – Segment dependency attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | The identification of the unique instance of the *segment dependency*.  Required attribute. | PSD001 | 34 | A35 | PSA-I-5563 |
| Description | Contains additional information and descriptions of the *segment dependency* definition. | Defines the ordering of assembly processes the Widget Assembly process segment | Do not start until production is complete | Can pull samples anytime during production | Do not move to storage until released by quality |
| Dependency type | Defines the execution dependency constraints of one segment to another segment.as the type of the execution or dependency factor between the segments.  Defined values are (explained using dependency type between segment A and segment B)   * at start: start B at A start; * after start: start B after A start; * after end: start B after A end; * not follow: B cannot follow A; * possible parallel: B may run in parallel to A; * not in parallel: B may not run in parallel to A; * no later after start: start B no later than dependency factor after A start: * no earlier after start: start B no earlier than dependency factor after A start; * no later after end: start B no later than dependency factor after A end; * no earlier after end: B no earlier than dependency factor after A end. | Start *Cleanout* -  no earlier after start-  (dependency factor) *Work,* | Start *Motor Replacement*-  after end-*Cleanout.* | *Pull Sample*-possible parallel-  *MIX* | Move *Inventory* -after end- *Quality Release* |
| Dependency factor | Factor used by dependency | 25 | <True, False> | 50 | <True, False> |
| Dependency factor unit of measure | The units of measure of the dependency factor | Minutes | Boolean | Minutes | Boolean |

EXAMPLE Using ‘A’ and ‘B’ to identify the *process segments*, or specific resources within the segments, and *T* to identify the timing factor as shown in Figure 15.



Figure 15 – Example, Segment dependency

## Operations test information

Operations test information is exchanged to communicate criteria that are to be applied to perform tests of *personnel, equipment, physical assets* and/or *materials* and to communicate the results of those tests.

### Operations test model

The operations test model shown in Figure 16 defines *test specification* and *test result* information and how those two sets of exchanged information are related to

* testable object and testable object property as an interface object to be or has been tested (listed in Table 100);
* *operations test requirement* as an interface object (listed in Table 98);
* *resource actual* as an interface object (listed in Table 115); and
* *work definition* (defined in Part 4 of this standard) as the test method to be or has been used to perform the test(s) to the *test specification*.

Table 97 lists the relationships of the objects in the operations test model.

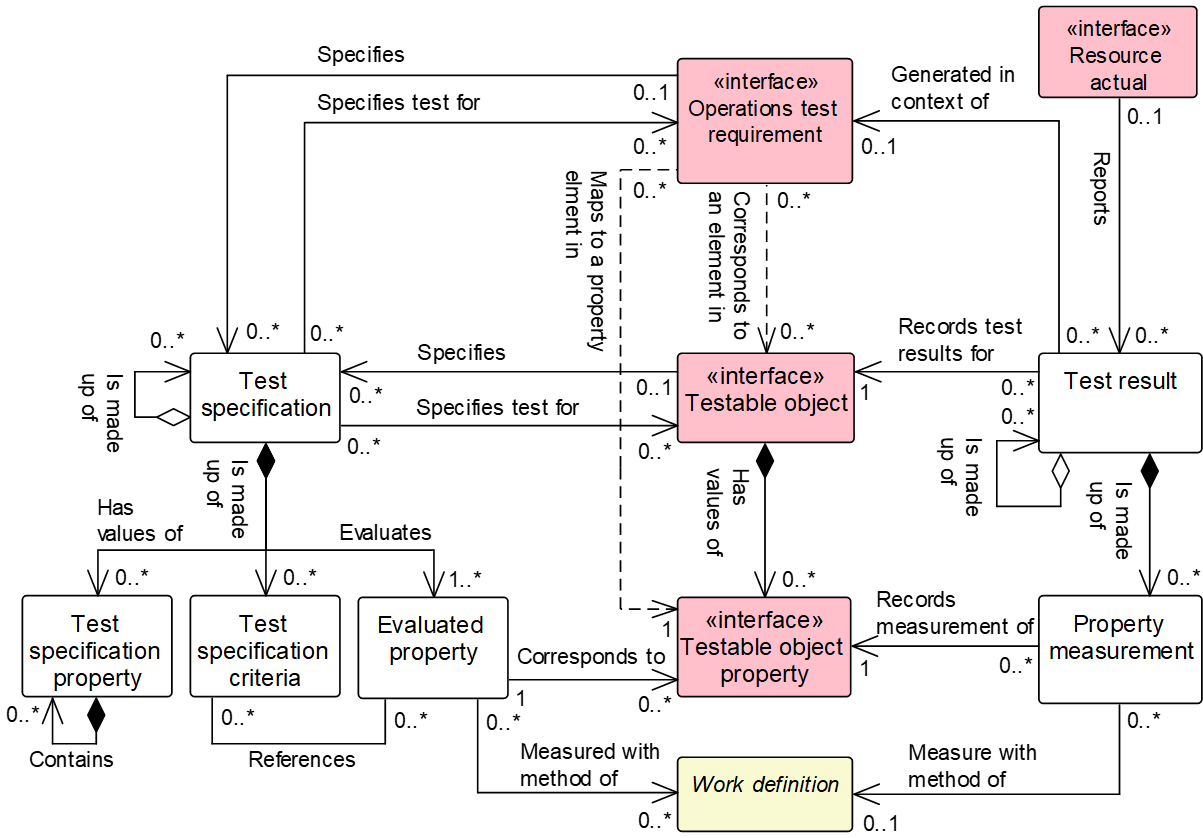


Figure 16 – Operations test model

The objects depicted in Figure 16 with italicised names represent abstract object names. They are realized through use of associated objects defined in this standard.

NOTE 1 The work definition model, *work definition*, and its *work master* and *work directive* objects are defined in Part 4 of this standard.

NOTE 2 The object color convention used in the Part 2 and Part 4 UML diagrams for this information model is as shown in Clause 3.3.3.

Table 97 – Operations test model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations test requirement <<interface>> | Test specification | Association | Specifies |
| Operations test requirement <<interface>> | Testable object <<Interface>> | Association | Corresponds to an element in |
| Operations test requirement <<interface>> | Testable object property <<Interface>> | Dependency | Maps to a property element in |
| Test specification | Operations test requirement <<interface>> | Association | Specifies test for (ID) |
| Test specification | Test specification | Aggregation hierarchy | Is made up of |
| Test specification | Testable object <<Interface>> | Association | Specifies test for |
| Test specification | Test specification property | Composition whole | Has values of |
| Test specification | Test specification criteria | Composition whole | Is made up of |
| Test specification | Evaluated property | Composition whole | Evaluates |
| Test specification property | Test specification property | Composition hierarchy | Contains |
| Evaluated property | Testable object property <<interface>> | Association | Corresponds to |
| Evaluated property | Work definition (Defined in Part 4) | Association | Measured with method of |
| Evaluated property | Test specification property | Association | References |
| Test specification property | Evaluated property | Association | References |
| Testable object <<Interface>> | Testable object property <<interface>> | Composition whole | Has values of |
| Testable object <<Interface>> | Test specification | Association | Specifies |
| Resource actual <<Interface>> | Test result | Association | Reports |
| Test result | Operations test requirement <<interface>> | Association | Generated in context of |
| Test result | Testable object <<interface>> | Association | Records test results for |
| Test result | Test result | Aggregation hierarchy | Is made up of |
| Test result | Property measurement | Composition whole | Is made up of |
| Property measurement | Testable object property <<interface>> | Association | Records measurement of |
| Property measurement | Work definition (Defined in Part 4) | Association | Measured with method of |

### Operations test requirement

The *operations test requirements* are represented as abstract interface objects to simplify the operations test model diagram.

The interface objects are realized by the objects listed in Table 98 where the *operations test requirement* object specifies the *test specification(s)* required for evaluation per the *operations request* (or *work request* defined in Part 4 of this standard).

The *test result*(s) is generated in the context of the listed *operations test requirement* based on the designated *test specification(s)*.

Table 98 – Instances of operations test requirement

| Operations test requirement object |
| --- |
| *Segment requirement /personnel requirement* |
| *Segment requirement /equipment requirement* |
| *Segment requirement /physical asset requirement* |
| *Segment requirement /material requirement* |
| *Operations segment /personnel specification* or  *Operations definition /operations segment /personnel specification* |
| *Operations segment /equipment specification* or  *Operations definition /operations segment /equipment specification* |
| *Operations segment /physical asset specification* or  *Operations definition /operations segment /physical asset specification* |
| *Operations segment /material specification* or  *Operations definition /operations segment /material specification* |
| *Process segment /personnel segment specification* or  *Operations segment /process segment /personnel segment specification* or  *Operations definition /operations segment /process segment /personnel segment specification* |
| *Process segment /equipment segment specification* or  *Operations segment /process segment /equipment segment specification* or  *Operations definition /operations segment /process segment /equipment segment specification* |
| *Process segment /physical asset segment specification* or  *Operations segment /process segment /physical asset segment specification* or  *Operations definition /operations segment /process segment /physical asset segment specification* |
| *Process segment /material segment specification* or  *Operations segment /process segment /material segment specification* or  *Operations definition /operations segment /process segment /material segment specification* |
| *Job order /personnel requirement* |
| *Job order /equipment requirement* |
| *Job order /physical asset requirement* |
| *Job order /material requirement* |
| *Job order /work definition /personnel specification* |
| *Job order /work definition /equipment specification* |
| *Job order /work definition /physical specification* |
| *Job order /work definition /material specification* |

NOTE 1 *Work request, job order, and work definition* objects with beige background in Table 98 are defined in Part 4 of this standard.

Table 99 defines the relationship roles in the operations test model for the *operations test requirement* interface objects listed in Table 98*.*

The attributes for each of the *operations test requirement* interface objects are defined in their associated clause in this part and Part 4 of this standard.

Table 99 – Operations test requirement relationship roles in the operations test model

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Test specification | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *operations test requirement.* |
| Test specification | NA | 0..\* | Specifies test for | This *operations test requirement ID(s)* evaluated by the *test specification.* |
| Test result | NA | 0..1 | Generated in context of | This *operations test requirement* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a *test result ID*. |
| Testable object <<interface>> (object ID) | Testable object <<interface>> (object ID) | 0..\* | Corresponds to an element in | A cross-model association to an element in the resource model for the *testable object* as explained in Clause 3.3.8.  Identifies the associated *testable object* of this *operations test requirement* for a specific *segment requirement*. |
| Testable object property <<interface>> (object ID) | Testable object property <<interface>> (object ID) | 0..\* | Maps to a property element in | A cross-model dependency to a property element in the resource model for the *testable object property* as explained in Clause 3.3.8. |

### Testable object and testable object property

The *testable object* and *testable object property* are represented as abstract interface objects to simplify the operations test model diagram.

The interface objects represent the objects that are able to be tested by a *test specification(s)*. They shall be realized by any object listed in Table 100.

Table 100 – Instances of testable object / testable object property pair

| **Testable object** | **Testable object property** |
| --- | --- |
| *Personnel class* | *Personnel class property* |
| *Person* | *Person property* |
| *Equipment class* | *Equipment class property* |
| *Equipment* | *Equipment property* |
| *Physical asset class* | *Physical asset class property* |
| *Physical asset* | *Physical asset property* |
| *Material class* | *Material class property* |
| *Material definition* | *Material definition property* |
| *Material lot* | *Material lot property* |
| *Material sublot* | *Material lot property* |

Table 101 defines the relationship roles in the operations test model for the *testable object* listed in Table 100*.*

The attributes for each of the *testable object* are defined in their associated clause in this standard.

Table 101 – Testable object relationship roles in operations test model

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations test requirement <<interface>> (object ID) | NA | 0..\* | Corresponds to an element in | A cross-model association to an element in the resource model for the *testable object* as explained in Clause 3.3.8.  Identifies this associated *testable object* of the *operations test requirement* for a specific *segment requirement*. |
| Test specification | NA | 0..\* | Specifies test for | The ID of this *testable object* ID(s) evaluated by the *test specification.* |
| Test specification | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *testable object.* |
| Testable object property <<interface>> (object ID) | Testable object property <<interface>> (object ID) | 0..\* | Has values of | The *testable object property* values of this *testable object.* |
| Test result | NA | 0..\* | Records test results for | This *testable object* who’s the test result is being recorded. |

Table 102 defines the relationship roles in the operations test model for the *testable object property* listed in Table 100*.*

The attributes for each of the *testable object property* are defined in their associated clause in this standard.

Table 102 – Testable object property relationship roles in the operations test model

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Testable object <<interface>> (object ID) | NA | 1 | Has values of | These *testable object property* values are for the *testable object*. |
| Evaluated property | NA | 1 | Corresponds to | This *testable object property* is measured by this *test specification* with the *evaluated property*. |
| Property measurement | NA | 0..\* | Records measurement of | This *testable object property* for which the *property measurement* is recording the measurement result. |

### Test specification

The *test specification* details the *test specification criteria* and the tested *evaluated property(s)* required for a testable object to match the quality or performance requirements of the business or particular customers.

NOTE The *test specification* communicates the test tolerances and related target values for a *specific testable object* referencing a set of *operations test requirements* for context of the test.

A *test specification* may contain other *test specifications* to form a hierarchy of *test specifications*. When a hierarchy of *test specifications* are used, the result of the parent object in the hierarchy shall be the worst-case result of all the respective child object results.

Table 103 defines the relationship roles for the *test specification.*

Table 104 lists the attributes of the *test specification*.

Table 103 – Test specification relationship roles

| Related Object | Role | Multiplicity |  | Relationship Name | Description |
| --- | --- | --- | --- | --- | --- |
| Test specification | Test specification child | 0..\* |  | Is made up of | The child *test specifications* of this *test specification*. |
| Operations test requirement. <<interface>> (object ID) | NA | 0..1 |  | Specifies | This *test specification(s)* is used to evaluate the *operations test requirement.* |
| Operations test requirement. <<interface>> (object ID) | Operations test requirement. <<interface>> (object ID) | 0..\* |  | Specifies test for | The *operations test requirement ID(s)* evaluated by this *test specification.* |
| Test specification property | Test specification property | 0..\* |  | Has values of | The *test specification property* values of this *test specification.* |
| Test specification criteria | Test specification criteria | 0..\* |  | Is made up of | The *test specification criteria* which is to be applied to determine the test outcome upon evaluation of the *test specification*. |
| Evaluated property | Evaluated property | 1..n |  | Evaluates | The *evaluated* property(s) measured and evaluated by this *test specification.* |
| Testable object <<interface>> (object ID) | NA | 0..1 |  | Specifies | This *test specification(s)* is used to evaluate the *testable object.* |
| Testable object <<interface>> (object ID) | Testable object <<interface>> (object ID) | 0..\* |  | Specifies test for | The ID of the *testable object* tested by this *test specification.* |

Table 104 – Test specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a test for certifying one or more values. | BTOR-101 | MI336 | QA8899 | 63 |
| Description | A description of the *test specification.* | Oven residence time test. | Test of diesel engine cylinder wear. | Check of vendor’s Certificate of Analysis on pH. | Check of vendor’s Certificate of Analysis for material grade. |
| Version | An identification of the version of the *test specification.* | 1.0 | 1.0 | 2.1 | A.1 |
| Effective start date | The effective start date and time for use of the *test specification* or set of *test specifications* | 2015-01-01 00:00 UTC | 2015-11-01 08:00 UTC | 2015-01-15 11:00 UTC | 2000-01-22 23:45 UTC |
| Effective end date | The effective end date and time for use of the *test specification* or set of *test specifications* | 2015-12-31 23:59 UTC | 2020-11-01 08:00 UTC | 2999-01-01 00:00 UTC |  |
| Published date | The date and time on which the *test specification* was published or generated. | 2014-09-01 09:34 UTC | 2015-10-30 15:45 UTC | 2013-07-25 14:37 UTC | 1999-04-01 12:00 UTC |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Bread Line #2(WORK CENTER) | Mobile Equipment Workshop | Test Cell 4  Receiving | Warehouse B |
| Test sample size | Sample size required to perform the test. |  |  | 1 lot | 20 kg |
| Physical sample | Defines whether physical sampling is required to perform the test.  Defined values are   * yes: physical samples are required; * no: physical samples are not required. | No | No | No | Yes |
| Recurrence quantity | The amount of operations activity required between samples.  EXAMPLE 1  Material produced, work hours, run hours, etc. |  |  | 1 lot | 15 kt |
| Recurrence time interval | The duration of operational activity required between samples*.* | 20 min | 5,000 hours |  |  |

EXAMPLE 2 An online test can be specified to be performed for each 20 minutes of production time. In which case the recurrence time interval attribute would have a value of 20 min.

EXAMPLE 3 An online test can be specified to be performed over every 15,000 metric tons of material produced. In which case the recurrence quantity attribute would have a value of 15 kt.

EXAMPLE 4 An offline test for engine oil contamination can require a physical sample of 50 milliliters to be taken for analysis. In which case the test sample size would have a value of 50 mL, and the physical sample attribute would have a value of yes.

### Test specification property

The *test specification property* object defines properties of the *test specification*. These properties are not the characteristics to be tested.

Table 105 defines the relationship roles for the *test specification property.*

Table 106 lists the attributes of the *test specification property*.

Table 105 – Test specification property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Test specification property | Test specification property child | 0..\* | Contains | The child *test specification property(s)* of this *test specification property.* |
| Test specification | NA | 1 | Has values of | These *test specification property* values are for the *test specification.* |

Table 106 – Test specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the *test specification property* | 001 | Display Name | Test Classification | Criticality |
| Description | Description of the *test specification property* | Approver of the test specification | Short name used to display on a device user interface. | Classification of the test | Indicates the safety criticality of the test |
| Value | The value, set of values, or range of the property. | Quality Control Supervisor | Cylinder Wear | Microbiological | High |
| Value unit of measure | The unit of measure of the associated property values, if applicable. | String | String | <Chemical, Physical, Microbiological> | <High, Medium, Low, N/A> |

### Test specification criteria

The *test specification criteria* object defines the set of criterion to evaluate and the *test result* to be reported when a *testable object* satisfies those criteria.

Table 107 defines the relationship roles for the *test specification criteria.*

Table 108 lists the attributes of the *test specification criteria*.

Table 107 – Test specification criteria relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Test specification | NA | 1 | Is made up of | This *test specification criteria* determine the test outcome upon evaluation of the *test specification.* |
| Evaluated property | Evaluated property | 0..\* | References | This *test specification criteria* used to evaluate the *evaluated property* of a *testable object property*. |

Table 108 – Test specification criteria attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the *test specification criteria.* | 001 | cyl\_worn | 035 | Fe\_warn |
| Description | Description of the *test specification criteria.* | Baking time OK | Excessive Cylinder Wear | Maximum Alkalinity | Iron Range Warning |
| Sequence | Specifies the sequence of evaluation of *test specification criteria.*  The sequence shall be executed lowest first. Duplicate sequence values shall be executed in parallel with worst case result reported if both criterion are evaluated as true. | 1 | 1 | 1 | 2 |
| Expression | An expression of the *test specification criteria* to be evaluated. If the expression is empty, then the *test specification criteria* represents the else criterion.  EXAMPLE 1  If (criterion 1) then ‘pass’  else if (criterion 2) then ‘warn’  else ‘fail’ | If Oven Residence Time > 10 min and < 11 min, then ‘pass’ | If Cylinder Diameter > 71.960 mm, then ‘fail’ | If pH < 7.2, then ‘pass’ | If Fe > 0.585 and Fe < 0.615, then ‘warn’ |
| Result | The value to be given to the result of the test if the *test specification criteria* expression is evaluated as true. | Pass | Fail | Pass | Warn |

When the expression is empty, it shall be the last *test specification criteria* for the *test specification*.

EXAMPLE 2 Consider the following sequence of *test specification criteria* where the sequence, result and expression are shown. A *material definition property* of Fe has been defined in the *material definition* where the *test specification* is associated using the *evaluated property* object:

1. Pass: Fe > 59% and Fe < 61%;
2. Warn: Fe > 58.5% and Fe < 61.5%; and
3. Fail.

### Evaluated property

The *evaluated property* object identifies the set of *testable object / testable object property* pairs to be measured and the applicable *test method* to obtain a *property measurement*.

Table 109 defines the relationship roles for the *evaluated property.*

Table 110 lists the attributes of the *evaluated property*.

Table 109 – Evaluated property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Testable object property <<interface>> (object ID) | Testable object property <<interface>> (object ID) | 0..\* | Corresponds to | The *testable object property ID* which is to be measured by this *test specification*. |
| Work definition (Defined in Part 4) | Work master ID, work directive ID | 0..1 | Measured with method of | The work master ID or work directive ID which is applied test method to obtain the measurement of this *evaluated property* for *test specification* of the testable object property ID. |
| Test specification | NA | 1 | Evaluates | This *evaluated property(s)* is measured and evaluated by the *test specification.* |
| Test specification criteria | Test specification criteria | 0..\* | References | This *test specification criteria* used to evaluate the *evaluated property* of a *testable object property.* |

Table 110 – Evaluated property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the *evaluated property* | ORT | cyl\_dia | pH | Fe |
| Description | Description of the evaluated property | Oven residence time for the material lot | Cylinder diameter | Alkalinity | Material grade |

### Test result

The results from the test evaluation of *property measurement* of the *testable object property* of the *testable object* per the *test specifications* shall be presented as *test results.* A *test result* reports the measured results and evaluation of *test specification criteria* from a test for a specific *person, piece of equipment, physical asset, material lot* or *material sublot.*

NOTE The *test result* can be exchanged as a first order object or exchanged in an *operations event record entry,* a resource actual object in a *segment response,* a *work record entry* (Defined in Part 4), and a resource actual object in a *job response* (Defined in Part 4)*.*

Table 111 defines the relationship roles for the *test result.*

Table 112 lists the attributes of the *test result*.

Table 111 – Test result relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Test result | Test result child | 0..\* | Is made up of | The child *test result(s)* of this *test result*. |
| Property measurement | Property measurement | 0..\* | Is made up of | The measurement obtained for each *testable object property*. |
| Operation test requirement <<interface>> (object ID) | Operations test requirement <<interface>> (object ID) | 0..1 | Generated in context of | The *operations test requirement* objectapplied to execute the test and generate the *test result*. |
| Testable object <<interface>> (object ID) | Testable object <<interface>> (object ID) | 1 | Records test results for | The *tested object* recorded by this *test result*. |
| Resource actual  <<interface>> | NA | 0.1 | Reports | The *resource actual* reports this test result in a *segment response* or *job response* (Defined in Part 4). |

Table 112 – Test result attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *test result*. | BTOR-101.6473 | MT- 998 | pH-494981 | 63.30582 |
| Description | Additional information about the *test result*. | Baking time oven residence time test result. | Diesel engine cylinder wear test result | Result of check of vendor’s COA for pH | Result of check of vendor’s COA for material grade |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally defines the scope of the *test result,* such as the site or area it is defined for. | East Wing(AREA)/ Baking Line #2(WORK CENTER) | Mobile Equipment Workshop | Test Cell 4  Receiving | Warehouse B |
| Evaluation date | Date and time of evaluation of the test result. | 2015-07-25 13:59 UTC | 2016-10-25 13:30 | 2016-10-25 13:30 | 2001-10-25 13:30 |
| Evaluated criterion result | Result obtained from evaluation of the associated *test specification criteria*. | Pass | Fail | Pass | Warn |
| Expiration | Date of the expiration of the *test result criteria*. | 2017-10-25 13:30 | 2017-10-25 13:30 | 2000-10-25 13:30 | 2002-10-25 13:30 |

### Property measurement

The measurement obtained during execution of *work master* (defined in Part 4 of this standard) shall be presented as a *property measurement*. A *property measurement* reports the measurement obtained for a single *testable object property* corresponding to an *evaluated property* of a *test specification* for a specific *person*, *equipment*, *physical asset*, *material lot* or *material sublot*.

Table 113 defines the relationship roles for the *property measurement.*

Table 114 lists the attributes of the *property measurement*.

Table 113 – Property measurement relationship roles

| **Related Object** | **Role** | **Multiplicity** | **Relationship Name** | **Description** |
| --- | --- | --- | --- | --- |
| Testable object property <<interface>> (object ID) | Testable object property <<interface>> (object ID) | 1 | Records measurement of | The *testable object property ID* for which this *property measurement* is records the measurement result. |
| Test result | NA | 1 | Is made up of | This *property measurement* obtained for each *testable object property* in the *test result.* |
| Work definition (Defined in Part 4) | Work master ID,  work directive ID | 0..1 | Measured with method of | The work master ID or work directive ID which is applied test method to obtain the measurement of this *property measurement* for *test specification* of the testable object property ID. |

Table 114 – Property measurement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *property measurement*. | BTOR-101.6473.1 | MT- 998-1 | pH-494981-1 | 63.30582.1 |
| Description | Additional information about the *property measurement*. | Baking time oven residence time measure. | Measured diesel engine cylinder diameter. | pH reported on vendor’s Certificate of Analysis | Material grade reported on vendor’s Certificate of Analysis |
| Measurement date | The date and time when the measurement was obtained. | 2015-07-25 13:59 UTC | 2016-10-25 13:30 | 2016-10-25 13:30 | 2001-10-25 13:30 |
| Value | The measured value for the *testable object property.* | 10.3 | 71.963 | 7.16 | 59.2 |
| Value unit of measure | The unit of measure of the measured value, if applicable. | min | mm |  | % |
| Expiration | The date of the expiration of the *property measurement*. | 2017-10-25 13:30 | 2017-10-25 13:30 | 2000-10-25 13:30 | 2002-10-25 13:30 |

### Resource actual

The *resource actual* represents an abstract interface object to simplify the operations test model diagram. The interface object represents the objects that can report *test result(s)*. The *resource actual* object shall be realized by any object listed in Table 115.

Table 115 – Instances of resource actual

| **Resource actual** |
| --- |
| *Personnel actual* |
| *Equipment actual* |
| *Physical asset actual* |
| *Material actual* |

The *test result* can be exchanged as a first order object or exchanged in an *operations event record entry*, a *resource actual* object in a *segment response*, a *work record entry* (Defined in Part 4), and a *resource actual* object in a *job response* (Defined in Part 4).

Table 116 defines the relationship roles in the operations test model for the *resource actual.*

The attributes for each of the *resource actual* are defined in their associated clause in this standard.

Table 116 – Resource actual relationship roles in operations test model

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Test result | Test result | 0..\* | Reports | The *resource actual* reports this test result in a *segment response* or *job response* (Defined in Part 4). |

## Operations record information

### Operations record model (abstract)

The operations record model is shown in Figure 17. The *operations record template, operations record entry template,* and *operations record specification template* are abstract types meaning they are not standalone exchange objects. These abstract objects are realized in specialized implementations as occurrences of the *operations event record template* in this Part 2 and the *work record* in Part 4 of this standard. The operations record model represents a common structure for representing bundled information reported in data exchanges. The *operations record template* bundles *operations record entry template* objects by the type of action specifying the attribute, action, with defined values of created, changed, deleted and observed. The *operations record entry template* embeds objects defined in this standard and manufacturing operations profiles or references to external objects. The *operations record specification template* specifies the content and form of objects in an *operations record template* within the associated *operations record entry template(s).*

NOTE 1 In an implementation, the *operations record entry template* can be validated against the *operations record specification template*.

Table 117 lists the relationships of the objects in the operations record model.

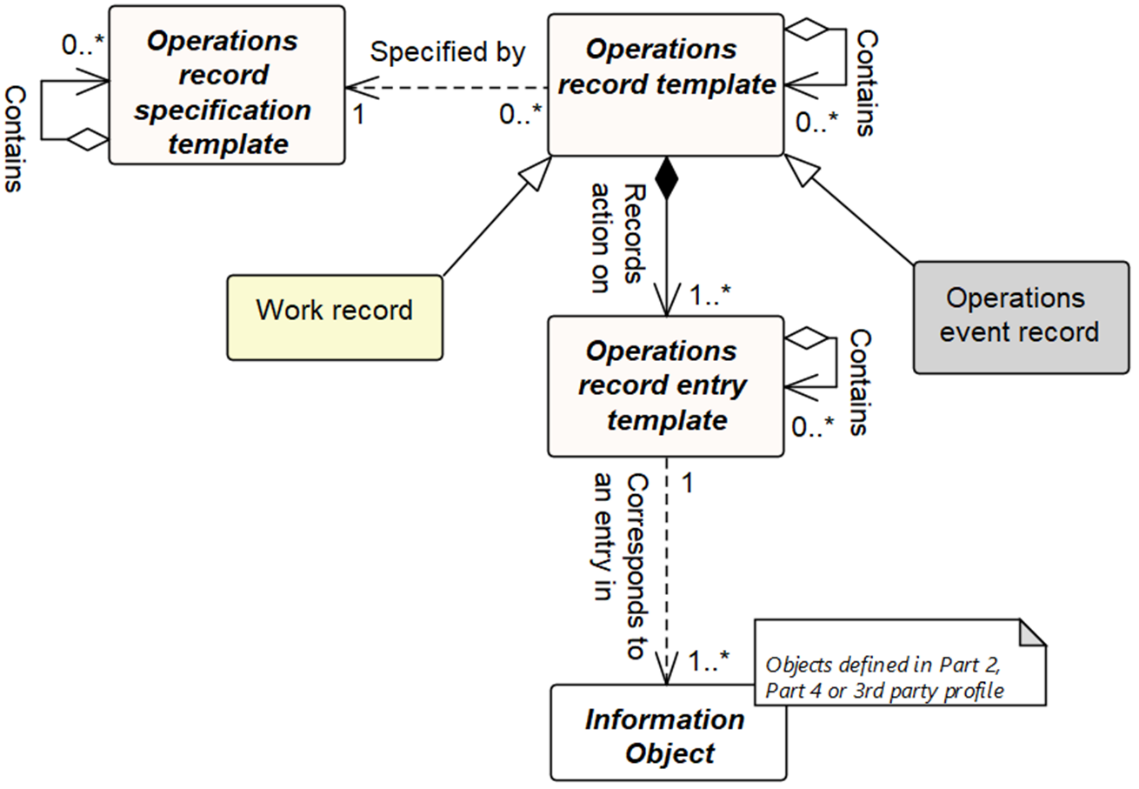


Figure 17 – Operations record model (abstract)

NOTE 2 The *work record* object is defined in Part 4 of this standard.

NOTE 3 The object color convention used in the Part 2 and Part 4 UML diagrams for information models is as shown as shown in Clause 3.3.3.

Table 117 – Operations record model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations record template | Operations record specification template | Dependency | Specified by |
| Operations record template | Operations record entry template | Composition | Records action on |
| Operations record entry template | Information object | Dependency | Corresponds to an entry in |
| Operations record template | Operations record template | Aggregation hierarchy | Contains |
| Operations record specification template | Operations record specification template | Aggregation hierarchy | Contains |
| Operations record entry template | Operations record entry template | Aggregation hierarchy | Contains |

An *information object* can be represented by any object defined in the standard.

### Operations record specification template (abstract)

Specification of the permitted content and form of objects in an *operations record* *template* shall be defined in an associated *operations record specification template*.

EXAMPLE 1 A *work record specification* (derived from an *operations record specification* *template*) defined in Part 4 specifies the contents of *operations record* *template* objects in a *work record* instance.

The publisher/sender of an *operations record* *template* shall follow the *operations record specification template* to construct the data exchange. Subscribers/receivers shall use the *operations record specification template* to validate the content of the exchange.

Table 118 defines the relationship roles for the *operations record specification template*.

Table 119 defines the attributes for the *operations record specification template*.

Table 118 – Operations record specification template relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations record template | NA | 0..\* | Specified by | The *operations record* maps to this corresponding *operations record specification template.*  Allowed content in the *operations record template* is defined by this *operations record specification template.* |
| Operations record specification template | Operations record specification template child | 0..\* | Contains | This parent *operations record specification template* is whole of the child *operations record specification template(s)* as the part. |

Table 119 – Operations record specification template attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the associated instance of *operations record* *specification template*.  Required attribute.  *Operations record* *template* derived type instances include this value with their *operations record template(s)* to enable specification / validation of the message contents. | CR-87 | Uuid - 1FCF9DA1-DCC5-4012-BDEF-D76C754F4826 | 2016-03 | AB45 |
| Description | Contains additional information and description of the *operations record specification template*. | Mixer event record MX-3P | Mixer PM Workflow record MX-3A | CAPA workflow event record QA-5P | KanBan event record CAP-5 |
| Information object type | Permitted set of information objectsallowed in the *operations* *record* *template* occurrence.  An *operations record entry* *template* contains the reference to the information object for *operations record template.*  NOTE 1 An unconstrained set of values can be represented with the \* entry. | [Equipment, Personnel], | [JobList] | [TestSpecfication, Test Results] | [Material Lot, Material Sublot], |
| Information object type multiplicity | The range of the information object(s) in *operations record entry template* allowed in the *operations record template* occurrence.  If no limit is explicitly specified, the unbounded keyword is specified.  If no *multiplicity* entry is specified, this is equivalent to no constraint.  EXAMPLE 2  {Min: 0, Max: Unbounded} | {Min: 1, Max: 1} | {Min:0, Max: 1} | {Min:0, Max: 10} | {Min:1, Max: Unbounded} |
| Action | The permitted set of *actions* applied to the *operations record entry* *template* object in the *operations record* *template* by the publisher.  Defined values for *action* are  added, changed, deleted, and observed.  If no *action* is specified, this is equivalent to all *actions* being allowed. | [Added, Deleted, Changed, Observed] | [Changed] | [Added, Deleted, Changed] | [Added] |
| Action multiplicity | The range of *actions* allowed to be represented in the *operations record* *template* occurrence.  If no limit is explicitly specified, the unbounded keyword is specified.  If no *multiplicity* entry is specified, this is equivalent to no constraint.  EXAMPLE 3  {Min: 0, Max: Unbounded}. | {Min: 1, Max: 1} | {Min:0, Max: 1} | {Min:0, Max: 10} | {Min:1, Max: Unbounded} |

Each *operations record* *template* represents a single action. An *operations record specification* *template* defines the content options permitted from one to many types of *operations records template*. The number of *operations record entry template* occurrences allowed in each *operations record template* shall be specified using the attribute, information object type multiplicity. The number of *operations record template* actions allowed to be applied to *operations record entry* *template* shall be represented using the attribute, action multiplicity.

NOTE 2 The IDs can use the fully qualified name (FQN) syntax to avoid ID name collisions.

### Operations record template

The bundle of *operations record entr*y *template* objects pertinent to a specified real-world manufacturing recording activity shall be defined as an *operations record template*.

Table 120 defines the relationship roles for the *operations record template*.

Table 121 defines the attributes for the *operations record template*.

Table 120 – Operations record template relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations record entry template | Operations record entry template | 1..\* | Records action on | This *operations record template* acts as a container for *operations record entry template (s)* applying a common action for each *operations record template.* |
| Operations record specification template | Operations record specification template | 1 | Specified by | The *operations record specification template* defines the *information object(s)* allowed to be contained within an *operations record entry template* in this *operation record template.* The specified action must match the value in the attribute, action, in this *operations record template.* |
| Operations record template | Operations record specification child | 0..\* | Contains | This parent *operations record template* is whole of the child *operations record template(s)* as the part. |

Table 121 – Operations record template attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the associated instance of *operations record template*.  Required attribute. | CR-87 | Uuid - 1FCF9DA1-DCC5-4012-BDEF-D76C754F4826 | 2016-03 | AB45 |
| Description | Contains additional information and description of the *operations record template*. | Job order start | Schedule released | QA test scheduled | Lot 4A stored |
| Action | The action performed on the *operations record entry template(s)* within the *operations record template.*  Defined values are  added, changed, deleted and observed. | Deleted  Observed | Added | Changed | Changed |
| Effective timestamp | The date and time that the *operations record entry template* was/is effective as the time of the real-world event’s recording.  If no effective timestamp is provided with *operations record entry template*, the effective timestamp is represented by the effective timestamp attribute in the *operations record template*. | Mon August 15 at 01:36 PM | 2014-03-06 11:00 UTC | 2010-04-26 10:30 | 2011-01-20 12:45 UTC-10 |
| Record timestamp | The date and time the publisher recorded/ transacted the action. Record timestamp explicitly states the time that the publisher took the action of the *operations record* *template*. | Mon August 16 at 01:36 PM | 2014-03-07 10:05 UTC | 2010-04-27 10:00 | 2011-01-20 14:45 UTC-10 |

NOTE 1 Due to external factors, receivers of an *operations record template* can have a different data record of *operations record entry templates’* *information objects* so the record timestamp attribute is used by the receiver to compare the same *operations record entry template*(s) in each *operations record template* occurrence.

NOTE 2 The action attribute can be recorded at times after the real-world *operations event* took place which is reported in the effective timestamp attribute of the *operations record entry template*.

### Operations record entry template

The *operations record entry* *template* objectshall be a single *information object* as an object defined in this part and Part 4 of this standard, and any third-party manufacturing operations message profile within an *operations record* *template*. There shall be one or more *operations record entry* *template* objectsin an *operations event* *record* *template*.

The relationships and their roles in an *operations record entry template* are defined in the *operations record specification template*.

EXAMPLE 1 *Operations schedule* and *material lot* as *information objects* require two *operations record entry* *template* objects in an *operations record template*.

Table 122 defines the relationship roles for *operations record entry* *template*.

Table 123 defines the attributes for *operations record entry* *template*.

Table 122 – Operations record entry template relationships

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations record template | NA | 1 | Records action on | The *operations record template* applying a single common action acts as a container for this *operations record entry* *template(s)*.  EXAMPLE 2 Changed |
| Operations record entry template | Operations record entry template child | 0..\* | Contains | This parent *operations record entry template* is whole of the child *operations record entry template(s)* as the part. |
| Information object | Information object | 0..1 | Corresponds to an entry in | An embedded *information object.*  If data is referenced in this *operations record entry template*, the attribute is not used.  The format of the *information object* is specified in the *operations record specification template.* |
| Information object | External reference | 0..1 | Corresponds to an entry in | The reference to external data *(information object)* which is stored external to this *operations record entry* *template*.  If data is embedded in this *operations record entry template*, the attribute is not used.  The format of the reference is specified in the *operations record specification template*. |

Table 123 – Operations record entry template attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | ID is unique within the scope of *operations record entry template.*  Required attribute. | 1 | 4A34B | 239432 | A11 |
| Description | Additional information about the *operations record entry template*. | The control recipe is embedded in this *operations record* *template.* |  |  | Data set time series data is stored in the historian database |
| Information object | An embedded information object.  If data is referenced in this *operations record entry template*, the attribute is not used.  The format of the *information object* is specified in this *operations record specification template*. | Material Lot 11A | Mixer 4 | Work Master QC5001 | Material Lot 59B |
| Information object ID | The reference to external data *(information object)* which is stored external to this *operations record entry template*.  If data is embedded in this *operations record entry* *template,* the attribute is not used.  The format of the reference is specified in this *operations record specification* *template*. | Material Lot 11A | Mixer 4 | Work Master QC5001 | Material Lot 59B |
| Effective timestamp | The date and time that the *operations record entry* *template* was/is effective.  If no effective timestamp is provided with *operations record entry* *template*, the effective timestamp is represented by the effective timestamp attribute in the *operations record template*, | Mon August 15 at 01:36 PM | 2014-03-06 11:00 UTC | 2010-04-26 10:30 | 2011-01-20 12:45 UTC-10 |
| Record timestamp | The date and time the publisher recorded / transacted the action.  If no entry is provided, the record timestamp is the record timestamp attribute in the *operations record* *template*. | Mon August 16 at 01:36 PM | 2014-03-07 10:00 UTC | 2010-04-27 12:30 |  |
| Information object type | Identifies the type of information object type that an operations record entry template is based upon.  The allowed information object types are defined in the *operations record specification template.* | Work Master  Control Recipe | Physical Asset | Test Specification | Equipment |

NOTE When multiple *operations record entry* *template* are exchanged, the effective timestamps of the *actions* of when each occurred can be relevant to the interpretation of the *operations recor*d template.

EXAMPLE 2 A *OperationsScheduleUpdate* (event) creates requirements for new *material lot* and *person* objects in the source system. The publisher/sender advises that the *operations schedule* was created after the new *material lot* and *person* objects were created.

## Operations event information

Operations event information is generated as result of the occurrence of a real-world event that warrants notification to interested parties. Operations event information is published as time stamped notifications using the *operations event* information exchange object. The *operations event* exchange explicitly includes the process context of the real-world event and all pertinent information actioned by the publisher that is associated with the real-world event. The subsequent processing of *operations events* by subscribers is not of concern to the *operations event* publisher.

### Operations event model

The operations event model represents a generic representation of event notifications using the *operations event* object and the constructs required to define, group and structure the *operations event* occurrences. Figure 18 shows the operations event model. Table 124 lists the relationships of the objects in the operations event model.

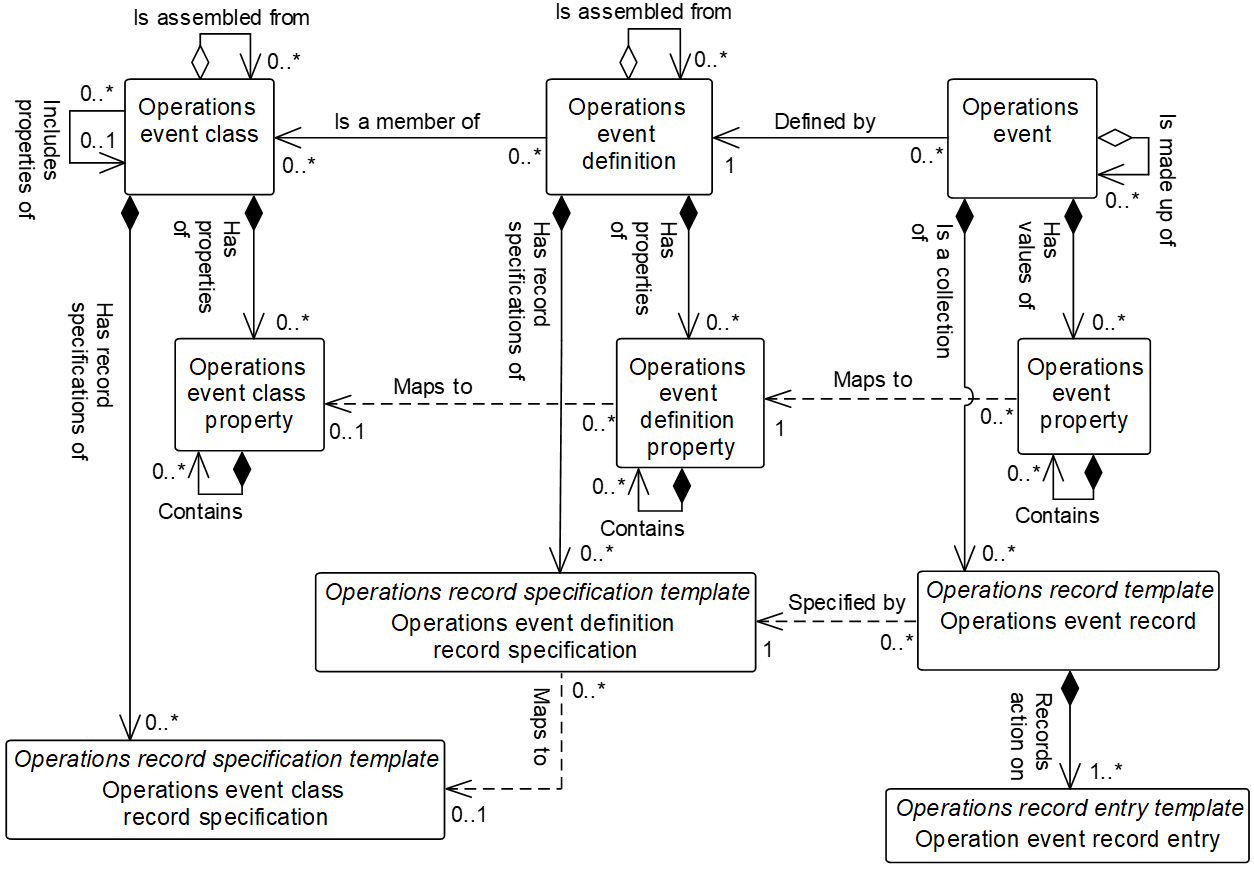


Figure 18 – Operations event model

NOTE 1 The operations event model in Figure 18 represents the abstract objects from operations record model in *italics* within each object derived from an abstract object. See the operations record modelfor specific details of the model.

The operations event model specializes the *operations record* object to represent required information per the scope requirements of the operations event model. The attributes and relationships for the *operations event record* shall include the attributes of the abstract object, *operations record*.

The operations record model specializes the supporting objects, *operations event class record specification* and the *operations event definition record specification*. The *operations event class record specification* and *operations event definition record specification* shall include the attributes of the abstract *operations record specification*.

Table 124 – Operations record model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations event class | Operations event class | Aggregation hierarchy | Is assembled from |
| Operations event class | Operations event class | Association | Includes properties of |
| Operations event class | Operations event class property | Composition | Has properties of |
| Operations event class | Operations event class record specification | Composition | Has record specification of |
| Operations event definition | Operations event definition | Aggregation hierarchy | Is assembled from |
| Operations event definition | Operations event class | Association | Is a member of |
| Operations event definition | Operations event definition property | Composition | Has properties of |
| Operations event definition | Operations event definition record specification | Composition | Has record specification of |
| Operations event | Operations event definition | Association | Defined by |
| Operations event | Operations event property | Composition | Has values of |
| Operations event | Operations event record | Composition | Is collection of |
| Operations event | Operations event | Aggregation hierarchy | Is made up of |
| Operations event record | Operations event record entry | Composition | Record action on |
| Operations event record | Operations event definition record specification | Dependency | Specified by |
| Operations event class property | Operations event class property | Composition hierarchy | Contains |
| Operations event definition property | Operations event definition property | Composition hierarchy | Contains |
| Operations event property | Operations event property | Composition hierarchy | Contains |
| Operations event property | Operations event definition property | Dependency | Maps to |
| Operations event definition property | Operations event class property | Dependency | Maps to |
| Operations event definition record specification | Operations event class record specification | Dependency | Maps to |

The structure of an *operations event* shall be defined by an *operations event definition*. The *operations event definition* provides a specification for an *operations event* message. This includes definition of the process context of the event (e.g. *work completed*) and the set of *information objects*, inclusive of their multiplicity rules, to be included in the *operations event*.

The *operations event class* defines grouping of *operations event definitions*. *Operations event definitions* can be grouped into zero, one or many *operations event classes*.

The *operations event profile* provides a documented scope and namespace separation for the *operations event definition* and *operations event class* entries. The *operations event profile* allows co-existence of notification messages defined by different standards (e.g. this standard, industry vertical standard, local enterprise standard, local business unit standard, etc.) to be communicated in a single messaging implementation with different standards message specifications partitioned by *operations profile*. An *operations event profile* typically exists in a physical *operations profile* document or messaging requirements specification, which represents the *operations event* *profile* alongside other documented characteristics (transaction profiles, message specifications, transaction channels, etc.) and requirements within the operating environment.

### Operations event class

An *operations event class* is a representation of groupings of *operations event definitions*.

Table 125 defines the relationship roles for the *operations event class*.

Table 126 defines the attributes for the *operations event class*.

An *operations event definition* (and the *operations event* occurrences created on the *operations event definition*) shall be a member of zero of more *operations event classes*.

Table 125 – Operations event class relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event class | Operations event class child | 0..\* | Is assembled from | The nested *operations event class(s)* makes up part of this *operations event class* as the whole. |
| Operations event class | Operations event class parent type | 0..1 | Includes properties of | This *operations event class(s)* include properties of the *operations event class*. |
| Operations event definition | NA | 0..\* | Is a member of | The *operations event definition(s)* that supports this *operations event class.*  The *operations event definition(s)* support the *operations event class property(s)* associated with this *operations event class.* |
| Operations event class property | Operations event class property | 0..\* | Has properties of | The *operations event class property(s)* of this *operations event class.* |
| Operations event class record specification | Operations event class record specification | 0..\* | Has record specification of | The *operations event class record specification(s)* related to this *operations event class.* |

Table 126 – Operations event class attributes

| Attribute names | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *operations event class.*  Required attribute. | Production, Deviation Alarm | Maintenance | MyOrg:Quality | MyOrg:Inventory |
| Description | Additional information and description about the *operations event class.* | Notification of job started | Reminder that PM is overdue | Test setup complete | Shipment arrived |
| Extension | Defines constraints on the inclusion of the respective *operations event class* in a hierarchy.  Defined value are   * sealed: no entry can use this entry as its parent; * (No entry): no entry allows any entry to represent this entry as its parent /ancestor.   NOTE 1 *Extension* can contain a set of entries of other *operations event classes* who represent this entry in their parent. | Sealed | NA | Sealed | NA |

The *operations event class* hierarchy enables representation of classes as an explicit enumerated set of subclasses.

EXAMPLE 1 Table 127 shows an example representation of an approval level defined value in *operations event class* entries. The *operations event class* has its extension attribute set to *line supervisor* and *plant manager* indicating only those children are allowed. The *line supervisor* and *plant manager* as *operations event class* entries have the extension attribute set to the defined value of sealedwhich prevents new entries to represent them as parents. This effectively locks these classes from modification.

Table 127 – Example of operations event class locked hierarchy

|  |  |  |
| --- | --- | --- |
| Operations event class ID | Operations event class parent attribute | Extension / defined value |
| Approval level | NA | Line supervisor, plant manager |
| Line supervisor | Approval level | Sealed |
| Plant manager | Approval level | Sealed |

EXAMPLE 2 A *PlantManager* *operations event class* has its parent class set to the *ApprovalLevel* *operations event class*. An *operations event* declaring the event is a member of the *PlantManager* *operations event class* infers that it also is a member of the *ApprovalLevel*. The *operations event class properties* and *operations event class record specifications* that defined the *ApprovalLevel operations event class* are also supported by all child classes.

### Operations event class property

Properties of an *operations event class* shall be listed as *operations event class properties*. An *operations event class* shall be further characterized through zero or more *operations event class properties*. *Operations event class properties* may contain nested *operations event class properties*.

Table 128 defines the relationship roles for the *operations event class property*.

Table 129 defines the attributes for *operations event class property*.

Table 128 – Operations event class property relationship roles

| Related Object | Role |  | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- | --- |
| Operations event class | NA |  | 1 | Has properties of | The *operations event class* defined in part by this *operations event class property.* |
| Operations event definition property | NA |  | 0..\* | Maps to | If the same ID exists in this *operations event class property*, the attributes of the *operations event definition property* are the same. |
| Operations event class property | Operations event class property child |  | 0..\* | Contains | The child *operations event classes* contained within this *operations event class.* |

Table 129 – Operations event class property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *operations event class property* unique under the parent *operations event class*.  Required attribute. | Line Stop | Parts Staged | Thermocouple Calibrated | Kanban Low |
| Description | Additional information and description about the *operations event class property.* | On time switch over | Scheduled maintenance | Test Checkout | Low Curtain Alarm |
| Property type | Defines the type of the property.  Defined types are   * class type: the property value is defined for the class and there is no value associated with an instance; * instance type: the property value of the class is undefined; and * default type: the property value is defined for the class as the default instance value, but individual instances of the class may redefine specific values. | Instance Type | Instance Type | Class Type | Default Type |
| Value | The value, set of values, or range of the associated property.  EXAMPLE  A range of possible numeric values, a list of possible values, or it can be empty if any value is valid. | 99387A | 105 | 88765 | 1856 |
| Value unit of measure | The unit of measure of the associated property values. | number | Hrs | % | Kg |

### Operations event class record specification

*Operations event classes* define common structures of *operations event definitions* using *operations event class record specifications*. *Operations event definitions* as members of an *operations event class* that contain *operations event class record specifications* must support the record specification entries indicated in the *operations event class*.

The structure and semantics of the *operations event class record specification* is the same as the *operations event definition record specification*.

Table 130 defines the relationship roles for the *operations event class record specification*.

Table 119 – Operations record specification template attributes are the abstract type definitions that define the attributes for the *operations event class record specification*.

Table 130 – Operations event class record specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event class | NA | 1 | Has record specification of | The *operations event class* defined in part by this *operations event definition record specification.* |
| Operations event definition record specification | NA | 0..\* | Maps to | If the *operations event definition* supports an *operations event class*, this *operations event class record specification(s)* is applied in the *operations event definition record specification(s).*  The *operations event definition record specification* maps to the corresponding *operations event class record specification.* |
| Operations event definition record specification | Operations event definition record specification child | 0..\* | Contains | This parent *operations event definition record specification* is whole of the child *operations event definition record specification(s)* as the part. |

The action attribute is the change on the data of an *information object* resulting because of the *operations event*. The action attribute is used in the following objects:

* *operations event class record specification;*
* *operations event definition record specification;* and
* *operations event record.*

The *operations event record* represents the action applied by the publisher/sender of the *information objects* included in the *operations event* exchange. The action attribute has the following defined values:

* created: create or add new entries;
* changed: update or edit existing entries;
* deleted: delete/deactivate/remove existing entries; and
* observed: the information object is included in the *operations event* for information purpose only.

### Operations event definition

Definition and structure of *operations event* occurrences shall be shown as an *operations event definition*. The *operations event definition* of an *operations event* is identified by the definition ID attribute in the *operations event* occurrence. Those constructing or interpreting an *operations event* obtain and validate the structure and definition from the *operations event definition*. Figure 19 depicts the relationship of *operations event definition* with *operations events*.

Table 131 defines the relationship roles for the *operations event definition*.

Table 132 defines the attributes for the *operations event definition*.

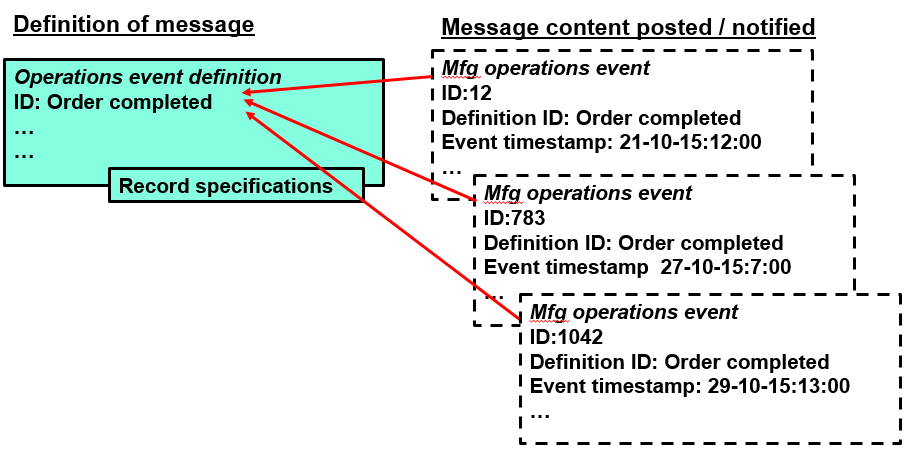


Figure 19 – Example, Relationship of operations event definition with operations events

*Operations event class and definition record specifications* shall provide explicit specification of the allowed content of *operations event record* attributes contained in an *operations event* occurrence.

An *operations event record* is validated against the corresponding *operations event class and definition record specification*.

EXAMPLE 1 XML representation extract of the *operations event* objects as depicted in Figure 19.

<OperationsEvent>

<DefinitionID>MyProfile:Order Completed</DefinitionID> // DefinitionID

NOTE 1 This indicates which *operations event definition* is followed in this message. The definition is represented as a FQN using the operations profile name to avoid clashes with other implementations.

………

</OperationsEvent>

NOTE 2 Some attributes in the *operations event* occurrence can be represented in the corresponding *operations event definition*.

NOTE 3 The representation of attributes in the *operations event* can explicitly provide potential value for infrastructure and application components to route, filter and process events based on these attributes without needing to lookup information in the corresponding *operations event definition* (which cannot be accessible in some environments).

Table 131 – Operations event definition relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event definition | Operations event definition child | 0..\* | Is assembled from | The nested *operations event definition(s)* makes up part of this *operations event definition* as the whole. |
| Operations event | NA | 0..\* | Defined by | The *operations event* that supports this *operations event definition.*  The *operations event* supports the *operations event definition property(s)* and *operations event definition record specification* associated with this *operations event definition.*  The *operations event* occurrences of the *operations event definition* where there are many occurrences for each definition. |
| Operations event class | Operations event class | 0..\* | Is a member of | *Operations event class(s)* supported by this *operations event definition.*  The *operations event definition* supports the *operations event class property(s)* and *operations event class record specification* associated with the *operations event class.* |
| Operations event definition record specification | Operations event definition record specification | 0..\* | Has record specifications of | The *operations event definition record specification(s)* related to this *operations event definition.* |
| Operations event definition property | Operations event definition property | 0..\* | Has properties of | The *operations event definition property(s)* specifies this *operations event definition.* |

Table 132 – Operations event definition attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the operations event definition.  Required attribute. | WorkAlert ScheduleUpdate DowntimeStart | JobCompleted | TestReport | Inven88 MaterialMovement |
| Description | Contains additional information and descriptions of the *operations event definition*. | Notification of job started | Reminder that PM is overdue | Test setup complete | Shipment arrived |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing | Manufacturing Line #2 | CNC Machine Asset ID 13465 | Test Cell 4 Receiving Warehouse B |
| Priority | List of the priorities that act as a guide to the relative level of importance of an *operations event.* | {1,2,3} | {Low, Medium, High} | {Information, Error} | {1...10} |
| Operations event type | The type of Level 3 *operations event.*  Defined values are  event, alert, and alarm. | Alarm | Alert | Event | Event |
| Operations event level | Defines the domain level of the *operations event* publisher.  Defined values are  Level 3 and Level 4. | 4 | 4 | 3 | 3 |
| Operations type | Describes the category of operation.  Required attribute.  Defined values are  production, inventory, quality, maintenance, and mixed.  “Mixed” can be used when the *operations event* does not refer to a specific operations activity or refers to several operation activities. | Production | Maintenance | Quality | Inventory |
| MOM function | Defines the MOM function of the *operations event* publisher.  Defined values from Part 3 MOM Activity Model are  resource management, definition management, detailed scheduling, dispatching, execution management, data collection, performance analysis, and tracking. | Detailed Scheduling | Dispatching | Analysis | Tracking |
| Enterprise function | Defines the enterprisefunction of the *operations event* publisher.  Defined values from Part 1 Functional Model are  order processing, operations scheduling, production control, material and energy control, procurement, quality assurance, product inventory control, product cost accounting, product shipping administration, maintenance management, marketing and sales, R&D, and engineering. | Order processing, | Maintenance management | Quality assurance | Product inventory control |
| Category | General grouping associated with an *operations event definition.*  EXAMPLE 2  Scheduling, PM, Lab, Receiving | Scheduling | Calibration | At Line Analysis | Receiving |
| Source | The activity that generated the *operations event*.  NOTE 3 This can be typically a process step or system application component. | Mixing phase,  Infeed |  | Lab C |  |
| Acknowledgment | The *operations event definition ID’s* of any expected subsequent notification. | MyProfile:A25 |  |  |  |

NOTE 4 The purpose of specifying an acknowledgement in an *operations event definition* is to satisfy application-level requirements for acknowledgement of an *operations event*. There can be some level of local transaction processing by the receiving application before publication of the acknowledgment *operations event*. It is not intended to provide a method for message receipt acknowledgement. Message receipt acknowledgement can be considered an infrastructure consideration of the messaging implementation.

EXAMPLE 3 A *operations event definition* for an *operations event type,* alarm, can be defined for flagging a specific alarm condition to another application, with the requirement that another application confirm that it has taken responsibility to manage the alarm condition to resolution. In such a case, the acknowledge attribute of the *operations event definition* for the alarm would contain the *operations event id* of the alarm acknowledgement *operations event*. The application that takes responsibility to manage the alarm condition to resolution would publish the alarm acknowledgement *operations event* when it has received the alarm *operations event* and executed its own internal logic to assume responsibility for resolution of the alarm condition.

### Operations event definition property

Properties of an *operations event definition* shall be defined as *operations event definition properties*. An *operations event definition* shall be further characterised through zero or more *operations event definition properties*. *Operations event definition properties* may contain nested *operations event definition properties*.

Table 133 defines the relationship roles for the *operations event definition property*.

Table 134 defines the attributes for the *operations event definition property*.

Table 133 – Operations event definition property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event definition | NA | 1 | Has properties of | The *operations event definition* defined in part by this *operations event definitions property.* |
| Operations event class property | Operations event class property | 0..1 | Maps to | If the *operations event definition* supports a *operations event class*, the *operations event class property(s)* are applied in the *operations event definition property(s)*.  This *operations event definition property* maps to the corresponding *operations event class property.* |
| Operations event property | NA | 0..\* | Maps to | The *operations event definition record specification(s)* related to this *operations event definition.* |
| Operations event definition property | Operations event definition property child | 0..\* | Contains | The nested *operations event definition property(s)* makes up part of this *operations event definition property* as the whole. |

Table 134 – Operations event definition property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *operations event definition property*.  Required attribute. | 124 | SM | 001 | 45 |
| Description | Additional information and description about the *operations event definition property.* | On time switch over | Scheduled maintenance | Test ready | Not applicable |
| Property type | Defines the type of the property.  Defined types are   * class type: the property value is defined for the *operations event definition* and there is no value associated with an instance; * instance type: the property value of the *operations event definition* is undefined; and * default type: the property value is defined for the *operations event definition* as the default instance value, but individual instances of the class may redefine specific values. | Instance Type | Instance Type | Class Type | Default Type |
| Value | The value, set of values, or range of the associated property.  EXAMPLE  A range of possible numeric values, a list of possible values, or it can be empty if any value is valid. | 99387A | 105 | 88765 | 1856 |
| Value unit of measure | The unit of measure of the associated property values. | number | Hrs | % | Kg |

### Operations event definition record specification

Specification of the allowed content of *operations event record* shall be defined as the *operations event definition record specification*.

Information object contents in an *operations event* vary depending on the process context of the *operations event*. The *operations event definition record specification* describes and specifies the information objects and associated actions that are allowed in the *operations event* occurrence. The publisher/sender shall follow this specification to construct the message. Subscribers/receivers shall use the *operations event definition record specification* to validate the content of the message.

Table 135 defines the relationship roles for the *operations event definition record specification*

Table 119 – Operations record specification template attributes are the abstract type definitions that define the attributes for the *operations event definition record specification*.

Table 135 – Operations event definition record specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event definition | NA | 1 | Has record specifications of | The *operations event definition(s)* defined in part by this *operations event definition record specification.* |
| Operations event record | NA | 0..\* | Specified by | If the *operations event* supports an *operations event definition*, the *operations event record(s)* is applied in this *operations event definition record specification.*  This *operations event record* maps to this corresponding *operations event definition record specification.*  Allowed Information object in *operations event record* defined by this entry. |
| Operations event class record specification | Operations event class record specification | 0..1 | Maps to | If the *operations event* supports an operations event class, the *operations event class record specification(s)* is applied in this *operations event definition record specification.*  This *operations event definition record specification* maps to the corresponding *operations event class record specification*. |
| Operations event definition record specification | Operations event definition record specification child | 0..\* | Contains | This parent *operations event definition record specification* is whole of the child *operations event definition record specification (s)* as the part. |

Each *operations event record* represents a single action. An *operations event definition record specification* may manage the contents of one to many *operations event records* in an *operations event* occurrence. The number of information object occurrences allowed in the *operations event* occurrences is specified using the information object type multiplicity attribute. The number of *actions* allowed for each *information object* is represented using the action multiplicity attribute.

*Operations event definition record specification* specify the required content of *operations event records* in an *operations event* occurrence.

The information object type multiplicity attribute specifies the number of *information object* occurrences allowed in each *operations event record* in an *operations event* occurrence.

The attribute, action multiplicity, specifies the number of each actions (e.g. added, changed, deleted, observed) allowed for each *information object* (represented in *operations record entry* objects in the *operations event* occurrence*)*.

EXAMPLE Operations event definition record specification ID, CR-87

Information object type: Material X,

Information object type multiplicity: 1,

Action: Added,

Action multiplicity: 1.

Each occurrence of the *operations event definition record specification ID,* CR-87, for a real-world *operations event* must contain an *operations event record* with one Material X (*information object*) with one *operations record entry* that has an action attribute with a value of added.

NOTE The ID entries can use the fully qualified name (FQN) syntax to avoid ID collisions.

### Operations event

Large numbers of real world events occur in any given manufacturing system. Only some real-world events are associated with manufacturing operations management activities and functions. The subset of those real-world events that require notification of process context specific information exchanges of this standard shall be defined as *operations events*. *Operations events* may be generated by any Level 4 or Level 3 function or activity.

*Operations events* notify subscribers of the publishers’ perspective of the real-world event process context and all pertinent information.

The following facets express the context of the *operations event.*

1. The ID of the *operations event definition* provides the process context.

EXAMPLE 1 *Resource acquired, work completed, operation scheduled*, etc.

1. The pertinent information as *operations event records*, each containing a bundle of *information objects*. The allowed *information objects* in an *operations event* occurrence are specified in the *operations event definition record specification* and/or *operations event class record specification*.

There are two models for conveying the *operations event* message:

* self-contained: all information relating to the context of the *operations event* is contained in the *operations event* message;
* referenced: the information pertaining to the context of the *operations event* can be accessed by the *operations event* subscriber using a known lookup process where the *operations event ID* is used as a token. The lookup process is outside the scope of the operations event model.

Table 136 defines the relationship roles for the *operations event*.

Table 137 defines the attributes for the *operations event*.

Table 136 – Operations event relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event record | Operations event record | 0..\* | Is a collection of | The *operations event records* related to this *operations event.* |
| Operations event property | Operations event property | 0..\* | Has values of | The *operations event property* values of this *operations event.* |
| Operations event definition | Operations event definition | 1 | Defined by | The *operations event definition* that defines the structure and generic context of the *operation event* message. |
| Operations event | Associated event child | 0..\* | Is made up of | This *operations event* is part of the related object as the whole. The associated events related to this *operations event* message. The reference is an ID with any additional attributes required. |

Table 137 – Operations event attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Unique identification of the *operations event*.  Required attribute. | P\_0004293 | M32D | 834 | Inven88 |
| Description | Additional information and description of the *operations event* occurrence. | The order P894 is delayed | The order M894 is delayed | The order Q894 is delayed | The order Inv894 is delayed |
| Effective timestamp | The date and time the real world event occurred. | Mon August 16 at 01:36 PM | 2014-03-07 10:00 UTC | 2010-04-27 10:30 | 2011-01-20 14:45 UTC-10 |
| Record timestamp | The time the *operations event* was recorded / transacted by the publisher. | Mon August 16 at 01:36 PM | 2014-03-07 10:01 UTC | 2010-04-27 10:30 | 2011-01-20 14:45 UTC-10 |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the object, such as the site or area. | East Wing manufacturing line #2 | CNC Machine  Asset ID 13465 | Test cell 4  Receiving | Warehouse B |
| Priority | *Priority* of the *operations event* thatIs a guide to the relative level of importance of an *operations event.* | 2 | Low | Error | 9 |
| Operations event type | The type of Level 3 *operations event.*  Defined values are  event, alert, and alarm.  This attribute must be defined in the corresponding *operations event definition*. | Alarm | Alert | Event | Event |
| Operations event level | Defines the *domain level* of the *operations event* publisher.  Defined values are  Level 3 and Level 4. | 4 | 4 | 3 | 3 |
| Operations type | Describes the category of operation.  Required attribute.  Defined values are production, inventory, quality, maintenance, and mixed.  “Mixed” can be used when the *operations event* does not refer to a specific operations activity or refers to several operation activities. | Production | Maintenance | Quality | Inventory |
| MOM function | Defines the *MOM function* of the *operations event* publisher.  Part 3 MOM Activity Model defined values are  resource management, definition management, detailed scheduling, dispatching, execution management, data collection, performance analysis, and tracking, | Detailed Scheduling | Dispatching | Analysis | Tracking |
| Enterprise function | Defines the enterprise function of the operations event publisher.  Defined values from Part 1 Functional Model are  order processing, operations scheduling, production control, material and energy control, procurement, quality assurance, product inventory control, product cost accounting, product shipping administration, maintenance management, marketing and sales, R&D, and engineering. | Order processing | Maintenance management | Quality assurance | Product inventory control |
| Category | General grouping associated with an *operations event definition*.  EXAMPLE 2  Scheduling, PM, Lab, Receiving | Scheduling | Calibration | At Line Analysis | Receiving |
| Source | The activity, function, task or phase that generated the *operations event*.  EXAMPLE 3  Procedural element, equipment module, workflow step or business process activity. | Mixing phase,  Infeed | Maintenance Work Order started | Lab C received Sample A12 | Kanban Level Low |

*Operations events* may be associated with other events to advise their relationship in the system. Typical application is the representation of *operations events* consumed by a process that then notified/published a new *operations event* that referenced the associated consumed event(s).

An individual *operations event* message indicates other associated *operations events* as a list of operations event ID’s.

EXAMPLE 4 Reporting of source operations event.

When an *operations event* (Definition ID: *JobOrderStarted*) is generated during the execution of a job order, the ID of the associated *WorkDispatched operations event* that contained the *job order* information can be represented as an associated operation event ID in the associated *operations event* list.

EXAMPLE 5 Detailed Scheduling.

When a *WorkDispatched* *operation event* is published after detailed scheduling of an *OperationsScheduled* *operations event,* the *WorkDispatched* *operations event* can reference the original *OperationsScheduled* operations event ID as an associated operations event ID in the associated *operations event* list.

EXAMPLE 6 Association of context with data to generate process centric events.

1. A MOM application suite based on process centric messaging interfaces to other MOM applications that are based on data centric messaging. The incoming data centric messages are republished as process centric events with the ID of the data centric event as an associated operations event ID in the associated event list. The data centric event can be represented as an *operations event* for consistency.
2. A scheduled data update event is received by a MOM application from another MOM application. An application receives the data event associates context with the data and republishes the event with the added context. The ID of the scheduled data update is reported as an associated operations event ID in the associated event list.

NOTE 1 Within manufacturing systems, there are two understood forms of *operations event* being alerts and alarms.

1. An *operations alert* is distinguished from other *operations events* (visually, audibly …)

EXAMPLE 7 List boxes in human machine interface. *Operations alerts* can be generated by any Level 4 or Level 2 action or activity related to Level 4 or Level 3 manufacturing operations activities.

1. An *operations alarm* which is distinguished from other *operations events* and can specify an acknowledgement *operations event* from subscribers. The acknowledgement is generated as a separate notification.

NOTE 2 ISA-18.02-2009 Management of Alarm Systems Process Industries represents detailed information on alarm management.

### Operations event property

Properties of an *operations event* shall be defined as *operations event properties*. An *operations event* shall be further characterized through zero or more *operations event properties*. *Operations event properties* may contain nested *operations event properties*.

Table 138 defines the relationship roles for the *operations event property*.

Table 139 defines the attributes for the *operations event property*.

Table 138 – Operations event property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event | NA | 1 | Has value of | This *operations event property(s)* values in part for the *operations event* as the whole. |
| Operations event definition property | *Operations* event definition property | 1 | Maps to | The *operations event(s)* supports the *operations definition.* The *operations event definition property(s)* is applied in this *operations event property(s).*  This *operations event property* maps to the corresponding *operations event definition property*  If the same ID exists in an *operations event definition property,* the attributes of the property will be the same. |
| Operations event property | Operations event property child | 0..\* | Contains | The nested *operations event property(s)* makes up part of this *operations event property* as the whole |

Table 139 – Operations event property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *operations event property.*  Required attribute. | 124 | SM | 001 | 45 |
| Description | Additional information about the *operations event property*. | On time switch over | Scheduled maintenance | Test ready | Not applicable |
| Value | The value, set of values, or range of the property. | 99387A | 105 | 88765 | 1856 |
| Value unit of measure | The unit of measure / format of the value. | Number | Hrs | % | Kg |

### Operations event record

The bundle of *operations event record entry* objects that are pertinent to the real-world MOM event shall be defined as an *operations event record*.

Table 140 defines the relationship roles for the *operations event record*.

Table 141 defines the attributes for the *operations event record*.

Table 140 – Operations event record relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event | NA | 1 | Is a collection of | The *operations event record* related to this *operations event record.*  *Operations event records* are child objects within an *operations event.* |
| Operations record entry | Operations record entry | 1..\* | Records action on | This *operations record* acts as a container for *operations record entry(s)* with common actionattribute applied. |
| Operations event definition record specification | Operations event definition record specification | 1 | Specified by | The *operations event definition record specification* defines the allowed information objects contained within this *operations event record.* The specified actions must match the action attribute in this *operations event record entry* |
| Operations event record | Operations event record child | 0..\* | Contains | This parent *operations event record* is whole of the child *operations event record(s)* as the part. |

Table 141 – Operations event record attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Unique identification of the *operations event record.*  Required attribute. | 459293A1-T423 ver 1.0  A4Q59492-X43S  Polymer56-PRS42 | 2014-03-06 10:00 UTC | 2010-04-26 10:30 | 2011-01-20 12:45 UTC-10 |
| Description | Contains additional information and description of the *operations event record*. | Mixer event record MX-3P | Mixer PM Workflow record MX-3A | CAPA workflow event record QA-5P | KanBan event record CAP-5 |
| Action | The action performed on the *operations event record entry* within the *operations event record.*  Defined values are  added, changed, deleted and observed. | Deleted  Observed | Added | Changed | Changed |
| Effective timestamp | The date and time for which the *operations event record* and its *action* was/is effective.  The effective timestamp attribute explicitly states the time of the real-world event.  If no entry is provided, the *effective timestamp* is the *effective timestamp* represented in the *operations event*. | Mon August 15 at 01:36 PM | 2014-03-06 10:00 UTC | 2010-04-26 10:30 | 2011-01-20 12:45 UTC-10 |
| Record timestamp | The date and time the publisher recorded/transacted the *action*.  The record timestamp attribute explicitly states the time that the publisher/sender took the reported *action*.  If no entry is provided, the *record timestamp* is the *record timestamp* represented in the *operations event*. | Mon August 16 at 01:36 PM | 2014-03-07 10:05 UTC | 2010-04-27 10:00 | 2011-01-20 14:45 UTC-10 |

NOTE 1 An action attribute can be recorded or be available at times after the real-world event took place. Recipients of the *operations event* can have a different record of information objects at the time reported for the *operations event* occurrence due to external factors.

NOTE 2 If there are multiple actions recorded, the times that these actions occurred can be relevant to the interpretation and context of the *operations event*.

EXAMPLE A *operations* *schedule* update (event) creates requirements for new *material lot* and *person* objects in the source system. The publisher/sender advises that the *operations schedule* was created after the new *material lot* and *person* objects were created.

NOTE 3 The ID entries can use the FQN syntax to avoid ID collisions.

### Operations event record entry

The *operations event record entry* objectshall be a single information object and any third-party manufacturing operations message profile within an *operations event record*. There shall be one or more *operations event record entry* objectsin an *operations event* *record*.

The relationships and their roles in an *operations event record entry* are defined in the *operations record specification*.

EXAMPLE 1 *Operations schedule* and *material lot* as information objects require two *operations event record entry* objects in an *operations event record*.

Table 142 defines the relationship roles for *operations event record entry*.

Table 143 defines the attributes for *operations event record entry*.

Table 142 – Operations event record entry relationships

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations event record | NA | 1 | Records action on | The *operations event record* applying a single common action (e.g. Changed) acts as a container for this *operations event entry(s)*. |
| Operations event record entry | Operations event record entry child | 0..\* | Contains | This parent *operations event record entry* is whole of the child *operations event* *record entry(s)* as the part. |
| Information object | Information object | 0..1 | Corresponds to an entry in | An embedded information object.  If data is referenced in this *operations event record entry*, the attribute is not used.  The format of the *information object* is specified in the *operations event record specification*. |
| Information object | External reference | 0..1 | Corresponds to an entry in | The reference to external data (information object) which is stored external to this *operations event record entry*.  If data is embedded in this *operations event record entry*, the attribute is not used.  The format of the reference is specified in the *operations event record specification*. |

Table 143 – Operations event record entry attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | ID which is unique within the scope of *operations event record.*  Required attribute. | 1 | 4A34B | 239432 | A11 |
| Description | Additional information about the *operations event record entry*. | The control recipe is embedded in this *operations event record* |  |  | Data set time series data is stored in the historian database |
| Information object | An embedded information object  If data is referenced in this *operations event record entry*, the attribute is not used.  The format of the information object is specified in this *operations record specification*. | Material Lot 11A | Mixer 4 | Work Master QC5001 | Material Lot 59B |
| Information object ID | The reference to external data *(information object*) which is stored external to this *operations event record entry*.  If data is embedded in this *operations event record entry,* the attribute is not used.  The format of the reference is specified in this *operations event record specification*. | Material Lot 11A | Mixer 4 | Work Master QC5001 | Material Lot 59B |
| Effective timestamp | The date and time that the *operations event record entry* was/is effective.  If no effective timestamp is provided with *operations event record entry*, the effective timestamp is represented by the effective timestamp attribute in the *operations event record*. | Mon August 15 at 01:36 PM | 2014-03-06 11:00 UTC | 2010-04-26 10:30 | 2011-01-20 12:45 UTC-10 |
| Record timestamp | The date and time the publisher recorded / transacted the action.  If no entry is provided, the record timestamp is the record timestamp attribute in the *operations event record*. | Mon August 16 at 01:36 PM | 2014-03-07 10:00 UTC | 2010-04-27 12:30 |  |
| Information object type | Identifies the type of information object type that an *operations event record* entry is based upon.  The allowed information object types are defined in the *operations event record specification.* | Work Master  Control Recipe | Physical Asset | Test Specification | Equipment |

NOTE When multiple *operations event record entry(s)* are exchanged, the effective timestamps of these *actions* of when each occurred can be relevant to the interpretation of the *operations event record*.

EXAMPLE 2 A *OperationsScheduleUpdate* (event) creates requirements for new *material lot* and *person* objects in the source system. The publisher/sender advises that the operations *schedule* was created after the new *material lot* and *person* objects were created.

## Containers, tools and software

### Containers

A container for *material* shall be presented as role based *equipment* or a *physical asset* or both where it is specified as a *storage location* with *storage location type* of storage zone or storage unit*.*

EXAMPLE 1 In a refinery; bulk storage tanks can be represented as storage units and as containers for specific *materials*.

EXAMPLE 2 In an automotive plant; assembly parts bins can be represented as storage units and as containers for an assembly of parts.

EXAMPLE 3 In a pharmaceutical plant; portable tote bins or pallets that hold tablets can be represented as storage units for a specific *material lot* or *material sublot.*

EXAMPLE 4 In rail transportation; wagons can be represented as *physical assets*, assembled into rakes and trains.

EXAMPLE 5 Properties of containers can be represented as *equipment class, equipment, physical asset class, or physical asset properties*, such as: readiness, transportability, disposable, and cleanness.

The association of *material lots* and *material sublots* to containers shall be via the storage location and hierarchy scope attributes of the *material lot* or *material sublot*.

### Tools

A tool shall be presented as role based *equipment*, *physical asset*, or both.

EXAMPLE 1 In a pharmaceutical plant; a tablet die used to compress and shape tablets would be represented as a work unit. The tablet die work unit can have properties that identified the expected use time and the actual use time.

EXAMPLE 2 In plastics parts manufacturing; an extruder die would be represented as a work unit. The extruder machine could be represented as a work cell.

EXAMPLE 3 In semiconductor manufacturing; a multi-platen multi-wafer CMP (chemical mechanical polishing) tool would be represented as a work cell.

EXAMPLE 4 A micrometer used for measuring sheet metal thickness in a general purpose machine shop can be recorded as *equipment* but not tracked as a *physical asset*.

### Software

Software shall be presented as role based *equipment*, *physical asset*, or both.

NOTE Level 3 applications can have responsibility for keeping the actual software up to date. In the context of this standard, information about the software can need to be specified, reported or synchronized with Level 4 systems.

EXAMPLE 1 When a patch is applied to software the change can need to be known by Level 3 systems to allow additional testing and Level 4 systems to update security settings.

EXAMPLE 2 When a *physical asset* is decommissioned, and it contains licensed software, then a Level 4 system can need the information to order software uninstalls, to order asset memory clearing or to know to cancel the maintenance license fee.

# Operations management information

## Operations definition information

### Operations definition model

An *operations definition* defines the resources required to perform a specified operation. The *operations definition* may apply to defining production, maintenance, quality test and inventory operations. The actual definition of how to perform the operation is not included in the object model and are defined in a *work definition*.

*Work definitions* are defined as the information used to instruct a manufacturing operation how to perform the operation.

NOTE 1 Based on the production strategy used, production operations specific instructions can be called a

* general recipe (IEC 61512 series),
* site recipe (IEC 61512 series),
* master recipe (IEC 61512 series),
* standard operating procedure (SOP),
* standard operating conditions (SOC),
* master or product routing, or
* assembly steps.

An *operations definition* may be a specialization of another *operations definition*. An *operations definition* shall be defined as pattern or instance. A pattern *operations definition* defines a ‘template’, upon which other or instance *operations definitions* may be based. Unlike instance *operations definitions*, pattern *operations definitions* shall not be directly scheduled or tracked. Therefore, *operations requests* and *operations responses* shall not reference pattern *operations definitions*.

Pattern *operations definitions* shall provide a basis for standardization and reuse of pattern *operations definitions* across many instance *operations definitions* across and between plants. Where an *operations definition* references a *work master* defined in Part 4 of this standard, the definition type (pattern or instance) attribute of the referenced *work master* shall have the same value as that of the *operations definition*.

The *operations material bill* and *bill of resources* of an *operations definition* may map to those of any pattern *operations definition* upon which the *operations definition* is based.

EXAMPLE 1 A pattern *operations definition* can reference an *operations material bill* that contains items referencing *material classes*, while a instance *operations definition* based on this pattern *operations definition* can reference an *operations material bill* that contains items referencing *material definitions* belonging to those *material classes*.

EXAMPLE 2 A mining organization could define the following pattern and instance *operations definitions*:

* loading (pattern);
* train loading (pattern), specialization of loading (pattern);
* ship loading (pattern), specialization of loading (pattern);
* Site S1 train loading (instance), specialization of train loading (pattern);
* Site S2 ship loading (instance), specialization of ship loading (pattern)

Figure 20 illustrates the operations definition model. Table 144 lists the relationships of the objects in the operations definition model.

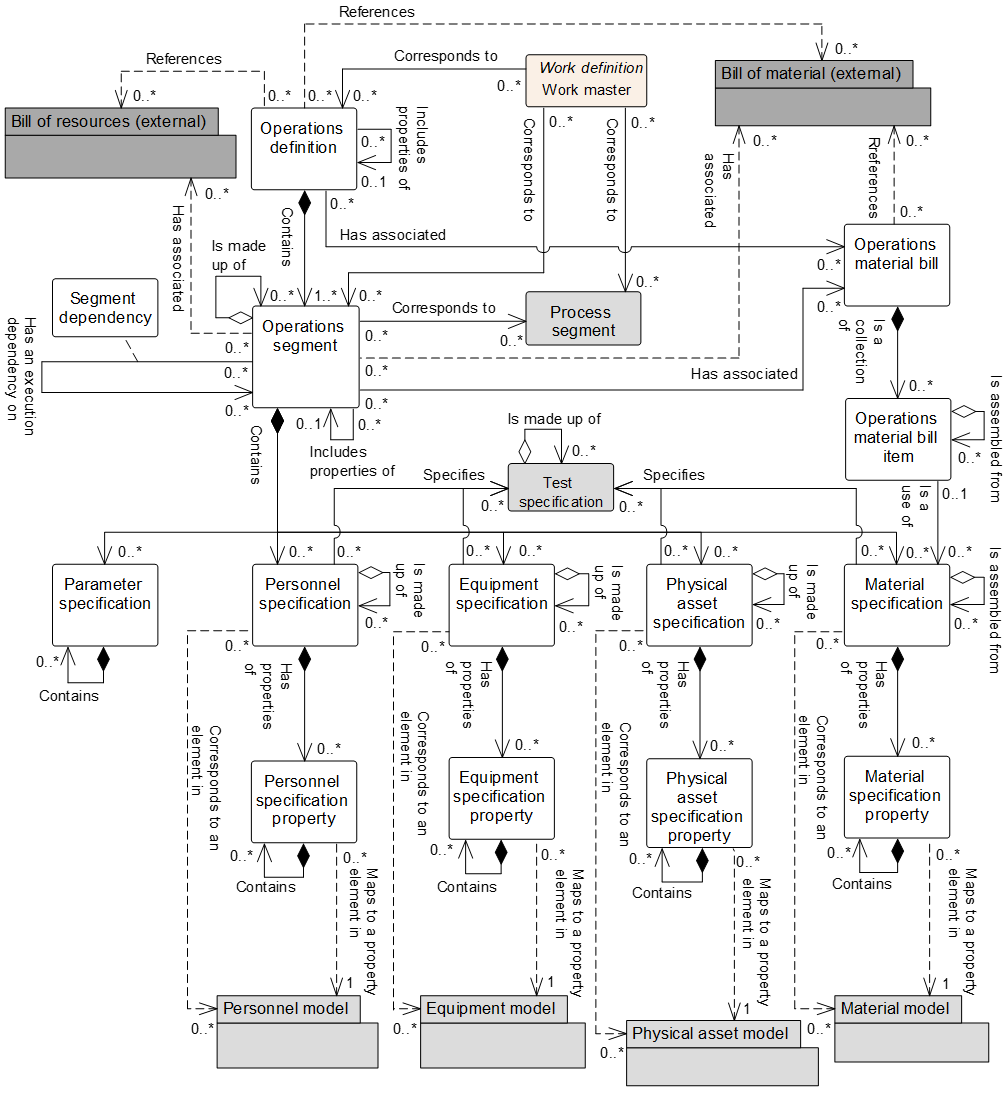


Figure 20 – Operations definition model

NOTE 2 Two options can be used to exchange an external bill of material.

Option 1: The *operations segment* has its “has associated” dependency relationship to external *bill of resources* (BOR) that can be exchanged using the *operations segment* to exchange an operations bill of resource(s) using each resource specification object and the “is made up of” aggregation hierarchy to list the associated resource items of the operation BOR.

EXAMPLE 3 An external bill of material can use a *material specification* object to exchange the operations bill of material that is part of an overall external bill of resources.

Option 2: The *operations definition* and the *operations material bill* have the “references” dependency relationship to the external *bill of material;* in addition, the *operations definition* and the *operations segment* have the “has associated” association relationship to the *operations material bill* object that can be used to exchange the external bill of materials.

This duplication of capability in the operation definition model exist because the only *operations material bill* object and its relationships were defined in earlier versions of the standard. Option 2 is widely applied across industry.Both the *operations definition* and the *operations segment* can be used to exchange bill of material information while the *operations segment* can be used to exchange a complete bill of resource as described in Option 1.

To simplify Figure 20, the relationships between the resource specification objects and *test specification* are shown but not their relationships to the *test result*. For the complete contextual view of the information model, Table 144 does lists the all relationships between the resource specification objects and *test specification* and *test result* with all relationship roles defined in each object subclause in their relationship role table.

All relationships to *test specification* and *test result* are shown in Figure 16 – Operations test model and listed in Table 99 – Operations test requirement relationship roles.

NOTE 3 The work definition model and its *work master* object are defined in Part 4 of this standard.

NOTE 4 The object color convention used in the Part 2 and Part 4 UML diagrams for information models is as shown as shown in Clause 3.3.3.

Table 144 – Operations definition model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations definition | Operations definition | Association | Includes properties of |
| Operations definition | Operations segment | Composition whole | Contains |
| Operations definition | Operations material bill | Association | Has associated |
| Operations definition | Bill of resources (external) | Dependency | References |
| Operations definition | Bill of material (external) | Dependency | References |
| Work master  (Defined in Part 4) | Operations definition | Association | Corresponds to |
| Operations segment | Operations segment | Association class with *segment dependency* | Has an execution dependency on |
| Segment dependency | Operations segment | Association class with *segment dependency* | Has an execution dependency on |
| Operations segment | Operations segment | Aggregation hierarchy | Is made up of |
| Operations segment | Operations segment | Association | Includes properties of |
| Operations segment | Process segment | Association | Corresponds to |
| Operations segment | Bill of resources (external) | Dependency | Has associated |
| Operations segment | Bill of material (external) | Dependency | Has associated |
| Operations segment | Operations material bill | Association | Has associated |
| Work master (Defined in Part 2) | Operations segment | Association | Corresponds to |
| Operations segment | Parameter specification | Composition whole | Contains |
| Operations segment | Personnel specification | Composition whole | Contains |
| Operations segment | Equipment specification | Composition whole | Contains |
| Operations segment | Physical asset specification | Composition whole | Contains |
| Operations segment | Material specification | Composition whole | Contains |
| Parameter specification | Parameter specification | Composition hierarchy | Contains |
| Operations material bill | Operations material bill item | Composition whole | Is a collection of |
| Operations material bill | Bill of material (external) | Dependency | References |
| Operations material bill item | Operations material bill item | Aggregation hierarchy | Is assembled from |
| Operations material bill item | Material specification | Association | Is a use of |
| Personnel specification,  equipment specification,  physical asset specification, and  material specification. | Test specification  Refer to Figure 16. | Association | Specifies |
| Test specification  Refer to Figure 16. | Personnel specification,  equipment specification,  physical asset specification, and  material specification. | Association | Specifies test for |
| Test result  Refer to Figure 16. | Personnel specification,  equipment specification,  physical asset specification, and  material specification. | Association | Generated in context of |
| Personnel specification | Personnel specification | Aggregation hierarchy | Is made up of |
| Personnel specification | Personnel specification property | Composition whole | Has properties of |
| Personnel specification property | Personnel specification property | Composition hierarchy | Contains |
| Personnel specification | Personnel class | Association (A) | Corresponds to |
| Personnel specification | Person | Association (C) | Corresponds to |
| Personnel specification property | Personnel class property | Dependency (B) | Maps to |
| Personnel specification property | Person property | Dependency (D) | Maps to |
| Equipment specification | Equipment specification | Aggregation hierarchy | Is made up of |
| Equipment specification | Equipment specification property | Composition whole | Has properties of |
| Equipment specification property | Equipment specification property | Composition hierarchy | Contains |
| Equipment specification | Equipment class | Association (A) | Corresponds to |
| Equipment specification | Equipment | Association (C) | Corresponds to |
| Equipment specification property | Equipment class property | Dependency (B) | Maps to |
| Equipment specification property | Equipment property | Dependency (D) | Maps to |
| Physical asset specification | Physical asset specification | Aggregation hierarchy | Is made up of |
| Physical asset specification | Physical asset specification property | Composition whole | Has properties of |
| Physical asset specification property | Physical asset specification property | Composition hierarchy | Contains |
| Physical asset specification | Physical asset class | Association (A) | Corresponds to |
| Physical asset specification | Physical asset | Association (C) | Corresponds to |
| Physical asset specification property | Physical asset class property | Dependency (B) | Maps to |
| Physical asset specification property | Physical asset property | Dependency (D) | Maps to |
| Material specification | Material specification | Aggregation hierarchy | Is assembled from |
| Material specification | Material specification property | Composition whole | Has properties of |
| Material specification property | Material specification property | Composition hierarchy | Contains |
| Material specification | Material class | Association (A) | Corresponds to |
| Material specification | Material definition | Association (A) | Corresponds to |
| Material specification | Material lot | Association (C) | Corresponds to |
| Material specification | Material sublot | Association (C) | Corresponds to |
| Material specification property | Material class property | Dependency (B) | Maps to |
| Material specification property | Material definition property | Dependency (B) | Maps to |
| Material specification property | Material lot property | Dependency (D) | Maps to |

### Operations definition

The resources required to perform a specified operation shall be presented as an *operations definition*.

Table 145 defines the relationship roles for the *operations definition*.

Table 146 defines the attributes for the *operations definition*.

Table 145 – Operations definition relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations segment | Operations segment | 1..\* | Contains | The detailed information needed to quantify a specific *operation definition.* |
| Operations definition | Operations definition parent type | 0..1 | Includes properties of | This *operations definition class(s)* include properties of the *operations definition class*. |
| Work master (Defined in Part 4) | NA | 0..\* | Corresponds to | This *operations definition(s)* applies zero to many *work masters.* |
| Bill of resources (external) | Bill of resources (external) | 0..\* | References | Identification of the external *bill of resource* associated with this *operation definition*. |
| Bill of material (external) | Bill of material (external) | 0..\* | References | Identification of the external *bill of material* associated with this *operation definition.* |
| Operations material bill | Operations material bill | 0..\* | Has associated | Identification of the *operations material bill* associated with this *operations definition.* |

Table 146 – Operations definition attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Uniquely identifies the *operations definition.*  Required attribute.  The ID is used in other parts of the model when the *operations definition* needs to be identified. | Export Quality Widget | Medium Size AC Motor Overhaul | Potency Test Procedure | Tank Transfer Procedure |
| Version | An identification of the version of the *operations definition*.  In cases where there are multiple versions of an *operations definition*, then the version attribute shall contain the additional identification information to differentiate each version. | 1.0 | 1.4 | 1.1 | 1.1 |
| Description | Contains additional information and descriptions of the *operations definition.* | Information defining resources required for production of a single ‘Export Quality Widget’. | For overhauls of motors less than 200 HP. | Test for potency of product | Movement of material from one tank to another |
| Operations type | Describes the category of operation.  Required attribute.  Defined values are  production, maintenance, quality, inventory, or mixed.  “Mixed” can be used when the *operations definition* contains several types of *operations requests* and/or *segment requirements.* | Production | Maintenance | Quality | Inventory |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Definition type | Defines the type of the *operations definition*.  Defined values are   * pattern: an *operations definition* used as a template for other *operations definitions*; * instance: an *operations definition* that may be directly scheduled and tracked. | Pattern | Instance | Instance | Pattern |

NOTE 1 In the case of production, an operations definition IDcan be the same ID as a *material definition.*

NOTE 2 A MIMOSA solution package is the equivalent of an *operations definition* for maintenance.

### Operations material bill

The collection of all material used in the operation, independent of the *process segment* the material is used in, shall be presented as *operations material bills*.

There may be multiple *operations material bills* with different uses.

EXAMPLE There can be one *operations material bill* for consumed materials and a second *operations material bill* for produced materials.

Table 147 defines the relationship roles for the *operations material bill*.

Table 148 defines the attributes for the *operations material bill*.

Table 147 – Operations material bill relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations definition | NA | 0..\* | Has associated | Identification of the *operations definition* associated with this *operations material bill.* |
| Operations segment | NA | 0..\* | Has associated | Identification of the *operations segment* associated with this *operations material bill.* |
| Bill of material | Bill of material | 0..\* | References | Identification of the *bill of material* associated with this *operations material bill*. |
| Operations material bill item | Operations material bill item | 0..\* | Is a collection of | The *material bill items* that are part of this *operations material bill.* |

Table 148 – Operations material bill attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a *manufacturing* *bill*.  Required attribute. | 10000 | 552619 | Q123AC3 | 755433 |
| Description | Contains additional information of the *manufacturing* *bill.* | All materials required in the manufacturing process for a single widget. | Silicon Base Bearing Grease | Chart Paper | Pallet |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Use type | Defines the use of the *material*.  EXAMPLE 1  Consumed: indicates that *operations material bill items* are all consumed *material*.  EXAMPLE 2  Produced: indicates that *operations material bill items* are all produced *materials*. | Consumed | Consumed | Consumed | Consumed |

### Operations material bill item

The items that make up the complete *operations material bill* shall be presented as *operations material bill items*.

1. An *operations material bill item* may be defined as containing an assembly of *operations material bill items* and as part of an assembly of *operations material bill items*.
2. An *operations material bill item* may define an assembly of zero or more *operations material bill items*.
3. An *operations material bill item* may be an assembly element of zero or more *operations material bill items*.
4. An assembly may be defined as a permanent or transient assembly of *operations material bill items*.
5. An assembly may be defined as physical or a logical assembly of *operations material bill items*.

Table 149 defines the relationship roles for the *operations material bill item*.

Table 150 defines the attributes for the *operations material bill item*.

Table 149 – Operations material bill item relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations material bill | NA | 1 | Is a collection of | The *operations material bill* that this *operations material bill item* is a part. |
| Operations material bill item | Operations material bill item child | 0..\* | Is assembled from | The child *operations material bill item(s)* makes up part of this *operations material bill item* as the whole. |
| Material specification | Material specification | 0..\* | Is use of | The *material specification(s)* defines this specified *operation material bill item(s).* |

Table 150 – Operations material bill item attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a *bill* item.  Required attribute. | 10000827 | 552619 | Q123AC3 | 755433 |
| Description | Contains additional information of the *operations material* *bill* item*.* | All materials required in the manufacturing process for a single widget. | Silicon Base Bearing Grease | Chart Paper | Pallet |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Material class | Identifies the associated *material class* or set of *material classes* required. | {Polymer sheet stock 1001A, Rivets} | Fred’s Bearing, Grease | Circular Chart Paper | 4x4 pallet |
| Material definition | Identifies the associated *material definition* or set of *material definitions* required. | {Sheet stock 1443a , Rivet-10002} | {20 mm Bearing, NLGI Grade 2 Grease} | 10” diameter circular chart paper | 1 000 lb Weight load 4x4 pallet |
| Use type | Defines the use of the *material*.  EXAMPLE 1  Consumed: indicates that *operations material bill items* are all consumed *material*.  EXAMPLE 2  Produced: indicates that *operations material bill items* are all produced *materials*. | Consumed | Consumed | Consumed | Consumed |
| Assembly type | Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area; * logical: the components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process; * transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit. | Permanent | Transient | Permanent | Transient |
| Quantity | Specifies the amount of resources required. | {1,0, 26} | {2, 30} | 5 | 100 |
| Quantity unit of measure | The unit of measure of the associated quantity. | {Sheets / piece, Number / piece} | {piece, ml} | Each | Each |

### Operations segment

The information needed to quantify a segment for a specific operation shall be presented as an *operations segment*. An *operations segment* identifies, references, or corresponds to a *process segment*.

An *operations segment* within an *operations definition* that is specialization of another *operations definition* may be a specialization of an *operations segment* within that other *operations definition*.

A pattern *operations segment* defines a ‘template’, upon which other pattern or instance *operations segments* may be based. Unlike instance *operations segments*, pattern *operations segments* shall not be directly scheduled or tracked. Therefore, *segment requirements*, *segment responses* and *operations segment capabilities* shall not reference pattern *operations segments*.

*Operations segments* shall assume the definition type (pattern or instance) of the *operations definition* to which they belong. Therefore, all *operations segments* contained within a pattern *operations definition* shall be assumed to be a pattern, while all *operations segments* contained within an instance *operations definition* shall be assumed to be an instance.

Where an *operations segment* references a *work master*, the definition type attribute of the referenced *work master* shall have the same value as that of the *operations segment*. Where an *operations segment* references a *process segment*, the definition type attribute of the referenced *process segment* shall have the same value as that of the *operations segment*.

The parameter, personnel, equipment, physical asset and material specifications of an *operations segment* may map to those of any pattern *operations segment* upon which the *operations segment* is based.

EXAMPLE 1 A pattern *operations segment* can contain *material specifications* that reference *material classes*, while an instance *operations segment* based on this pattern *operations segment* can contain *material specifications* that reference *material definitions* belonging to those *material classes.*

Table 151 defines the relationship roles for the *operations segment*.

Table 152 defines the attributes for the *operations segment*.

Table 151 – Operations segment relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations definition | NA | 1 | Contains | A collection information required to perform the specified operation.  EXAMPLE 2  - Material Bill  - Bill of Resources  - Work Definition |
| Operations segment | Operations segment parent type | 0..1 | Includes properties of | This *operations segment class(s)* include properties of the *operations segment* *class*. |
| Process segment | Process segment | 0..\* | Corresponds to | The *process segments* correspond to this *operations segment.* Identifies the associated *process segments.* There can be multiple alternate *process segments* used for this *operations segment.* |
| Work master (Defined in Part 4) | NA | 0..\* | Corresponds to | *Work masters* related to this *operations segment.*  Information used to instruct **how** to perform the operation based on strategy used.  EXAMPLE 3  - master recipe  - routing  - assembly steps  - standard operating procedure (SOP)  - standard operation condition (SOC)  - work master (Defined in Part 4) |
| Operations segment | Operations segment child | 0..\* | Is made up of | *Operations segment(s)* makes up part of this *operations segment* as the whole. |
| Operations segment | Operations segment | 0..\* | Has an execution dependency on | *Operations segment has an association class relationship with segment dependency.*  *The operations segment(s) applying the ordering / sequencing rules from the segment dependency related to the operations segment* execution. |
| Segment dependency | Segment dependency | 0..\* | Has an execution dependency on | *Operations segment* has an association class relationship with *segment dependency.*  The ordering / sequencing rules related to the *operations segment* execution. The source *operations segments* that the target *operations segments* are dependent. |
| Bill of resources (external) | Bill of resources (external) | 0..\* | Has associated | Identification of the *external bill of material* associated with this *operation segment.* |
| Bill of material (external) | Bill of material (external) | 0..\* | Has associated | Identification of the *external bill of material* associated with this *operation segment.* |
| Operations material bill | Operations material bill | 0..\* | Has associated | Identification of the *operations material bill* associated with this *operations segment.* |
| Parameter specification | Parameter specification | 0..\* | Contains | The *parameter specification(s)* related to this *operations segment.* |
| Personnel specification | Personnel specification | 0..\* | Contains | The *personnel specification(s)* related to this *operations segment.* |
| Equipment specification | Equipment specification | 0..\* | Contains | The *equipment specification(s)* related to this *operations segment.* |
| Physical asset specification | Physical asset specification | 0..\* | Contains | The *physical asset specification(s)* related to this *operations segment.* |
| Material specification | Material specification | 0..\* | Contains | The *material specification(s)* related to this *operations segment.* |

Table 152 – Operations segment attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific segment within the scope of the information exchanged.  Required attribute.  The ID is used in other parts of the model when the segment needs to be identified. | Final Polished Widget | 200 HP AC Motor Disassemble | 120VAC Meter Test 001 | Line 1 Raw Material Stage |
| Description | Contains additional information of the segment. | A brightly polished widget. | Disassembly of motor prior to rebuild | Test range of volt meter | Material staging for shift |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA) | Asset ID 13465 | Test Cell 4 | Ware-house B |
| Duration | Duration of segment, if known. | 25 min | 4 | 15 | 30 |
| Duration unit of measure | The units of measure of the duration, if defined. | Minutes | Hours | Seconds | Minutes |
| Operations type | Describes the category of operation.  Defined values are  production, maintenance, quality, inventory, or mixed.  “Mixed” can be used when the *operations segment* contains several types of *operations requests* and/or *segment requirements*. | Production | Maintenance | Quality | Inventory |
| Definition type | Defines the type of the *operations definition*.  Defined values are   * pattern: an *operations definition* used as a template for other *operations definitions*; * instance: an *operations definition* that may be directly scheduled and tracked. | Pattern | Instance | Instance | Pattern |

NOTE 1 A MIMOSA ordered list is the equivalent of an *operations segment* for maintenance operations.

NOTE 2 A MIMOSA ordered list resource item is the equivalent of a single item *personnel specification, equipment specification, physical asset specification* or *material specification* for a maintenance *operations segment*.

### Parameter specification

Specific parameters required for an *operations segment* shall be presented as *parameter specifications.* An *operations segment* may have an associated set of zero or more *parameter specifications*. The *parameter specification* contains the names and types of the values that may be sent to the Level 3 systems to parameterize the operation.

*Parameter specifications* may contain nested *parameter specifications*.

EXAMPLE 1 *Parameter specifications* can include pH of 3.5, pressure limit of 35 psi, and flange color = orange.

*Parameter specifications* shall include

1. an identification of the parameter and
2. the units of measure of the parameter value.

*Parameter specifications* should include

1. a default value for the parameter or
2. possible ranges of the parameter value.

EXAMPLE 2 Ranges can be alarm or quality ranges; tolerances for acceptable parameter values.

Table 153 defines the relationship roles for the *parameter specification*.

Table 154 defines the attributes for the *parameter specification*.

Table 153 – Parameter specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations Segment | NA | 1 | Contains | The *operations segment(s)* is defined in part by this *parameter specification*. |
| Parameter specification | Parameter specification child | 0..\* | Contains | The child *parameter specification(s)* that are part of this *parameter specification* as whole*.* |

Table 154 – Parameter specification attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| ID | Identification of the *parameter* for a specific segment*.*  Required attribute. | Widget roughness | Torque Value | Visco-meter spindle size | Cases per pallet |
| Description | Contains additional information of the *parameter.* | Range of acceptable surface roughness to be manufactured. | Maximum torque value for fly wheel assembly | Spindle size for correct viscosity range | Number of cases per pallet |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the object, such as the site or area. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Value | The value, set of values, or range of acceptable values. | {80..2 500} | 35 | 2 | 124 |
| Value unit of measure | Unit of measure of the values. | Angstroms | Nm | cP | Each |

### Personnel specification

An identification, reference, or correspondence to a personnel capability shall be presented as a *personnel specification*. A *personnel specification* usually specifies a *personnel class* but may specify a *person*. A *personnel specification* identifies the specific *personnel capability* that is associated with the identified *operations segment* or *operations segment*.

A *personnel specification* shall include

1. an identification of the *personnel capability* needed,
2. the quantity of the *personnel capability* needed, and
3. the unit of measure of the quantity.

Specific elements associated with a *personnel specification* may be included in one or more *personnel specification properties*.

Table 155 defines the relationship roles for the *personnel specification*.

Table 156 defines the attributes for the *personnel specification*.

Table 155 – Personnel specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations segment | NA | 1 | Contains | The *operations segment* that is in part defined by this *personnel specification*. |
| Personnel specification | Personnel specification child | 0..\* | Is made up of | The related object(s) makes up part of this *personnel specification* as the whole. |
| Personnel specification | Personnel specification child | 0..\* | Is made up of | The related object(s) makes up part of this *personnel specification* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *personnel specification.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *personnel specification* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *personnel specification* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Personnel specification property | Personnel specification property | 0..\* | Has properties of | The *personnel specification property(s)* of this *personnel specification.* |
| Personnel class | Personnel class | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *personnel class* or set of *personnel classes* of the specification for a specific *operations segment*. |
| Person | Person | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *person* or set of *persons* of the specification for a specific *operations segment*.  Typically, either *personnel class* or *person* is specified, but not both. |

Table 156 – Personnel specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *personnel segment specification.*  Required attribute. | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Description | Contains additional information of the *personnel specification*. | Polisher skill required for export quality polished widget | Certified Diesel mechanic for heavy equipment | Level 2 certified quality technician | Schedules line side inventory deliveries in terms of this segment |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Spatial definition | Spatially defines the personnel resource(s)specified by this *personnel specification* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the personnel resource(s) specified by this *personnel specification*. | SST57 | Maintenance Shed 4S | Sample Pickup 3 | Waypoint 7 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object, or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location;* * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Personnel use | Defines the expected use of the *personnel class* or *person* in the context of the *operations segment*. | Allocated | Allocated | Allocated | Allocated |
| Quantity | Specifies the amount of personnel resources required for the parent segment. | 0.25 | 2 | 1 | 0.000 1 |
| Quantity unit of measure | The unit of measure of the associated quantity. | person hours | People | Tech | Man years |

NOTE A *personnel specification* can specify both a spatial definition and an operational location where it is necessary to specify the spatial definition of the specified personnel resource(s) within a given *operational location.*

### Personnel specification property

Specific properties that are required for *personnel specifications* shall be presented as *personnel specification properties*.

EXAMPLE 1 *Personnel specification property* can include training level required, specific skill required, and exposure availability.

*Personnel specification properties* may contain nested *personnel specification properties*.

Table 157 defines the relationship roles for the *personnel specification property*.

Table 158 defines the attributes for the *personnel specification property*.

Table 157 – Personnel specification property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Personnel specification property | Personnel specification property | 0..\* | Contains | The *personnel specification property(s)* of this *personnel specification property.* |
| Personnel specification | NA | 1 | Contains | The *personnel specification property(s)* of this *personnel specification property.* |
| Personnel class property | Personnel class property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |
| Person property | Person property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |

Table 158 – Personnel specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *person property* or *personnel class property* for a specific segment.  Required attribute. | Polishing Certification Level | Grade 2 Diesel mechanic | Lab Tech II | warehouse manager |
| Description | Contains additional information and descriptions of the *personnel specification property* definition. | Level of polishing skill certification required for the widget polisher | Level of skill required to work on diesel engine | Level of skill required to operate lab instrument | Level of skill required to manage warehouse scheduling |
| Value | The value, set of values, or range of the property.  EXAMPLE 2  Apprentice, journeyman, master | Master | Level 2 | Level 2 certified quality technician | MBA |
| Value unit of measure | The unit of measure of the associated property value. | {Apprentice, Journeyman, Master} | Skill Level | Skill Level | Degree |
| Quantity | Specifies the amount of personnel resources required for the parent segment. | 0.10 | 2 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours / piece | People | Tech | Manager |

### Equipment specification

An identification, reference, or correspondence to an *equipment capability* shall be presented as an *equipment specification*. An *equipment specification* may specify either an *equipment class* or a piece of *equipment*. An *equipment specification* identifies the specific *equipment capability* that is associated with the segment.

An *equipment specification* shall include

1. an identification of the *equipment capability* needed either as the *equipment class* needed or specific equipment;
2. the quantity of the *equipment capability* needed; and
3. the unit of measure of the quantity.

Specific elements associated with an *equipment specification* may be included in one or more *equipment specification properties*.

Table 159 defines the relationship roles for the *equipment specification*.

Table 160 defines the attributes for the *equipment specification*.

Table 159 – Equipment specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations segment | NA | 1 | Contains | This *equipment specification* is a part of the *operations segment.* |
| Equipment specification | Equipment specification child | 0..\* | Is made up of | The related object(s) makes up part of this *equipment specification* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *equipment specification.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *equipment specification* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *equipment specification* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Equipment specification property | Equipment specification property | 0..\* | Has properties of | The *equipment specification property(s)* of this *equipment specification.* |
| Equipment class | Equipment class | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment class* or set of *equipment classes* of the specification for a specific *operations segment*. |
| Equipment | Equipment | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment* or set of *equipment* of the specification for a specific *operations segment*. |

Table 160 – Equipment specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *equipment specification.*  Required attribute. | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Description | Contains additional information and descriptions of the *equipment specification.* | Equipment required to polish Export Quality Widgets. | Battery operated drill required for remote, manual task | Gas chromatograph for analyzing volatiles | Intermediate bulk container |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Spatial definition | Spatially defines the *equipment* specified by this *equipment specification* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the *equipment* specified by this *equipment specification*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object, or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Equipment use | Defines the expected use of the *equipment class* or *equipment*. | Part finishing | Assembly setup | %VOC Test result | Raw material staging |
| Quantity | Specifies the amount of equipment resources required for the parent segment. | 0,5 {shared between two segments} | 1 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity. | Each | Each | Each | Each |

NOTE An *equipment specification* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified *equipment* within a given *operational location*.

### Equipment specification property

Specific properties that are required for *equipment specifications* shall be presented as *equipment specification properties*.

EXAMPLE 1 *Equipment specification propert*y can include a material of construction, maximum material capacity, and minimum heat extraction amount.

*Equipment specification properties* may contain nested *equipment specification properties*.

Table 161 defines the relationship roles for the *equipment specification property*.

Table 162 defines the attributes for the *equipment specification property*.

Table 161 – Equipment specification property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Equipment specification property | Equipment specification property | 0..\* | Contains | The *equipment specification property(s)* of this *equipment specification property.* |
| Equipment specification | NA | 1 | Contains | The *equipment specification property(s)* of this *equipment specification property.* |
| Equipment class property | Equipment class property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |
| Equipment property | Equipment property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |

Table 162 – Equipment specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *equipment property* or *equipment class property* for a specific segment.  Required attribute. | Voltage Rating | Chuck Size | Carrier Gas | Stainless Steel Type |
| Description | Contains additional information and descriptions of the *equipment specification property* definition. | The voltage rating required for operation | The range of the chuck | The carrier gas used to carry the sample | The type of SS |
| Value | The value, set of values, or range of the property.  EXAMPLE 2  Wet, dry | 190 ~ 240 | 20 to 40 | He | 316 |
| Value unit of measure | The unit of measure of the associated property value. | Volts | mm | <n/a> | Composi-tion |
| Quantity | Specifies the amount of equipment resources required for the parent segment. | n/a | 2 | 0.5 | n/a |
| Quantity unit of measure | The unit of measure of the associated quantity. | n/a | Each | L | n/a |

### Physical asset specification

An identification, reference, or correspondence to a physical asset capability shall be presented as a *physical asset specification*. A *physical asset specification* may specify either a *physical asset* or a *physical asset class*. A *physical asset specification* identifies the specific *physical asset capability* that is associated with the segment.

A *physical asset specification* shall include

1. an identification of the *physical asset capability* needed either as the *physical asset class* or *physical asset*;
2. the quantity of the *physical asset capability* needed; and
3. the unit of measure of the quantity.

Specific elements associated with a *physical asset specification* may be included in one or more *physical asset specification properties*.

Table 163 defines relationship roles for the *physical asset* *specification*.

Table 164 defines attributes of the *physical asset specification*.

Table 163 – Physical asset specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations segment | NA | 1 | Contains | The *operations segment* defined in part by this *physical asset specification.* |
| Physical asset specification | Physical asset specification child | 0..\* | Is made up of | The related object(s) makes up part of this *physical asset specification* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *physical asset specification.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *physical asset specification* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *physical asset specification* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Physical asset specification property | Physical asset specification property | 0..\* | Has properties of | The *physical asset specification property(s)* of this *physical asset specification.* |
| Physical asset class | Physical asset class | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset class* or set of *physical asset classes* of the specification for a specific *operations segment.* |
| Physical asset | Physical asset | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset* or set of *physical assets* of the specification for a specific *operations segment*. |

Table 164 – Physical asset specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *physical asset specification.*  Required attribute. | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Description | Contains additional information and descriptions of the *physical asset specification* | Polisher | Wrench used for specific torque rating | Used to measure VOC conc. | Stainless Steel 5000 lb capacity |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Spatial definition | Spatially defines the *physical asset(s)* specified by this *physical asset specification* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Physical location | Identifies the physical location of the *physical asset(s)* specified by this *physical asset specification*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Physical location type | Indicates whether the physical location attribute refers to an *operational* *location* object, or contains a description of the physical location.  Mandatory where a physical location attribute is specified.  Defined values are   * operational location: physical location attribute references an *operational* *location;* * description: physical location attribute contains a description of the physical location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Physical asset use | Defines the expected use of the *physical asset class* or *physical asset*. | Polish | Wrench required for proper tightening of motor head | Gas Chromatography test | Raw material staging |
| Quantity | Specifies the amount of physical asset resources required for the parent segment. | 1.25 | 2 | 1 | 5 000 |
| Quantity unit of measure | The unit of measure of the associated quantity. | Minutes / piece | Each | Each | Each |

NOTE A *physical asset specification* can specify both a spatial definition and a physical location attributes where it is necessary to specify the spatial definition of the specified *physical asset(s)* within a given physical location.

### Physical asset specification property

Specific properties that are required for *physical asset specifications* shall be presented as *physical asset specification properties*.

*Physical asset specification properties* may contain nested *physical asset specification properties*.

Table 165 defines the relationship roles for the *physical asset specification property*.

Table 166 defines the attributes for the *physical asset specification property*.

Table 165 – Physical asset specification property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset specification property | Physical asset specification property | 0..\* | Contains | The *physical asset specification property(s)* of this *physical asset specification property.* |
| Physical asset specification | NA | 1 | Contains | The *physical asset specification property(s)* of this physical asset specification property. |
| Physical asset class property | Physical asset class property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |
| Physical asset property | Physical asset property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |

Table 166 – Physical asset specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *physical asset property* or *physical asset class property* for a specific segment.  Required attribute. | Polisher Type | Torque range | Min. detectable concentration | Opening type |
| Description | Contains additional information and descriptions of the *physical asset specification property* definition. | Wet polisher required for fine polishing. | Min-Max torque ratings | Sensitivity of the detector | top bung opening |
| Value | The value, set of values, or range of the property.  EXAMPLE  Wet, dry | Wet | 10-80 | < 1 | Top bung |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | ft. lbs. | ppm | (not applicable) |
| Quantity | Specifies the amount of physical asset resources required for the parent segment. | 0.10 | 1 | 1 | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Minutes / piece | each | (not applicable) | (not applicable) |

### Material specification

An identification or correspondence to a *material capability* shall be presented as a *material specification*. A *material specification* specifies a *material, material definition* or *material class*. A *material specification* identifies the specific *material specification* that is associated with the identified *operations segment*.

A *material specification* shall include

1. an identification of the material needed;
2. the quantity of the material needed; and
3. the unit of measure of the quantity.

Specific elements associated with a *material specification* may be included in one or more *material specification properties*.

Table 167 defines the relationship roles for the *material specification*.

Table 168 defines attributes for the *material specification*.

Table 167 – Material specification relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations segment | NA | 1 | Contains | The *operations segment* defined in part by this *material specification.* |
| Material specification | Material specification child | 0..\* | Is assembled from | The related object(s) makes up part of this *material specification* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* used to evaluate this *material specification.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *material specification* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *material specification* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Material segment specification property | Material specification property | 0..\* | Has properties of | The *material specification property(s)* of this *material specification.* |
| Operations material bill item | NA | 0,,1 | Is a use of | This *material specification(s)* defines the specified *operation material bill item*. |
| Material class | Material class | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material class* or set of *material classes* of the specification for a specific *operations segment*. |
| Material definition | Material definition | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material definition* or set of *material definition* of the specification for a specific *operations segment*. |
| Material lot | Material lot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material lot* or set of *material lot* of the specification for a specific *operations segment*.  Typically, either a *material class* or *material definition* is specified. |
| Material sublot | Material sublot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material sublot* or set of *material sublot* of the specification for a specific *operations segment*.  Typically, either a *material class* or *material definition* is specified. |

Table 168 – Material specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *material specification.*  Required attribute. | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Description | Contains additional information and descriptions of the *material specification*. | Polishing material for Export Quality Widget polishing. | Replacement impeller | Calibration gas | 4x2 304 Stainless Steel bung |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Spatial definition | Spatially defines the material resource(s) specified by this *material specification* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Storage location | Identifies the storage location of the material resource(s) specified by this *material specification*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Storage location type | Indicates whether the storage location attribute refers to an *operational location*, *equipment* or *physical asset* object, or contains a description of the storage location.  Mandatory where a storage location is specified.  Defined values are   * operational location: storage location attribute references an *operational location*; * equipment: storage location attribute references an *equipment* object; * physical asset: storage location attribute references a *physical asset*; and * description: storage location attribute contains a description of the *storage location,* such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Material use | Defines the expected use of the *material class,* *material definition, material lot, or material sublot* in the context of the *operations segment*.  Defined values for production operations are  consumable, material consumed, material produced, by-product produced, co-product produced, and yield produced.  Defined values for maintenance operations are  consumable, material consumed, and material produced.  Defined values for quality test operations are  consumable, destructive sample, returned sample, and retained sample.  Defined values for inventory operations defined values are  consumable, material consumed, material produced, and inventoried. | Consumable | Consumable | Consumable | Consumable |
| Quantity | Specifies the amount of *material* resources required for the parent segment. | 10 | 1 | 1,5 | 1 |
| Quantity unit of measure | The unit of measure of the associated property value. | gm / piece | each | Liter | Each |
| Assembly type | Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area. * logical: he components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process; * transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit. | Permanent | Transient | Permanent | Transient |

NOTE A *material specification* can specify a spatial definition attribute in addition to a storage location attribute where it is necessary to specify the spatial definition of the *material* resource(s) within the given storage location.

A *material specification* may be defined as containing an assembly of *material specifications* and as part of an assembly of *material specifications.*

1. a *material specification* may define an assembly of zero or more *material specifications*;
2. a *material specification* may be an assembly element of zero or more *material specifications*;
3. an assembly may be defined as a permanent or transient assembly of *material specifications*;
4. an assembly may be defined as physical or a logical assembly of *material specifications*.

### Material specification property

Specific properties that are required for *material specifications* shall be presented as *material specification properties*.

EXAMPLE *Material specification property* can include a color range, density tolerance, and maximum scrap content.

*Material specification properties* may contain nested *material specification properties*.

Table 169 defines the relationship roles for the *material specification property*.

Table 170 defines the attributes for the *material specification property*.

Table 169 – Material specification property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material specification property | Material specification property | 0..\* | Contains | The *material specification property(s)* of this *material specification property.* |
| Material specification | NA | 1 | Contains | The *material specification property(s)* of this *material specification property.* |
| Material class property | Material class property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material definition property | Material definition property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material lot property | Material lot property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |

Table 170 – Material specification property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *material property* for a specific segment.  Required attribute. | Grit Size | Pitch | Purity | Material of Construction |
| Description | Contains additional information and descriptions of the *material specification property*. | Measure of required grit size for Export Quality Widget polishing. | Percentage of blade length per angle of progression | Reference gas concentration | MOC |
| Value | The value, set of values, or range for the associated property. | {1 300..1 500} | 16-21 | ± 500 | 304 Stainless Steel |
| Value unit of measure | The unit of measure of the associated property value. | Grit Number | Pitch | Ppb | Grade |
| Quantity | Specifies the amount of material resources required for the parent segment. | 5 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated property value. | gm / piece | (not applicable) | (not applicable) | (not applicable) |

### Segment dependency

Operations dependencies that are operation or product specific shall be presented as *segment dependencies*.

EXAMPLE 1 A wheel assembly operation and a frame assembly operation can run in parallel.

Table 171 lists the relationship roles of the *segment dependency*.

Table 172 lists the attributes of the *segment dependency*.

Table 171 – Segment dependency relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations segment | Operations segment from | 0..\* | Has an execution dependency on | The source *operations segments* that the target *operations segment(s)* are dependent.  *Operations segment* has an association class relationship with *segment dependency.* |
| Operations segment | Operations segment to | 0..\* | Has an execution dependency on | The target *operations segments* that are dependent on source *operations segments.*  *Operations segment* has an association class relationship with *segment dependency.* |

Table 172 – Segment dependency attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | The identification of the unique instance of the *segment dependency*.  Required attribute. | PSD001 | 34 | A35 | PSA-I-5563 |
| Description | Contains additional information and descriptions of the *segment dependency* definition for a specific segment. | Defines the sequencing of widget washing during the Widget Assembly operations segment | Defines the sequence for replacing an impeller | Defines sampling sequence | Defines IBC sealing |
| Dependency type | Defines the execution dependency constraints of one segment to another segment.as the type of the execution or dependency factor between the segments.  Defined values are (explained using dependency type between segment A and segment B)   * at start: start B at A start; * after start: start B after A start; * after end: start B after A end; * not follow: B cannot follow A; * possible parallel: B may run in parallel to A; * not in parallel: B may not run in parallel to A; * no later after start: start B no later than dependency factor after A start: * no earlier after start: start B no earlier than dependency factor after A start; * no later after end: start B no later than dependency factor after A end; * no earlier after end: B no earlier than dependency factor after A end. | Start *Cleanout* -  no earlier after start-  (dependency factor) *Work,* | Start *Motor Replacement*-  after end-*Cleanout.* | *Pull Sample*-possible parallel-  *MIX* | Move *Inventory* -after end- *Quality Release* |
| Dependency factor | Factor used by dependency | 25 | <True, False> | 50 | <True, False> |
| Dependency factor unit of measure | The units of measure of the *dependency factor*, if defined. | Minutes | Boolean | Minutes | Boolean |

## Operations schedule information

### Operations schedule model

A request for operations to be performed is an *operations schedule*. The *operations schedule* may apply to scheduling of production, maintenance, quality test, and inventory operations.

Figure 21 is the operations schedule model. Table 173 lists the relationships of the objects in the operations schedule model.

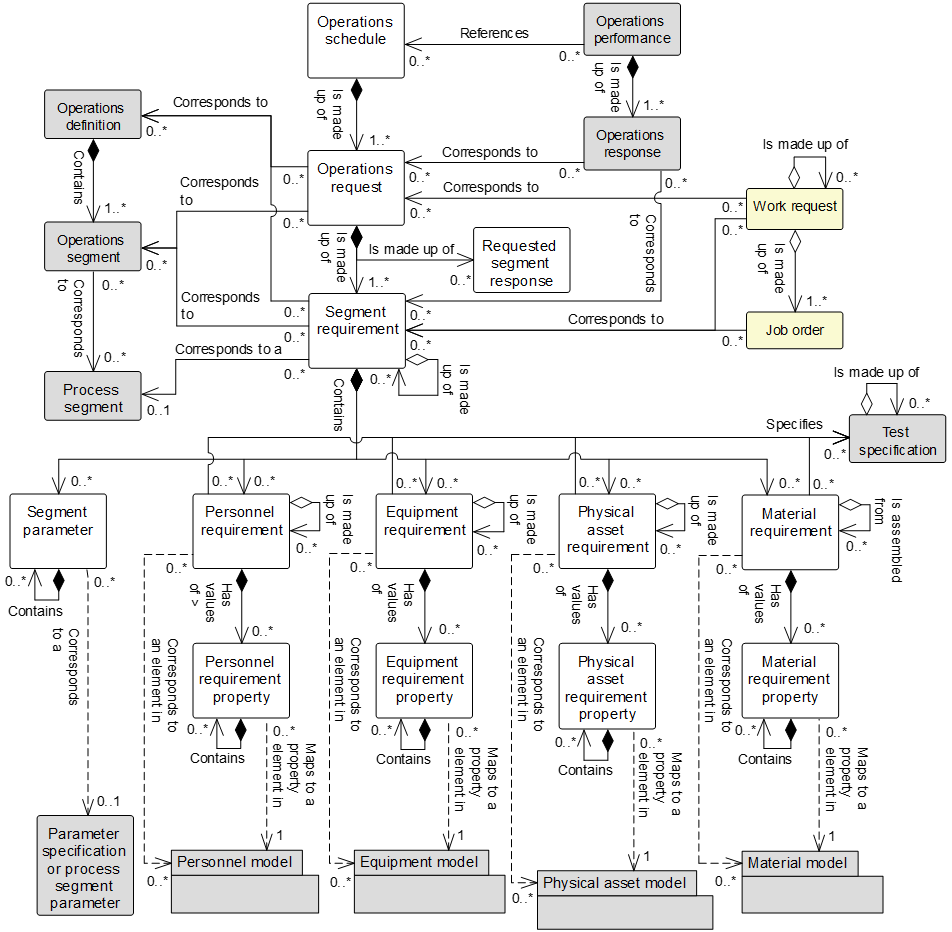


Figure 21 – Operations schedule model

To simplify Figure 21, the relationships between the resource requirements objects and *test specification* are shown but not their relationships to the *test result*. For the complete contextual view of the information model, Table 173 does lists the all relationships between the resource requirements objects and *test specification* and *test result* with all relationship roles defined in each object subclause in their relationship role table.

All relationships to *test specification* and *test result* are shown in Figure 16 – Operations test model and listed in Table 99 – Operations test requirement relationship roles.

NOTE 1 *Job order* and *work request* objects (shaded beige) in Figure 21, Operations schedule model, are defined in Part 4 of this standard.

NOTE 2 The object color convention used in the Part 2 and Part 4 UML diagrams for information models is as shown as shown in Clause 3.3.3.

Table 173 – Operations schedule model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations schedule | Operations request | Composition whole | Is made up of |
| Operations performance | Operations schedule | Association | References |
| Operations request | Segment requirement | Composition whole | Is made up of |
| Operations request | Requested segment response | Composition whole | Is made up of |
| Operations request | Operations definition | Association | Corresponds to |
| Operations request | Operations segment | Association | Corresponds to |
| Operations response | Operations request | Association | Corresponds to |
| Segment requirement | Operations definition | Association | Corresponds to |
| Segment requirement | Operations segment | Association | Corresponds to |
| Segment requirement | Process segment | Association | Corresponds to a |
| Work request\* (Defined in Part 4) | Segment requirement | Association | Corresponds to |
| Work request\* (Defined in Part 4) | Segment requirement | Association | Corresponds to |
| Job order | Segment requirement | Association | Corresponds to |
| Segment requirement | Segment requirement | Aggregation hierarchy | Is made up of |
| Segment requirement | Segment parameter | Composition whole | Contains |
| Segment requirement | Personnel requirement | Composition whole | Contains |
| Segment requirement | Equipment requirement | Composition whole | Contains |
| Segment requirement | Physical asset requirement | Composition whole | Contains |
| Segment requirement | Material requirement | Composition whole | Contains |
| Segment parameter | Segment parameter | Composition hierarchy | Contains |
| Segment parameter | Parameter specification | Dependency | Corresponds to a |
| Segment parameter | Process segment parameter | Dependency | Corresponds to a |
| Personnel requirement,  equipment requirement,  physical asset requirement, and  material requirement. | Test specification  Refer to Figure 16. | Association | Specifies |
| Test specification  Refer to Figure 16. | Personnel requirement,  equipment requirement,  physical asset requirement, and  material requirement. | Association | Specifies test for |
| Test result  Refer to Figure 16. | Personnel requirement,  equipment requirement,  physical asset requirement, and  material requirement. | Association | Generated in context of |
| Personnel requirement | Personnel requirement | Aggregation hierarchy | Is made up of |
| Personnel requirement | Personnel requirement property | Composition whole | Has values of |
| Personnel requirement property | Personnel requirement property | Composition hierarchy | Contains |
| Personnel requirement | Personnel class | Association (A) | Corresponds to |
| Personnel requirement | Person | Association (C) | Corresponds to |
| Personnel requirement property | Personnel class property | Dependency (B) | Maps to |
| Personnel requirement property | Person property | Dependency (D) | Maps to |
| Equipment requirement | Equipment requirement | Aggregation hierarchy | Is made up of |
| Equipment requirement | Equipment requirement property | Composition whole | Has values of |
| Equipment requirement property | Equipment requirement property | Composition hierarchy | Contains |
| Equipment requirement | Equipment class | Association (A) | Corresponds to |
| Equipment requirement | Equipment | Association (C) | Corresponds to |
| Equipment requirement property | Equipment class property | Dependency (B) | Maps to |
| Equipment requirement property | Equipment property | Dependency (D) | Maps to |
| Physical asset requirement | Physical asset requirement | Aggregation hierarchy | Is made up of |
| Physical asset requirement | Physical asset requirement property | Composition whole | Has values of |
| Physical asset requirement property | Physical asset requirement property | Composition hierarchy | Contains |
| Physical asset requirement | Physical asset class | Association (A) | Corresponds to |
| Physical asset requirement | Physical asset | Association (C) | Corresponds to |
| Physical asset requirement property | Physical asset class property | Dependency (B) | Maps to |
| Physical asset requirement property | Physical asset property | Dependency (D) | Maps to |
| Material requirement | Material requirement | Aggregation hierarchy | Is assembled from |
| Material requirement | Material requirement property | Composition whole | Has values of |
| Material requirement property | Material requirement property | Composition hierarchy | Contains |
| Material requirement | Material class | Association (A) | Corresponds to |
| Material requirement | Material definition | Association (A) | Corresponds to |
| Material requirement | Material lot | Association (C) | Corresponds to |
| Material requirement | Material sublot | Association (C) | Corresponds to |
| Material requirement property | Material class property | Dependency (B) | Maps to |
| Material requirement property | Material definition property | Dependency (B) | Maps to |
| Material requirement property | Material lot property | Dependency (D) | Maps to |

### Operations schedule

A request for operations to be performed shall be presented as an *operations schedule*. An *operations schedule* shall be made up of one or more *operations requests*.

An *operations schedule* may be defined for any specific category of operations; production, maintenance, quality, or inventory, or it may be defined for a combination of categories. When a combination is selected, then the *operations requests* or *segment requirements* specify the category of the operation.

Table 174 defines the relationship roles for the *operations schedule*.

Table 175 defines the attributes for the *operations schedule*.

Table 174 – Operations schedule relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations request | Operations request | 1..\* | Is made up of | The *operations requests* that make up the *operations sched*ule. |
| Operations performance | NA | 0..\* | References | The *operations performance(s)* reporting the actuals and states references this *operations schedule(s).* |

Table 175 – Operations schedule attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of the *operations schedule* and could include version and revision identification.  Required attribute.  The ID is used in other parts of the model when the *operations schedule* needs to be identified. | PMMFUF | MWOIDND | QNFKVUV | IECBDU |
| Description | Contains additional information and descriptions of the *operations schedule.* | Widget manufacturing schedule | Daily Planned Maintenance | Widget raw material testing schedule | Widget raw material staging schedule |
| Operations type | Describes the category of operation.  Defined values are  production, maintenance, quality, inventory, and mixed.  “Mixed” can be used when the *operations schedule* contains several types of *operations requests* and/or *segment requirements*. | Production | Maintenance | Quality | Inventory |
| Start time | The starting time for the associated *operations schedule*. | 10-28-2006 | 10-27-2006 | 10-28-2006 | 10-28-2006 |
| End time | The ending time for the associated *operations schedule*. | 10-30-2006 | 10-31-2006 | 10-30-2006 | 10-30-2006 |
| Published date | The date and time on which the *operations schedule* was published or generated. | 10-17-2006 18:30 UTC | 10-17-2006  18:30 UTC | 10-17 2006  18:30 UTC | 10-17-2006  18:30 UTC |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Schedule state | Indicates the state of the *operations schedule*.  Defined values are  forecast, released, cancelled, waiting, ready, running, completed, aborted, held, suspended, and closed. | Completed | Closed | Running | Suspended |

The defined values for state attributes for the following objects shall be clarified as the “principal name” per Part 7 of this standard, enterprise/control system integration – alias service model: *operations schedule, operations request, segment requirement, operations performance, operations response,* and *segment response*.

NOTE 1 A MIMOSA segment request for work and an asset request for work are the equivalent of an *operations request* for either *equipment* or for a *physical asset*. The table of request for work is the equivalent of the *operations schedule*.

NOTE 2 The scheduled state attribute from earlier versions of Part 2 is deprecated and replaced with schedule state attribute.

NOTE 3 The parts of this standard do not address the exchange of planning state model meta data to define the states of systems to another system; the exchange objects only address the implementation design state attribute’s defined values. In an information exchange implementation, a planning and/or job order state engine can have an agreement via an implementation manufacturing profile for the state model definitions. Exchanges based on this standard transact the current state as a value/enumeration. The sending and receiving applications can be “expected” to understand the state value being exchanged.

The defined values for the schedule state attribute of the *operations schedule*, *request state* attribute for the *operations request*, and segment state attribute for *segment requirement* have the following definitions:

1. forecast: the requirements have not been released for planning;

EXAMPLE This can be a schedule which is an estimate to allow long term planning by the receiver, with a later “released” schedule when the schedule has been approved and released to production.

1. released: the requirements have been released for execution;
2. cancelled: a scheduling decision has been taken to cancel the requirements prior to commencement of execution;
3. waiting: necessary pre-conditions have not been met and the *job orders* or activities are not ready to run;
4. ready: necessary pre-conditions have been met and the *job orders* or activities are ready to run;
5. running: job orders or activities are in execution;
6. completed: *job orders* or activities have been completed and are no longer in execution;
7. aborted: an execution decision has been taken to terminate the *job orders* or activities that may, or may not, have been previously commenced;
8. held: *job orders* or activities have been temporarily stopped due to a constraint of some form;
9. suspended: *job orders* or activities have been temporarily stopped due to a deliberate decision within execution; and
10. closed: *job orders* or activities have been completed and fully reconciled. No further changes, or restatement of actuals is expected

### Operations request

A request for an element of an *operation schedule* shall be presented as an *operations request*. An *operations request* contains the information required by manu­facturing to fulfill the scheduled operation. An *operations request* may be a subset of the business information, or it may contain additional information not normally used by the business system.

An *operations request* may identify or reference the associated operations instructions. An *operations request* shall contain at least one *segment requirement*, even if the *segment requirement* spans all of the operation.

An *operations request* may include

1. when to start the operation, typically used if a scheduling system controls the schedule;
2. when the operation is to be finished, typically used if the manufacturing operations system controls its internal schedule to meet deadlines; and
3. the priority of the request, typically used if exact ordering of production is not externally scheduled.

An *operations request* may be reported on by one or more *operations responses*. Additional information may be described in the *parameters, personnel requirements, equipment requirements, physical asset requirements* and *material requirements*.

Table 176 defines the relationship roles for the *operations request*.

Table 177 defines the attributes for the *operations request*.

Table 176 – Operations request relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations schedule | NA | 1 | Is made up of | The *operations schedule* object defined in part by this *operations request.* |
| Requested segment response | Requested segment response | 0..\* | Is made up of | The requested information to be returned in *segment responses* during the processing / execution of this this *operations request.* |
| Operations definition | Operations definition | 0..\* | Corresponds to | The *operations definition* reference that corresponds to this *operations request*. |
| Operations segment | Operations segment | 0..\* | Corresponds to | The associated *operations segment*s reference that corresponds to this *operations request*. If the *operations segment* reference is insufficient to identify the *operations segment*, then the *segment requirement* should also identify the *operations definition reference*. |
| Segment requirement | Segment requirement | 1..\* | Is made up of | The *segment requirements* related to this *operations request.* |
| Work request (Defined in Part 4) | NA | 0..\* | Corresponds to | The *work request(s)* related to this *operations* *request(s)*. |
| Operations response | NA | 0..\* | Corresponds to | The *operations response(s)* related to this *operations* *request(s)*. |

NOTE *Work request* object (shaded beige) in Figure 21, Operations schedule model, are defined in Part 4 of this standard.

Table 177 – Operations request attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of the *operations request*.  Required attribute.  The ID is used in other parts of the model when the *operations request* needs to be identified. | 1001091 | 59328AC8 | E938723 | KIT493 |
| Description | Contains additional information and descriptions of the *operations request.* | Operations request for export quality widgets for October 29, 1999. | Daily maintenance request | Test incoming materials | Prepare kit for production run |
| Operations type | Describes the category of operations.  Defined values are  production, maintenance, quality, inventory, and mixed.  “Mixed” can be used when the operations request contains several types of operations requests. | Production | Maintenance | Quality | Inventory |
| Start time | When operation is to be started. | 1999-10-27 8:00 UTC | 10-28-2006 2:00 UTC | 10-28-2006 4:00 UTC | 10-28-2006 2:00 UTC |
| End time | When operation is to be completed. | 1999-10-27 17:00 UTC | 10-28-2006 2:30 UTC | 10-28-2006 4:30 UTC | 10-28-2006 4:00 UTC |
| Priority | The priority of the request. | Highest | 1 | B | High |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing Manufacturing Line #2 | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Request state | Indicates the state of the *operations request.*  Defined values are  forecast, released, cancelled, waiting, ready, running, completed, aborted, held, suspended, and closed. | Completed | Closed | Running | Suspended |

### Segment requirement

An *operations request* shall be made up of one or more *segment requirements*. Each *segment requirement* shall correspond to, or reference, an identified *operations definition, operations segment* or *process segment*. The *segment requirement* identifies or references the segment capability to which the associated *personnel, equipment, physical assets, materials*, and *segment parameter*s correspond.

The *segment requirement properties* and *segment parameters* shall align with the parameters sent as part of an *operations request*.

EXAMPLE There can are multiple *segment requirements* defined. There is one master *segment requirement* that applies to the entire *operations request*. The master *segment requirement* can be made up of multiple nested *segment requirements* for individually specified and reported segments.

NOTE 1 Information that applies across all segments of the *operations request*, such as a customer name, can be represented as a *segment parameter* in the master *segment requirement*. Information that applies to specific *segment requirements* can be specified as part of the *segment requirement*.

Table 178 defines the relationship roles for the *segment requirement*.

Table 179 defines the attributes for the *segment requirement*.

Table 178 – Segment requirement relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations request | NA | 1 | Is made up of | The *operations request* is defined in part by this *segment requirement*. |
| Operations definition | Operations definition | 0.\* | Corresponds to | The *operations definition* reference that corresponds to this *segment requirement*. |
| Operations segment | Operations segment | 0..\* | Corresponds to | The associated *operations segment*s that corresponds to this *segment requirement*. If the *operations segment* reference is insufficient to identify the *operations segment*, then this *segment requirement* should also identify the *operations definition reference*. |
| Process segment | Process segment | 0..1 | Corresponds to a | An identification of the *process segment* associated with this *segment requirement*. |
| Segment requirement | Segment requirement child | 0..\* | Is made up of | The related object(s) makes up part of this *segment requirement* as the whole. |
| Work request (Defined in Part 4) | NA | 0..\* | Corresponds to | The *work request(s)* related to this *segment requirement(s)*. |
| Job order (Defined in Part 4) | NA | 0..\* | Corresponds to | The *job order(s)* related to this *segment requirement(s)*. |
| Segment parameter | Segment parameter | 0..\* | Contains | The *segment parameters* related to this *segment requirement.* |
| Personnel requirement | Personnel requirement | 0..\* | Contains | The *personnel requirements* related to this *segment requirement.* |
| Equipment requirement | Equipment requirement | 0..\* | Contains | The *equipment requirements* related to this *segment requirement.* |
| Physical asset requirement | Physical asset requirement | 0..\* | Contains | The *physical asset requirements* related to this *segment requirement.* |
| Material requirement | Material requirement | 0..\* | Contains | The *material requirements* related to this *segment requirement.* |

NOTE 2 *Job order* and *work request* objects (shaded beige) are defined in Part 4 of this standard.

Table 179 – Segment requirement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of the *segment requirement* within the scope of an *operations request*.  Required attribute. | A6646 | KU492 | 48283 | 4883DV |
| Description | Contains additional information and descriptions of the *segment requirement.* | Polishing segment, containing specifications for personnel, materials and equipment. | Test program to verify X-Y coordinates within calibration | Verify stock dimensions | Pull part from ware-house, tag, and forward stage |
| Operations type | Describes the category of operation.  Defined values are  production, maintenance, quality, inventory, and mixed. | Production | Maintenance | Quality | Inventory |
| Earliest start time | The expected earliest start time of this *segment requirement*. | 10-28-2006 4:00 UTC | 10-28-2006 2:00 UTC | 10-28-2006 4:00 UTC | 10-28-2006 4:00 UTC |
| Latest end time | The expected latest ending time of this *segment requirement*. | 10-28-2006 10:00 UTC | 10-28-2006 2:15 UTC | 10-28-2006 4:30 UTC | 10-28-2006 6:30 UTC |
| Duration | The expected duration of this *segment requirement*.  Duration attribute should match the associated segment duration attribute. | 15 | 4 | 0.5 | 2.5 |
| Duration unit of measure | The unit of measure of the duration. | Minutes | Minutes | Hours | Hours |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing Manufacturing Line #2 | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Segment state | Indicates the state of the *segment requirement*.  Defined values are  forecast, released, cancelled, waiting, ready, running, completed, aborted, held, suspended, and closed. | Completed | Closed | Running | Suspended |

### Segment parameter

Specific parameters required for a *segment requirement* shall be presented as *segment parameters*.

A *segment parameter* shall include

1. an identification of the parameter that matches *parameter specification* of the *operations definition*, such as target acidity;
2. a value for the parameter, such as 3,4; and
3. the unit of measure of the parameter, such as pH.

A *segment parameter* should include a set of limits that apply to any change to the value, such as quality limits and safety limits.

*Segment parameters* may contain nested *segment parameters*.

Table 180 defines the relationship roles for the *segment parameter*.

Table 181 defines the attributes for the *segment parameter*.

Table 180 – Segment parameter relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment requirement | NA | 1 | Contains | The *segment requirement* containing this *segment parameter*. |
| Segment parameter | Segment parameter child | 0..\* | Contains | The *segment parameter(s)* that are part of this *segment parameter.* |
| Parameter specification | Parameter specification | 0..1 | Corresponds to | This *segment parameter(s)* corresponds to the *parameter specification(s)* in the *operations definition*. |
| Process segment parameter | Process segment parameter | 0..1 | Corresponds to | This *segment parameter(s)* corresponds to the *process segment parameter(s)* in the *process segment*. |

Table 181 – Segment parameter attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | The identification of the *segment parameter*.  Required attribute. | Widget roughness | Test hole location tolerance | Thickness | Staging location |
| Description | Contains additional information and descriptions of the *segment parameter.* | Range of acceptable surface roughness to be manufactured. | Range of acceptable hole locations | Thickness of stock sheets | Forward staging location for production use |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the object, such as the site or area. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Value | The value, set of values, or range of the value to be used for this parameter. | {80..2 500} | ± 0.01 | 5 | East Wing Manufacturing Line #2 |
| Value unit of measure | The engineering units in which the value is defined. | Angstroms | cm | mm | (not applicable) |

### Personnel requirement

The identification of the number, type, duration, and scheduling of specific certifications and job classifications needed to support the current *operations request* shall be presented as *personnel requirements*.

NOTE 1 Examples of job classification types include mechanics, operators, health and protection, and inspectors.

EXAMPLE There can be a requirement for one operator with a specified level of certification available 2 hours after production starts. There would be one *personnel requirement* for the requirement for the operator and two *personnel requirement properties*, one for the certification level and one for the time requirement.

A *personnel requirement* shall include

1. the identification of the *personnel* needed, such as milling machine operator; and
2. the quantity of *personnel* needed.

Specific elements associated with each *personnel requirement* may be included in one or more *personnel requirement properties*.

Table 182 defines the relationship roles for the *personnel requirement*.

Table 183 defines the attributes for the *personnel requirement*.

Table 182 – Personnel requirement relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment requirement | NA | 1 | Contains | This *personnel requirement* is a part of the *segment requirement* as the whole. |
| Personnel requirement | Personnel requirement child | 0..\* | Is made up of | The related object(s) makes up part of this *personnel requirement* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The specific *test specification(s)* applied for this *personnel requirement* in a specific *segment requirement* and *operations request.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *personnel requirement* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *personnel requirement* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Personnel requirement property | Personnel requirement property | 0..\* | Has values of | The values in the *personnel requirement property* are for this *personnel requirement.* |
| Personnel class | Personnel class | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *personnel class* or set of *personnel classes* of the *personnel requirement* for a specific *segment requirement*. |
| Person | Person | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *person* or set of *persons* of the *personnel requirement* for a specific *segment requirement*.  Typically, either *personnel class* or *person* is specified, but not both. |

Table 183 – Personnel requirement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *personnel requirement.*  Required attribute. | Employee 23 | 22828 | 999-123-4567 | 007 |
| Description | Contains additional information and descriptions of the *personnel requirement.* | Defines the specific polishing operator assigned to this operations request. | Trained CNC operator | Quality personnel trained in stock inspections | Person to assemble the kit |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Spatial definition | Spatially defines the personnel resource(s)specified by this *personnel requirement* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the *operational location* of the personnel resource(s) specified by this *personnel requirement*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational Location Type | Indicates whether the operational location attribute refers to an *operational* *location* object, or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Personnel use | Defines the expected use of the *personnel class* or *person* in the context of the *segment requirement*. | Allocated | Certified | Certified | Uncertified |
| Quantity | Specifies the amount of personnel resources required for the parent segment. Applies to each member of the *person* and *personnel class* sets. | 1 | 1 | 1 | 1 |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | Full Time Equivalents | Full Time Equivalents | Full Time Equivalents | Full Time Equivalents |

NOTE 2 A *personnel requirement* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified *personnel* resource(s) within a given *operational location*.

### Personnel requirement property

Specific properties that are required for *personnel requirements* shall be presented as *personnel requirement properties*.

EXAMPLE  *Personnel requirement properties* can include training and certification, specific skill, physical location, seniority level, exposure level, training certification, security level, experience level, physical requirements, and overtime limitations and restrictions.

*Personnel requirement properties* may contain nested *personnel requirement properties*.

Table 184 defines the relationship roles for the *personnel requirement property*.

Table 185 defines the attributes for the *personnel requirement property*.

Table 184 – Personnel requirement property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Personnel requirement | NA | 1 | Has values of | The values for this *personnel requirement* property in part are for the *personnel requirement.* |
| Personnel requirement property | Personnel requirement property child | 0..\* | Contains | The values in the child *personnel requirement* property for this *personnel requirement.* |
| Personnel class property | Personnel class property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |
| Person property | Person property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |

Table 185 – Personnel requirement property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *person property* or *personnel class property* for a specific *segment requirement*.  Required attribute. | Polishing Certification Level | CNC daily maintenance certification | Stock receiving inspection certification | Steel toed shoes |
| Description | Contains additional information and descriptions of the *personnel requirement property* definition. | Level of polishing skill certification required for the widget polisher | Training level required | current certification | PPE required |
| Value | The value, set of values, or range of the property.  EXAMPLE  Apprentice, Journeyman, Master | Journeyman | <True, False> | <True, False> | <True, False> |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | Boolean | Boolean | Boolean |
| Quantity | Specifies the amount of the property required for the parent *personnel requirement*. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |

### Equipment requirement

The identification of the number, type, duration, and scheduling of specific *equipment* and equipment classifications or equipment constraints needed to support the current *operations request* shall be presented as an *equipment requirement*. The *operations request* may include one or more *equipment requirements*.Requirements can be as generic as materials of construction, or as specific as a particular piece of equipment. Each of these requirements shall be an instance of an *equipment requirement*.

Properties of the *equipment requirement* shall be presented as *equipment requirement properties*.

Each *equipment requirement* identifies a general class of *equipment* (such as reactor vessels), a specific class of *equipment* (such as isothermal reactors), or a specific piece or set of *equipment* (such as isothermal reactor #7). The specific requirements on the *equipment,* or *equipment class* are listed as *equipment requirement property* objects.

An *equipment requirement* shall include

1. the identification of the *equipment* needed, such as milling machine;
2. the quantity of *equipment* needed.

Specific elements associated with each *equipment requirement* may be included in one or more *equipment requirement properties*.

Table 186 defines the relationship roles for the *equipment requirement*.

Table 187 defines the attributes for the *equipment requirement*.

Table 186 – Equipment requirement relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment requirement | NA | 1 | Contains | The *segment requirement d*efined in part by this e*quipment requirement.* |
| Equipment requirement | Equipment requirement child | 0..\* | Is made up of | The related object(s) makes up part of this *equipment requirement* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* applied for this *equipment requirement* in a specific *segment requirement* and *operations request.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *equipment requirement* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *equipment requirement* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Equipment requirement property | Equipment requirement property | 0..\* | Has values of | The values in the e*quipment requirement property* are for this *equipment requirement.* |
| Equipment class | Equipment class | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment class* or set of *equipment classes* of the *equipment requirement* for a specific *segment requirement*. |
| Equipment | Equipment | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment* set of *equipment* of the *equipment requirement* for a specific *segment requirement*.  Typically, either *equipment class* or *equipment* is specified, but not both. |

Table 187 – Equipment requirement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a specific *equipment requirement*.  Required attribute. | Jig 347 | Wldr445 | SN3883AT | VIN28203 |
| Description | Contains additional information and descriptions of the *equipment requirement* | Specifics the expected machine to be used for this operations request. | Automated drill press | Measure-ment tool | Ware-house bar code scanner |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Hierarchy scope identifies the “path”. *Equipment* scope is instance base. Equipment level attribute defines the generic level. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Spatial definition | Spatially defines the *equipment* specified by this *equipment requirement* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the *equipment* specified by this *equipment requirement*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational Location Type | Indicates whether the operational location attribute refers to an *operational* *location* object or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Equipment use | Defines the expected use of the *equipment class* or *equipment.* | Production | Repair | Testing | Transport |
| Quantity | Specifies the amount of equipment resources required for the parent segment. Applies to each member of the *equipment* and *equipment class* sets. | 1 | 1 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity. | Units | Machine | Tool | Tool |
| Equipment level | A definition of the level of the associated element of the *equipment* model. Equipment level attribute defines the generic level.  EXAMPLE  Enterprise, site, area, unit, equipment module, control module. | Production Line | Work Center | (not applicable) | (not applicable) |

NOTE An *equipment requirement* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified *equipment* within a given *operational location*.

### Equipment requirement property

Specific properties that are required for *equipment requirements* shall be presented as *equipment requirement properties*.

EXAMPLE 1 *Equipment requirement property* can include a *material* of construction and minimum *equipment capacity*.

*Equipment requirement properties* may contain nested *equipment requirement properties*.

Table 188 defines the relationship roles for the *equipment requirement property*.

Table 189 defines the attributes for the *equipment requirement property*.

Table 188 – Equipment requirement property relationships

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Equipment requirement | NA | 1 | Has values of | The values for this *equipment requirement property* in part are for the *equipment requirement.* |
| Equipment requirement property | Equipment requirement property child | 0..\* | Contains | The values in the child *equipment requirement property* for this *equipment requirement.* |
| Equipment class property | Equipment class property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |
| Equipment property | Equipment property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |

Table 189 – Equipment requirement property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *equipment property* or *equipment class property* for a specific *segment requirement*.  Required attribute. | Polisher Type | Spindle run-out | Scale definition | Portable with LED |
| Description | Contains additional information and descriptions of the *equipment requirement property* definition. | Polisher required for this operations request. | Max allowed spindle runout | Units of measure | Type description |
| Value | The value, set of values, or range of the associated property.  EXAMPLE 2  Wet, dry | Dry | less than 0,000 08 | Metric | <True, False> |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | Inches | (not applicable) | Boolean |
| Quantity | Specifies the amount of equipment requirement property required for the parent *equipment requirement*. | 1 | (not applicable) | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity. | Units | (not applicable) | Each | Each |

### Physical asset requirement

The identification of the number, type, duration, and scheduling of specific *physical assets* and *physical asset class* constraints needed to support the current *operations request* shall be presented as a *physical asset requirement*. The *operations request* may include one or more *physical asset requirements*.Requirements can be as generic as materials of construction, or as specific as a particular piece of *physical asset*. Each of these requirements shall be an instance of a *physical asset requirement*.

Properties of the *physical asset requirement* shall be presented as *physical asset requirement properties*.

A *physical asset requirement* shall include

1. the identification of the *physical asset* needed, such as milling machine serial number #345334;
2. the quantity of *physical asset* needed.

Specific elements associated with each *physical asset requirement* may be included in one or more *physical asset requirement properties*.

Table 190 defines the relationship roles for the *physical asset requirement*.

Table 191 defines the attributes for the *physical asset requirement*.

Table 190 – Physical asset requirement relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment requirement | NA | 1 | Contains | The *segment requirement* defined in part by this *physical asset requirement.* |
| Physical asset requirement | Physical asset requirement child | 0..\* | Is made up of | The related object(s) makes up part of this *physical asset requirement* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* applied for this *physical asset requirement* in a specific *segment requirement* and *operations request.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *physical asset requirement* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *physical asset requirement* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Physical asset requirement property | Physical asset requirement property | 0..\* | Has values of | The values in the *physical asset requirement property* are for this *physical asset requirement.* |
| Physical asset class | Physical asset class | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset model* or set of physical asset modelsof the *physical asset requirement* for a specific *segment requirement*. |
| Physical asset | Physical asset | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset* or set of *physical assets* of the *physical asset requirement* for a specific *segment requirement*.  Typically, either *physical asset* or *physical asset class* is specified, but not both. |

Table 191 – Physical asset requirement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a *physical asset requirement.*  Required attribute. | SN5246$9 | SN68928#1 | SN5247$3 | VIN 55262528 |
| Description | Contains additional information and descriptions of the *physical asset requirement.* | (not applicable) | Cameroon Drill Press | (not applicable) | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |
| Spatial definition | Spatially defines the *physical asset(s)* specified by this *physical asset requirement* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Physical location | Identifies the physical location of the *physical asset(s)* specified by this *physical asset requirement*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Physical location type | Indicates whether the physical location attribute refers to an *operational* *location* object, or contains a description of the physical location.  Mandatory where a physical location attribute is specified.  Defined values are   * operational location: physical location attribute references an *operational* *location*; * description: physical location attribute contains a description of the physical location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Physical asset use | Defines the expected use of the *physical asset class* or *physical asset.* | (not applicable) | Calibrate | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of equipment resources required for the parent segment. Applies to each member of the *physical asset* and *physical asset class* sets. | (not applicable) | 1 | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | (not applicable) | Machine | (not applicable) | (not applicable) |
| Equipment level | A level definition for the associated element in the hierarchy of the *physical asset* model | (not applicable) | Work Center | (not applicable) | (not applicable) |

NOTE A *physical asset requirement* can specify both a spatial definition and a physical location attributes where it is necessary to specify the spatial definition of the specified *physical asset(s)* within a given physical location.

EXAMPLE 1 The following list contains maintenance examples for *physical asset* use.

1. Repair: very frequent action. Take action to return asset to its condition prior to the event that prompted the request. Does not necessarily return to original design specs, but the condition immediately prior to which it was withdrawn from service. Generally performed in place. Action does not alter the value of the asset or its depreciation.

EXAMPLE 2 Pulley belt has broken on an induced draft fan; the belt needs to be replaced.

1. Remove: infrequent action. Remove of obsolete asset. Does not involve repair, does not involve replacement. It is removed from active service, and salvaged/scrapped/removed from an asset accounting perspective.

EXMAPLE 3 A truck off-loading transfer pump – used by a former trucking contractor – now no longer needed as trucks are all pump-equipped to do their own transfer.

1. Replacement: frequent action, where the entire asset is removed and replaced with an equal or like asset in terms of asset performance. Conditions are brought up to original performance of the asset. Action does not alter the value of the asset or its depreciation.

EXAMPLE 4 Remove and replace a 25 HP centrifugal transfer pump.

1. Calibrate: moderate frequency, but skilled action. The asset is calibrated and often verified (tested/certified) for accuracy and precision. Often associated with field instrumentation (sensors and valves). A related action is re-calibration or re-ranging to a differing process range. Action does not alter the value of the asset or its depreciation.

EXAMPLE 5 The remote temperature detector on tank 225 was re-ranged and calibrated to 0 – 200 °F.

1. Modify/Improve: relatively frequent. Often involving some elements of design, this involves altering the original asset design to improve its usability and performance in operations. This alters its design to make it perform better. Because of this, its asset value has increased by the amount of capital invested to make this improvement.

EXAMPLE 6 A rigid shaft coupling on a 50 hp centrifugal pump is replaced with a flexible coupler to reduce the frequent bearing and/or seal failures in the original design. A second (simple) example is to replace a failed 20 HP centrifugal pump with a 30 HP centrifugal pump: rather than replace like for like, it us up-graded to higher horsepower. Again, its asset value has increased by the amount of additional capital invested to make this improvement (30 HP vs. 20 HP pump).

### Physical asset requirement property

Specific properties that are required for *physical asset requirements* shall be presented as *physical asset requirement properties*.

EXAMPLE 1 *Physical asset requirement property* can include a *material* of construction and minimum physical asset capacity.

*Physical asset requirement properties* may contain nested *physical asset requirement properties*.

Table 192 defines the relationship roles for the *physical asset requirement property*.

Table 193 defines the attributes for the *physical asset requirement property*.

Table 192 – Physical asset requirement property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset requirement | NA | 1 | Has values of | The values for this *physical asset requirement property* in part are for the *physical asset requirement*. |
| Physical asset requirement property | Physical asset requirement property child | 0..\* | Contains | The values in the child *physical asset requirement property* for this p*hysical asset requirement.* |
| Physical asset class property | Physical asset class property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |
| Physical asset property | Physical asset property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |

Table 193 – Physical asset requirement property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *equipment property* or *equipment class property* for a specific *segment requirement*.  Required attribute. | (not applicable) | Repeatability | (not applicable) | (not applicable) |
| Description | Contains additional information and descriptions of the *equipment requirement property* definition. | (not applicable) | Drilling consistency | (not applicable) | (not applicable) |
| Value | The value, set of values, or range of the associated property.  EXAMPLE 2  Wet, dry | (not applicable) | 0.000 2 | (not applicable) | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | Inches | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of *physical asset requirement property* required for the parent *physical asset*. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |

### Material requirement

An identification of a *material* that is expected to be used in the operations request shall be presented as a *material requirement*. *Material requirements* contain definitions of *materials* that may be consumed, produced, replaced, sampled, or otherwise used in manufacturing.

Table 194 defines the relationship roles for the *material requirement*.

Table 195 defines the attributes for the *material requirement*.

Table 194 – Material requirement relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment requirement | NA | 1 | Contains | The *segment requirement* defined in part by this *material requirement*. |
| Material requirement | Material requirement child | 0..\* | Is assembled from | The related object(s) makes up part of this *material requirement* as the whole. |
| Material requirement property | material requirement property | 0..\* | Has values of | The values in the *material requirement property* are for this *material requirement*. |
| Material requirement | Material requirement child | 0..\* | Contains | The related object(s) makes up part of this *material requirement* as the whole. |
| Test specification  Refer to Figure 16. | Test specification | 0..\* | Specifies | The *test specification(s)* applied with this *material requirement* in a specific *segment requirement* and *operations request.* |
| Test specification  Refer to Figure 16. | NA | 0..\* | Specifies test for | This *material requirement* evaluated by the *test specification.* |
| Test result  Refer to Figure 16. | NA | 0..1 | Generated in context of | This *material requirement* provides the testing context to apply the associated *test specification* to execute the specified test to generate the *test result*. Each *test result* has a test result ID. |
| Material class | Material class | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material class* or set of *material classes* of the *material requirement* for a specific *segment requirement*. |
| Material definition | Material definition | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material definition* or set of *material definition* of the *material requirement* for a specific *segment requirement*. |
| Material lot | Material lot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material lot* or set of *material lot* of the *material requirement* for a specific *segment requirement*.  Typically, either a *material class* or *material definition* is specified. |
| Material sublot | Material sublot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material sublot* or set of *material sublot* of the *material requirement* for a specific *segment requirement*.  Typically, either a *material class* or *material definition* is specified. |

Table 195 – Material requirement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a specific *material requirement*,  Required attribute. | Sheet stock 1443a | DO200cpO | OA9929 | PW882929 |
| Description | Contains additional information and descriptions of the *material requirement* definition. | Master Segment - Number of Widgets to produce. | Blank sheet to run test on | Material to inspect/ test -- selected randomly from production lot | Export quality bolt |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Spatial definition | Spatially defines the material resource(s) specified by this *material requirement* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Storage location | Identifies the storage location of the material resource(s) specified by this *material requirement*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Storage location type | Indicates whether the storage location attribute refers to an *operational location*, *equipment* or *physical asset* object, or contains a description of the storage location.  Mandatory where a storage location is specified.  Defined values are   * operational location: storage location attribute references an *operational location*; * equipment: storage location attribute references an *equipment* object; * physical asset: storage location attribute references a *physical asset*; and * description: storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Material use | Defines the expected use of the *material class,* *material definition, material lot, or material sublot* in the context of the *segment requirement*.  Defined values for production operations are  consumable, material consumed, material produced, by-product produced, co-product produced, and yield produced.  Defined values for maintenance operations are  consumable, material consumed, and material produced.  Defined values for quality test operations are  consumable, destructive sample, returned sample, and retained sample.  Defined values for inventory operations are  consumable, material consumed, material produced, and inventoried. | Consumed | Consumed | Inspection | Consumable |
| Storage location | Identifies the proposed location of the *material*. | Finished Goods Inventory | Rack 11 | Finished Goods Inventory | Warehouse B, Bin 42 |
| Quantity | Specifies the amount of *material* to be used.  Applies to each member of the *material lot*, *materials definition*, or *material class* sets. | 1 500 | 1 | 1 | 4 |
| Quantity unit of measure | Identifies the unit of measure of the quantity if applicable. | Units | Sheet | Each | Each |
| Assembly type | Optional: Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area; * logical: the components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Optional: Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process. * transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit.   If *material lots* (or sublots) are merged or absorbed, then this is a new *material lot.* | Permanent | Transient | Permanent | Transient |

NOTE A *material requirement* may specify a spatial definition attribute in addition to a storage location attribute where it is necessary to specify the spatial definition of the *material* resource(s) within the given storage location.

A *material requirement* may be defined as follows by containing an assembly of *material requirements* and as part of an assembly of *material requirements*.

1. A *material requirement* may define an assembly of zero or more *material requirements*.
2. A *material requirement* may be an assembly element of zero or more *material requirements*.
3. An assembly may be defined as a permanent or transient assembly of *material requirements.*
4. An assembly may be defined as physical or a logical assembly of *material requirements*.

### Material requirement property

Properties of a *material requirement* shall be presented as *material requirement properties*. Specific elements associated with each *material require­ment* may be included in one or more *material requirement properties*. *Material requirement properties* may contain nested *material requirement properties*.

Table 196 defines the relationship roles for the *material requirement property*.

Table 197 defines the attributes for the *material requirement property*.

Table 196 – Material requirement property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material requirement | NA | 1 | Has values of | The values for this *material requirement property* in part are for the *material requirement.* |
| Material requirement property | Material requirement property child | 0..\* | Contains | The values in the child *material requirement property* for this *material requirement.* |
| Material class property | Material class property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material definition property | Material definition property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material lot property | Material lot property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |

Table 197 – Material requirement property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *material property* or *material class property* for a specific *segment requirement*.  Required attribute. | Color | Size | OD | MOC |
| Description | Contains additional information and descriptions of the *material produced requirement property* definition. | Specifies the color for this specific operations request., in the polishing segment | Size required by calibration test | Outside diameter | Material of Construction |
| Value | The value, set of values, or range of the associated property.  EXAMPLE  Red, orange, yellow, green, blue, indigo, violet | Red | 3 × 5 | 3.257 | 304 Stainless |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | Feet | cm | (not applicable) |
| Quantity | Specifies the amount of material to be produced. | 100 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity if applicable. | Units | (not applicable) | (not applicable) | (not applicable) |

### Requested segment response

The identification of the information sent back as a result of the *operations request* shall be presented as a *requested segment response*. This information is of the same form as a *segment response*, but without actual values. (see 6.3.4)

A *requested segment response* may include required information, which presents information reported from operations, such as the actual amount of *material* consumed.

A *requested segment response* may include optional information, which presents information that may be reported from operations, such as operator-entered comments.

Table 198 defines the relationship roles for the *requested segment response*.

Table 198 – Requested segment response relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations request | Operations request | 1 | The *operations request* that corresponds to this *requested segment response.* |

## Operations performance information

### Operations performance model

*Operations performance* reports on requested manufacturing and is a collection of *operations responses*. *Operations responses* are responses from manufacturing that may be associated with an *operations request*. There may be one or more *operations responses* for a single *operations request* if the manufacturing facility needs to split the *operations request* into smaller elements.

Figure 22 below is the operations performance model.

Table 199 lists the relationships of the objects in the operations performance model.

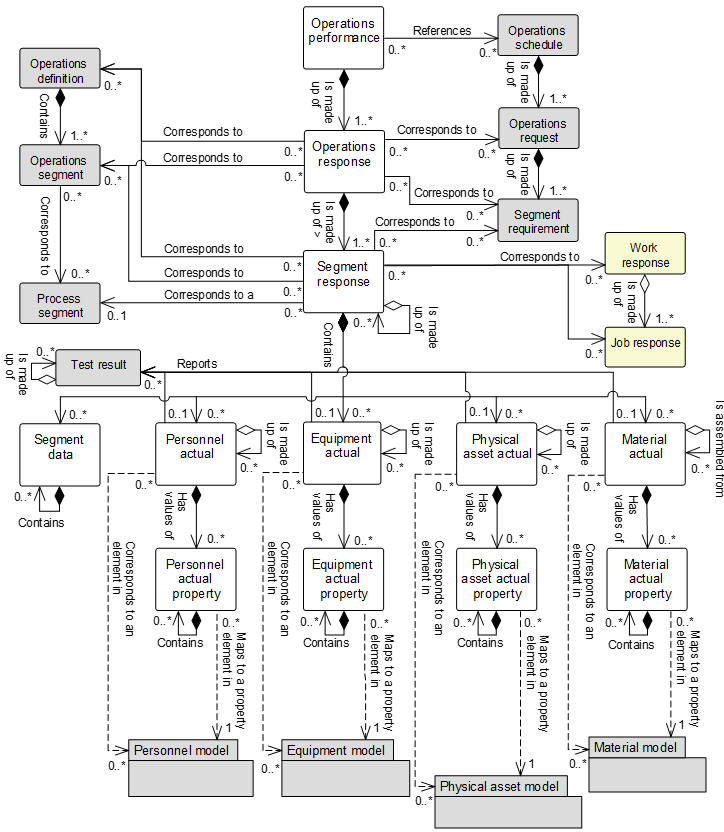


Figure 22 – Operations performance model

NOTE 1 *Work response* and *job response* objects (shaded beige) in Figure 22, Operations performance model, are defined in Part 4 of this standard.

NOTE 2 The object color convention used in the Part 2 and Part 4 UML diagrams for information models is as shown as shown in Clause 3.3.3.

Table 199 – Operations performance model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations performance | Operations response | Composition whole | Is made up of |
| Operations performance | Operations schedule | Association | References |
| Operations response | Segment response | Composition whole | Is made up of |
| Operations response | Operations definition | Association | Corresponds to |
| Operations response | Operations segment | Association | Corresponds to |
| Operations response | Operations request | Association | Corresponds to |
| Operations response | Segment Requirement | Association | Corresponds to |
| Segment response | Operations definition | Association | Corresponds to |
| Segment response | Operations segment | Association | Corresponds to |
| Segment response | Process segment | Association | Corresponds to a |
| Segment response | Segment response | Aggregation hierarchy | Is made up of |
| Segment response | Work response\* (Part 4) | Association | Corresponds to |
| Segment response | Job response\* (Part 4) | Association | Corresponds to |
| Segment response | Segment requirement | Association | Corresponds to |
| Segment response | Segment data | Composition whole | Contains |
| Segment response | Personnel actual | Composition whole | Contains |
| Segment response | Equipment actual | Composition whole | Contains |
| Segment response | Physical asset actual | Composition whole | Contains |
| Segment response | Material actual | Composition whole | Contains |
| Segment data | Segment data | Composition hierarchy | Contains |
| Personnel actual | Personnel actual | Aggregation hierarchy | Is made up of |
| Personnel actual | Personnel actual property | Composition whole | Has values of |
| Personnel actual property | Personnel actual property | Composition hierarchy | Contains |
| Personnel actual | Test result  Refer to Figure 16. | Association | Reports |
| Personnel actual | Personnel class | Association (A) | Corresponds to |
| Personnel actual | Person | Association (C) | Corresponds to |
| Personnel actual property | Personnel class property | Dependency (B) | Maps to |
| Personnel actual property | Person property | Dependency (D) | Maps to |
| Equipment actual | Equipment actual  Refer to Figure 16. | Aggregation hierarchy | Is made up of |
| Equipment actual | Equipment actual property | Composition whole | Has values of |
| Equipment actual property | Equipment actual property | Composition hierarchy | Contains |
| Equipment actual | Test result  Refer to Figure 16. | Association | Reports |
| Equipment actual | Equipment class | Association (A) | Corresponds to |
| Equipment actual | Equipment | Association (C) | Corresponds to |
| Equipment actual property | Equipment class property | Dependency (B) | Maps to |
| Equipment actual property | Equipment property | Dependency (D) | Maps to |
| Physical asset actual | Physical asset actual | Aggregation hierarchy | Is made up of |
| Physical asset actual | Physical asset actual property | Composition whole | Has values of |
| Physical asset actual property | Physical asset actual property | Composition hierarchy | Contains |
| Physical asset actual | Test result  Refer to Figure 16. | Association | Reports |
| Physical asset actual | Physical asset class | Association (A) | Corresponds to |
| Physical asset actual | Physical asset | Association (C) | Corresponds to |
| Physical asset actual property | Physical asset class property | Dependency (B) | Maps to |
| Physical asset actual property | Physical asset property | Dependency (D) | Maps to |
| Material actual | Material actual | Aggregation hierarchy | Is assembled from |
| Material actual | Material actual property | Composition whole | Has values of |
| Material actual property | Material actual property | Composition hierarchy | Contains |
| Material actual | Test result  Refer to Figure 16. | Association | Reports |
| Material actual | Material class | Association (A) | Corresponds to |
| Material actual | Material definition | Association (A) | Corresponds to |
| Material actual | Material lot | Association (C) | Corresponds to |
| Material actual | Material sublot | Association (C) | Corresponds to |
| Material actual property | Material class property | Dependency (B) | Maps to |
| Material actual property | Material definition property | Dependency (B) | Maps to |
| Material actual property | Material lot property | Dependency (D) | Maps to |

NOTE 3 \**Work response* and *job response* are defined in the work performance model in Part 4 of this standard.

### Operations performance

The performance of the requested manufacturing requests shall be presented as an *operations performance*. *Operations performance* shall be a collection of *operations responses*.

Table 200 defines the relationship roles for the *operations performance*.

Table 201 defines the attributes for the *operations performance*.

Table 200 – Operations performance relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations response | Operations response | 1..\* | Is made up of | The *operations responses* that make up part of this *operations performance* as the whole. |
| Operations schedule | Operations schedule | 0..\* | References | An identification of the associated *operations schedule*.  *Operations performance* may not relate to an *operations schedule*, it may be a report on all work for a specific time, or reported on by plant floor events. |

Table 201 – Operations performance attributes

| Attribute Name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of the *operations performance* and could include version and revision identification.  Required attribute.  The ID is used in other parts of the model when the *operations performance* needs to be identified. | 1999-10-27-A15 | 20061027M04 | 20061027M04 | 20061027M04 |
| Description | Contains additional information and descriptions of the *operations performance.* | Operations performance report on Oct 27, 1999 operations schedule. | Maintenance performance message | (not applicable) | (not applicable) |
| Operations type | Describes the category of operations.  Defined values are  production, maintenance, quality, inventory, or mixed.  “Mixed” can be used when *operations performance* contains several categories of *operations responses* or *segment responses.* | Production | Maintenance | Quality | Inventory |
| Start time | The starting time of the associated *operations performance*. | 10-28-1999 | 10-28-2006 2:00 UTC | 10-28-2006 2:00 UTC | 10-28-2006 2:00 UTC |
| End time | The ending time of the associated *operations performance*. | 10-30-1999 | 10-28-2006 2:30 UTC | 10-28-2006 2:30 UTC | 10-28-2006 2:30 UTC |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing Manufacturing Line #2 | CNC Machine  Asset ID 13465 | (not applicable) | (not applicable) |
| Performance state | Indicates the state of the *operations performance*.  Defined values are  waiting, ready, running, completed, aborted, held, suspended, and closed. | Ready | Completed | Held | Aborted |
| Published date | The date and time on which the *operations performance* was published or generated. | 10-27-1999 13:42 EST | 10-28-2006  11:00 UTC | 10-28-2006  11:00 UTC | 10-28-2006  11:00 UTC |

The defined values for the performance state attribute of the *operations performance* object, response state attribute for the *operations response* object, and segment state attribute for *segment response* object have the following definitions:

1. waiting: necessary pre-conditions have not been met and the *job orders* or activities are not ready to run;
2. ready: necessary pre-conditions have been met and the *job orders* or activities are ready to run;
3. running: *job orders* or activities are in execution;
4. completed: *job orders* or activities have been completed and are no longer in execution;
5. aborted: an execution decision has been taken to terminate the *job orders* or activities that may, or may not, have been previously commenced;
6. held: *job orders* or activities have been temporarily stopped due to a constraint of some form;
7. suspended: *job orders* or activities have been temporarily stopped due to a deliberate decision within execution;
8. closed: *job orders* or activities have been completed and fully reconciled. No further changes, or restatement of actuals is expected.

### Operations response

The responses from manufacturing that are associated with an *operations request* shall be presented as *operations responses*. There may be one or more *operations responses* for a single *operations request* if the manufacturing facility needs to split the *operations request* into smaller elements.

An *operations response* may include the status of the request, such as the percentage complete, a finished status, or an aborted status.

Table 202 defines the relationship roles for the *operations response*.

Table 203 defines the attributes for the *operations response*.

Table 202 – Operations response relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations performance | NA | 1 | Is made up of | The *operations performance* is defined in part by this *operations response*. |
| Operations request | Operations request | 0..\* | Corresponds to | The *operations request* that corresponds to this *operations respons*e if it exists or is relevant. |
| Operations definition | Operations definition | 0..\* | Corresponds to | The *operations definition(s)* that corresponds to this *operations respons*e if it exists or is relevant. |
| Operations segment | Operations segment | 0..\* | Corresponds to | The *operations segment(s)* that corresponds to this *operations respons*e if it exists or is relevant. |
| Segment requirement | Segment requirement | 0..\* | Corresponds to | The *segment requirement*(s) that corresponds to this *operations response.* |
| Segment response | Segment response | 1..\* | Is made up of | The *segment response(s)* related to this *operations response*. |

Table 203 – Operations response attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification within the associated *operations response*.  Required attribute.  The ID is used in other parts of the model when the *operations response* needs to be identified. | 1001091 | 8490234 | E938723 | KPP84022 |
| Description | Contains additional information and descriptions of the *operations response.* | July Actuals | Test program to verify X-Y coordinates within calibration | Verify stock dimensions | Pull part from warehouse, tag, and forward stage |
| Operations type | Describes the category of operations.  Defined values are  production, maintenance, quality, inventory, or mixed.  “Mixed” can be used when *operations response* contains several categories of *segment responses*. | Production | Maintenance | Quality | Inventory |
| Start time | The starting time of this *operations response*. | 1999-10-27 8:33 UTC | 10-28-2006 2:00 UTC | 10-28-2006 4:00 UTC | 10-28-2006 3:30 UTC |
| End time | The ending time of this *operations response*. | 1999-10-27 16:55 UTC | 10-28-2006 2:30 UTC | 10-28-2006 4:45 UTC | 10-28-2006 5:00 UTC |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing Manufacturing Line #2 | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Response state | Indicates the state of the *operations response*.  Defined values are  waiting, Ready, running, completed, aborted, held, suspended, and closed. | Ready | Completed | Held | Aborted |

### Segment response

Information on a *segment* of an *operations response* shall be presented as a *segment response*. A *segment response* shall be made up of zero or more sets of information on *segment data, personnel actual, equipment actual, physical asset actual,* and *material actual*. There may be one or more *segment responses* for a single *segment request* if the manufacturing facility needs to split the *segment requirement* into smaller elements.

An *operations response* shall be made up of one or more *segment responses*. Each *segment response* shall correspond to, or reference, an identified *operations segment* or *process segment*. The *segment response* identifies or references the *segment capability* to which the associated *personnel, equipment, materials,* and *segment parameters* correspond.

A *segment response* shall include

1. an identification of the associated *operations segment* or *process segment*;
2. the actual starting time;
3. the actual stopping time.

NOTE 1 A response actual can contain information that defines if the response was required or optional when the *segment response* is used as a requested *segment response*.

NOTE 2 Information that applies across all segments of the *operations response*, such as a final *material* produced, can be represented as a *material* produced in the master segment.

NOTE 3 Information that applies to specific segments, such as widget polishing equipment actually used can be reported as part of the polishing segment.

EXAMPLE 1 There can be multiple segments defined. There can be one master segment that applies to the entire *operations response*. The master segment is made up of multiple nested segments for individually reported segments.

Table 204 defines the relationship roles for the *segment response*.

Table 205 defines the attributes for the *segment response*.

Table 204 – Segment response relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations definition | Operations definition | 0..\* | Corresponds to | The *operations definition(s)* that corresponds to this *segment response.* |
| Operations segment | Operations segment | 0..\* | Corresponds to | The *operations segment(s)* that corresponds to this *segment response.* |
| Process segment | Process segment | 0..1 | Corresponds to a | The *process segment* that corresponds to this *segment response.* |
| Segment requirement | Segment requirement | 0..\* | Corresponds to | The *segment requirement*(s) that corresponds to this *segment response.* |
| Work response (Defined in Part 4) | Work response (Defined in Part 4) | 0..\* | Corresponds to | The *work response(s)* that corresponds to this *segment response.* |
| Job response (Defined in Part 4) | Job response (Defined in Part 4) | 0..\* | Corresponds to | The *job response*(s) that corresponds to this *segment response.* |
| Segment response | Segment response child | 0..\* | Is made up of | The related object(s) makes up part of this *segment response* as the whole. |
| Operations response | NA | 1 | Is made up of | This *segment response* is a part of the *operations response* as the whole. |
| Segment data | Segment data | 0..\* | Contains | The *segment data* related to this *segment response.* |
| Personnel actual | Personnel actual | 0..\* | Contains | The *personnel actuals* related to this *segment response.* |
| Equipment actual | Equipment actual | 0..\* | Contains | The *equipment actuals* related to this *segment response.* |
| Physical segment actual | Physical segment actual | 0..\* | Contains | The *physical asset actuals* related to this *segment response* |
| Material actual | Material actual | 0..\* | Contains | The *material actuals* related to this *segment response.* |

NOTE 4 *Work response* and *job response* are defined in the work performance model in Part 4 of this standard.

Table 205 – Segment response attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Uniquely identifies an instance of a *segment response* executed.  Required attribute.  NOTE 5 The same *process segment, operations definition, or operations segment* can be referenced multiple times in a *segment response.* | A54-1 | KU492-SP | 48283-SR | 4482837737883829 |
| Description | Contains additional information and descriptions of the *segment response.* | Master segment, containing material produced actuals. | Test program to verify X-Y coordinates within calibration | Verify stock dimensions | Pull part from warehouse, tag, and forward stage |
| Operations type | Describes the category of operations.  Defined values are  production, maintenance, quality, inventory, or mixed. | Production | Maintenance | Quality | Inventory |
| Actual start time | The actual start time of this *segment response*. | 1999-10-27 8:33 UTC | 10-28-2006 2:00 UTC | 10-28-2006 4:00 UTC | 10-28-2006 4:00 UTC |
| Actual end time | The actual end time of this *segment response*. | 1999-10-27 16:55 UTC | 10-28-2006 2:30 UTC | 10-28-2006 4:30 UTC | 10-28-2006 6:30 UTC |
| Posting date | The date and time used for posting resource actuals to supporting applications.  EXAMPLE 2  *Posting Date* indicates the date and time that the resource actuals should be financially and legally posted to accounting ledgers and to support planning applications. | 1999-10-27 16:55 UTC | 10-28-2006 2:30 UTC | 10-28- 2006 4:30 UTC | 11-01-2006 0:01 UTC |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing Manufacturing Line #2 | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Segment state | Indicates the state of the *segment response.*  Defined values are  waiting, ready, running, completed, aborted, held, suspended, and closed. | Ready | Completed | Held | Aborted |

### Segment data

Other information related to the actual operations made shall be presented as *segment data*.

*Segment data* may contain nested *segment data*.

Table 206 defines the relationship roles for the *segment data*.

Table 207 defines the attributes for the *segment data*.

Table 206 – Segment data relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment response | Segment response | 1 | Contains | The *segment response* defined in part by this *segment data.* |
| Segment data | Segment data child | 0..\* | Contains | The *segment data(s)* that is part of this *segment data* as the whole. |

Table 207 – Segment data attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | The identification of the *segment data*.  Required attribute. | Widget Clock Speed | Comment | Thickness | Location |
| Description | Contains additional information and descriptions of the *segment data*. | Defines average measured clock speed of the produced widgets. | Comment entered by maintenance | Actual measurement | Actual location kit was left in |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Value | The value or set of values of the *segment data*. | 233 | Sheet was nicked in first test. Second sheet was ok. | 6 | East Wing Manufacturing Line #2 |
| Value unit of measure | The engineering units in which the value is defined. | MHz | (not applicable) | mm | (not applicable) |

### Personnel actual

An identification of a *personnel capability* used during a specified *segment response* shall be presented as *personnel actual*.

NOTE 1 In operational functions, people can be a resource to carry out tasks.

*Personnel actuals* shall include the identification of each resource used, usually identifying a specific *personnel capability* or *personnel class, s*uch as end-point transmission assembly operators, or *personnel IDs* such as Jean Smith or SS# 999-123-4567.

Specific information about *personnel actuals* shall be presented in *personnel actual properties*.

EXAMPLE *Personnel actual property* can include

1. the actual *duration* of use of the *personnel* during the *operations segment*, such as 2 h; this information is often needed for actual costing analysis;
2. actual monitored exposure times by the *personnel* during the *operations segment; and*
3. the location of the *personnel* after use in the *operations segment,* such as area 51; this information is often used for short-term scheduling of *personnel* resources.

Table 208 defines the relationship roles for the *personnel actual*.

Table 209 defines the attributes for the *personnel actual*.

Table 208 – Personnel actual relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment response | NA | 1 | Contains | This *personnel* *actual* is a part of the *segment response* as the whole. |
| Personnel actual | Personnel actual child | 0..\* | Is made up of | The related object(s) makes up part of this *personnel actual* as the whole. |
| Personnel actual property | Personnel actual property | 0..\* | Has values of | The values in the *personnel actual property* are for this *personnel actual.* |
| Test result  Refer to Figure 16. | Test result | 0..\* | Reports | This *personnel actual* reports the *test result* in a *segment response* or *job response* (Defined in Part 4). |
| Personnel class | Personnel class | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *personnel class* or set of *personnel classes* actually used for a specific *segment response*. |
| Person | Person | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *person* or set of *persons* actually used for a specific *segment response*.  Typically, either *personnel class* or *person* is specified, but not both. |

Table 209 – Personnel actual attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *personnel actual*.  Required attribute. | Employee 23 | 22828 | 999-123-4567 | 007 |
| Description | Contains additional information and descriptions of the *personnel actual.* | Defines the specific polishing operator used in operations request. | Trained CNC operator | Quality personnel trained in stock inspections | Person to assemble the kit |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Spatial definition | Spatially defines the personnel resource(s)specified by this *personnel actual* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the personnel resource(s) specified by this *personnel actual*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object, or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Personnel use | Defines the expected use of the *personnel class* or *person* in the context of the *operations response*. | Allocated | Certified | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of personnel resources used in the parent segment. Applies to each member of the *person* and *personnel class* sets. | 1 | 1 | 1 | 1 |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | Full Time Equivalents | Full Time Equivalents | Full Time Equivalents | Full Time Equivalents |

NOTE 2 A *personnel actual* can specify both a spatial definition and an operational location attribute where it is necessary to specify the spatial definition of the specified *personnel* resource(s) within a given *operational location*.

### Personnel actual property

Specific properties that are required for a *personnel actual* shall be presented as *personnel actual properties*.

*Personnel actual properties* may contain nested *personnel actual properties*.

Table 210 defines the relationship roles for the *personnel actual property*.

Table 211 defines the attributes for the *personnel actual property*.

Table 210 – Personnel actual property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Personnel actual | NA | 1 | Has values of | The values for this *personnel actual property* in part are for the *personnel actual.* |
| Personnel actual property | Personnel actual property child | 0..\* | Contains | The values in the *child personnel actual property* for this *personnel actual.* |
| Personnel class property | Personnel class property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |
| Person property | Person property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |

Table 211 – Personnel actual property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *person property* or *personnel class property* for a specific *segment response*.  Required attribute. | Polishing Certification Level | CNC daily maintenance certification | Stock receiving inspection certification | (not applicable) |
| Description | Contains additional information and descriptions of the *personnel actual property* definition. | Level of polishing skill certification actually used for the widget polisher | Training level required | current certification | (not applicable) |
| Value | The value or set of values for the associated property.  EXAMPLE  Apprentice, journeyman, master | Master | True | True | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | Boolean | Boolean | (not applicable) |
| Quantity | Specifies the amount of personnel resources used in the parent segment. | 0.25 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | Hour | (not applicable) | (not applicable) | (not applicable) |

### Equipment actual

An identification of an *equipment capability* used during a specified segment shall be presented as an *equipment actual*.

NOTE 1 In operations functions, *equipment can be* a resource to carry out tasks.

*Equipment actual* shall include the identification of the equipment used, usually identifying a specific piece of *equipment*.

Specific information about *equipment actuals* shall be presented in *equipment actual properties*.

EXAMPLE *Equipment actual property* can include

1. the actual duration of use of the *equipment* during the *operations segment*; this information is often needed for actual costing analysis;
2. the *equipment* condition, after use in the *operations segment*, such as a status of available, out-of-service, or cleaning; this information is often used for short-term scheduling of *equipment* resources;
3. the equipment set-up procedures used for the *operations segment*; this information is often needed for actual costing analysis and scheduling feedback;
4. other *equipment* attributes, such as percentage of available capability used.

Table 212 defines the relationship roles for the *equipment actual*.

Table 213 defines the attributes for the *equipment actual*.

Table 212 – Equipment actual relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment response | NA | 1 | Contains | The *segment response* containing in part this *equipment* *actual*. |
| Equipment actual | Equipment actual child | 0..\* | Is made up of | The related object(s) makes up part of this *equipment actual* as the whole. |
| Equipment actual property | Equipment actual property | 0..\* | Has values of | The values in the *equipment actual property* are for this *equipment actual.* |
| Test result  Refer to Figure 16. | Test result | 0..\* | Reports | This *equipment actual* reports the *test result* in a *segment response* or *job response* (Defined in Part 4). |
| Equipment class | Equipment class | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment class* or set of *equipment classes* actually used for a specific *segment response*. |
| Equipment | Equipment | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment* or set of *equipment* actually used for a specific *segment response*.  Typically, either *equipment class* or *equipment* is specified, but not both |

Table 213 – Equipment actual attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a specific *equipment actual*.  Required attribute. | Jig 347 | Wldr445 | SN3883AT | VIN28203 |
| Description | Contains additional information and descriptions of the *equipment actual.* | Specifics the actual machine used for this operations request. | Automated drill press | (not applicable) | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Spatial definition | Spatially defines the *equipment* specified by this *equipment actual* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the *equipment* specified by this *equipment actual*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object, or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Equipment use | Defines the actual use of the *equipment class* or *equipment.* | (not applicable) | (not applicable) | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of equipment resources used in parent segment. Applies to each member of the *equipment* and *equipment class* sets. | 0.05 | 1 | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | Machine Hours | Machine | (not applicable) | (not applicable) |

NOTE 2 An *equipment actual* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified *equipment* within a given operational location.

### Equipment actual property

Specific properties that are required for an *equipment actual* shall be presented as *equipment actual properties*. *Equipment actual properties* may contain nested *equipment actual properties*.

Table 214 defines the relationship roles for the *equipment actual property*.

Table 215 defines the attributes for the *equipment actual property*.

Table 214 – Equipment actual property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Equipment actual | NA | 1 | Has values of | The values for this *equipment actual property* in part are for the *equipment actual.* |
| Equipment actual property | Equipment actual property child | 0..\* | Contains | The values in the *child equipment actual property* for this *equipment actual.* |
| Equipment class property | Equipment class property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |
| Equipment property | Equipment property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |

Table 215 – Equipment actual property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *equipment property* or *equipment class property* for a specific *segment response*.  Required attribute. | Polisher Type | Holes out of tolerance | (not applicable) | (not applicable) |
| Description | Contains additional information and descriptions of the *equipment actual property* definition. | Actual polisher used for this process segment. | Number of drilled hole out of x-y tolerance | (not applicable) | (not applicable) |
| Value | The value or set of values for the associated property.  EXAMPLE  Wet, dry. | Dry | 0 | (not applicable) | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | Number of Holes | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of equipment resources used in parent segment. | 0,05 | 2 | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | Machine Hours | Tests | (not applicable) | (not applicable) |

### Physical asset actual

An identification of a *physical asset capability* used during a specified segment shall be presented as a *physical asset actual*.

NOTE 1 In operations functions, *physical asset* can be a resource to carry out tasks.

*Physical asset actual* shall include the identification of the *physical asset* used, usually identifying a specific piece of *physical asset*.

Specific information about *physical asset* actuals shall be presented in *physical asset actual properties*.

Table 216 defines the relationship roles for the *physical asset actual*.

Table 217 defines the attributes for the *physical asset actual*.

Table 216 – Physical asset actual relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment response | NA | 1 | Contains | The *segment response* as whole defined in part by this *physical asset* *actual*. |
| Physical asset actual | Physical asset actual child | 0..\* | Is made up of | The related object(s) makes up part of this *physical asset actual* as the whole. |
| Physical asset actual property | Physical asset actual property | 0..\* | Has values of | The values in the *physical asset actual property* are for this *physical asset actual.* |
| Test result  Refer to Figure 16. | Test result | 0..\* | Reports | This *physical asset actual* reports the *test result* in a *segment response* or *job response* (Defined in Part 4). |
| Physical asset class | Physical asset class | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset class* or set of *physical asset classes* actually used for a specific *segment response*. |
| Physical asset | Physical asset | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset* or set of *physical assets* actually used for a specific *segment response*.  Typically, either *physical asset class* or *physical asset* is specified, but not both. |

Table 217 – Physical asset actual attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a *physical asset actual.*  Required attribute. | SN5246$9 | SN68928#1 | SN5247$3 | VIN 55262528 |
| Description | Contains additional information and descriptions of the *physical asset actual* | (not applicable) | Cameroon Drill Press | (not applicable) | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Spatial definition | Spatially defines the *physical asset(s)* specified by this *physical asset actual* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Physical location | Identifies the physical location of the *physical asset(s)* specified by this *physical asset actual*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Physical location type | Indicates whether the physical location attribute refers to an *operational* *location* object, or contains a description of the physical location.  Mandatory where a physical location attribute is specified.  Defined values are   * operational location: physical location attribute references an *operational* *location*; * description: physical location attribute contains a description of the physical location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Physical asset use | Defines the actual use of the *physical asset class* or *physical asset.*  EXAMPLE  Maintenance operations:  repaired, removed, replacement, calibrated, modified, and improved | (not applicable) | Calibrated | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of equipment resources used in parent segment. Applies to each member of the *equipment* and *equipment class* sets. | (not applicable) | 1 | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | (not applicable) | Machine | (not applicable) | (not applicable) |

NOTE 2 A *physical asset actual* can specify both a spatial definition and a physical location attribute where it is necessary to specify the spatial definition of the specified *physical asset(s)* within a given physical location.

### Physical asset actual property

Specific properties that are required for a *physical asset actual* shall be presented as *physical asset actual properties*.

*Physical asset actual properties* may contain nested *physical asset actual properties.*

Table 218 defines the relationship roles for the *physical asset actual property*.

Table 219 defines the attributes for the *physical asset actual property*.

Table 218 – Physical asset actual property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset actual | NA | 1 | Has values of | The values for this *physical asset actual property* in part are for the *physical asset actual.* |
| Physical asset actual property | Physical asset actual property child | 0..\* | Contains | The values in the *child physical asset actual property* for this *physical asset actual.* |
| Physical asset class property | Physical asset class property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |
| Physical asset property | Physical asset property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |

Table 219 – Physical asset actual property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *physical asset property* or *physical asset class property* for a specific *segment response.*  Required attribute. | Polisher Type | Repeatability | (not applicable) | (not applicable) |
| Description | Contains additional information and descriptions of the *physical asset actual property* definition. | Actual polisher used for this *process segmen*t. | Drilling consistency | (not applicable) | (not applicable) |
| Value | The value or set of values for the associated property.  EXAMPLE  Wet, dry. | Dry | 0,000 2 | (not applicable) | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | Inches | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of *physical asset* resources used in parent segment. | 0.05 | 2 | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | Machine Hours | Tests | (not applicable) | (not applicable) |

### Material actual

An identification of a material that was used in the *operations request* shall be presented as a *material actual*. *Material actuals* contain definitions of materials that may have be consumed, produced, replaced, sampled, or otherwise used in manufacturing.

A *material actual* may be defined as follows by containing an assembly of *material actuals* and as part of an assembly of *material actuals*.

1. A *material actual* may define an assembly of zero or more *material actuals*.
2. A *material actual* may be an assembly element of zero or more *material actuals*.
3. An assembly may be defined as a permanent or transient assembly of *material actuals*.
4. An assembly may be defined as physical or a logical assembly of *material actuals*.

Table 220 defines the relationship roles for the *material actual*.

Table 221 defines the attributes for the *material actual*.

Table 220 – Material actual relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Segment response | NA | 1 | Contains | The *segment response* defined as the whole in part by this *material* *actual*. |
| Material actual | Material actual child | 0..\* | Is assembled from | The related object(s) makes up part of this *material actual* as the whole. |
| Material actual property | Material actual property | 0..\* | Has values of | The values in the *material actual property* are for this *material actual.* |
| Test result  Refer to Figure 16. | Test result | 0..\* | Reports | This *material actual* reports the *test result* in a *segment response* or *job response* (Defined in Part 4). |
| Material class | Material class | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material class* or set of *material classes* of the *material* *actual* for a specific *segment response*. |
| Material definition | Material definition | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material definition* or set of *material definition* of the *material* *actual* for a specific *segment response*. |
| Material lot | Material lot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material lot* or set of *material lot* of the *material* *actual* for a specific *segment response*.  Typically, either a *material class* or *material definition* is specified. |
| Material sublot | Material sublot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material sublot* or set of *material sublot* of the *material* *actual* for a specific *segment response*.  Typically, either a *material class* or *material definition* is specified. |

Table 221 – Material actual attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Define a unique identification of a specific *material actual*.  Required attribute. | Sheet stock 1443a | DO200cpO | OA9929 | PW882929 |
| Description | Contains additional information and descriptions of the *material produced actual*. | Master Segment - Number of Widgets actually produced. | Blank sheet to run test on | (not applicable) | Export quality bolt |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Spatial definition | Spatially defines the material resource(s) specified by this *material actual* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | / / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Storage location | Identifies the storage location of the material resource(s) specified by this *material actual*. | SST57 | Shed4S-8 | 3822 |  |
| Storage location type | Indicates whether the storage location attribute refers to an *operational location*, *equipment* or *physical asset* object, or contains a description of the storage location.  Mandatory where a storage location is specified. Defined values are   * operational location: storage location attribute references an *operational location*; * equipment: storage location attribute references an *equipment* object; * physical asset: storage location attribute references a *physical asset*; * description: storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location |  |
| Material use | Defines the expected use of the *material class,* *material definition, material lot, or material sublot* in the context of the *segment response*.  Defined values for production operations are  consumable, consumed, produced, by-product produced, co-product produced, and yield produced.  Defined values for maintenance operations are  consumable, material consumed, and material produced.  Defined values for quality test operations are  consumable, destructive sample, returned sample, and retained sample.  Defined values for inventory operations are  consumable, material consumed, material produced, and inventoried. | Produced | Consumed | (not applicable) | Consumed |
| Quantity | Specifies the amount of material produced by the parent segment. Applies to each member of the *material lot*, *materials definition*, or *material class* sets. | 1 498 | 2 | (not applicable) | 4 |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | Units | Sheet | (not applicable) | Each |
| Assembly type | Optional: Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area; * logical: the components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process. * Transient: a temporary assembly using during production, such as a pallet of different *materials* or a batch kit. | Permanent | Transient | Permanent | Transient |
| \* Typically, either a *material class, material definition, material lot,* or *material sublot* is specified. | | | | | |

NOTE A *material actual* can specify a spatial definition attribute in addition to a storage location attribute where it is necessary to specify the spatial definition of the *material* resource(s) within the given storage location.

### Material actual property

Specific properties that are required for a *material actual* shall be presented as *material actual properties*.

*Material actual properties* may contain nested *material actual properties*.

Table 222 defines the relationship roles for the *material actual property*.

Table 223 defines the attributes for the *material actual property*.

Table 222 – Material actual property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material actual | NA | 1 | Has values of | The values for this *material actual property* in part are for the *material actual.* |
| Material actual property | Material actual property child | 0..\* | Contains | The values in the child *material actual property* for this *material actual property*. |
| Material class property | Material class property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material definition property | Material definition property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material lot property | Material lot property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |

Table 223 – Material actual property attributes midst

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *material property* or *material class property* for a specific *segment response*.  Required attribute. | Color | Size | (not applicable) | MOC |
| Description | Contains additional information and descriptions of the *material produced actual property* definition. | Defines the color actually produced, in the polishing segment | Size required by calibration test | (not applicable) | Material of Construction |
| Value | The value or set of values for the associated property.  EXAMPLE  Red, orange, yellow, green, blue, indigo, and violet. | Red | 3 x 5 | (not applicable) | 316 Stainless |
| Value unit of measure | The unit of measure of the associated property value. | Color | Feet | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of material produced by the parent segment. Applies to each member of the *material lot*, *materials definition*, or *material class* sets. | 1 002 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity. | Units | (not applicable) | (not applicable) | (not applicable) |

## Operations capability information

### Operations capability model

Operations capability information is the collection of information about all resources for operations for selected future and past times. This is made up of information about *equipment, physical assets, material, personnel,* and *process segments*. *Operations capability* describes the names, terms, statuses, and quantities of which the manufacturing control system has knowledge.

Figure 23 is the operations capability model that applies to production, maintenance, quality and inventory operations. Table 224 lists the relationships of the objects in the operations capability model.

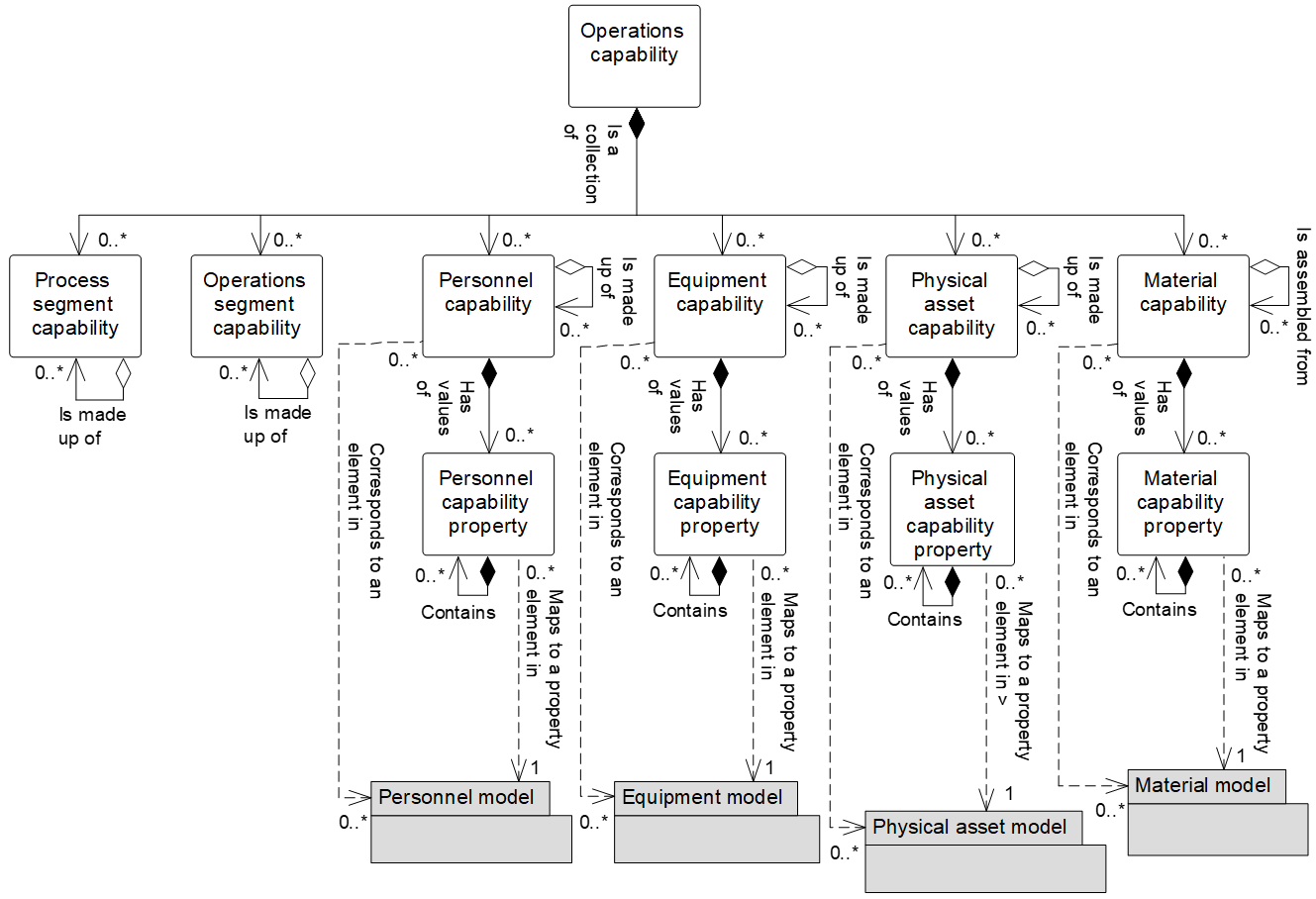


Figure 23 – Operations capability model

NOTE 1 The object color convention used in the Part 2 and Part 4 UML diagrams for information models is as shown as shown in Clause 3.3.3.

Table 224 – Operations capability model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations capability | Process segment capability | Composition whole | Is a collection of |
| Operations capability | Operations segment capability | Composition whole | Is a collection of |
| Operations capability | Personnel capability | Composition whole | Is a collection of |
| Operations capability | Equipment capability | Composition whole | Is a collection of |
| Operations capability | Physical asset capability | Composition whole | Is a collection of |
| Operations capability | Material capability | Composition whole | Is a collection of |
| Process segment capability | Process segment capability | Aggregation hierarchy | Is made up of |
| Operations segment capability | Operations segment capability | Aggregation hierarchy | Is made up of |
| Material capability | Material capability | Aggregation hierarchy | Is assembled from |
| Personnel capability | Personnel capability | Aggregation hierarchy | Is made up of |
| Personnel capability | Personnel capability property | Composition whole | Has values of |
| Personnel capability property | Personnel capability property | Composition hierarchy | Contains |
| Personnel capability | Personnel class | Association (A) | Corresponds to |
| Personnel capability | Person | Association (C) | Corresponds to |
| Personnel capability property | Personnel class property | Dependency (B) | Maps to |
| Personnel capability property | Person property | Dependency (D) | Maps to |
| Equipment capability | Equipment capability | Aggregation hierarchy | Is made up of |
| Equipment capability | Equipment capability property | Composition whole | Has values of |
| Equipment capability property | Equipment capability property | Composition hierarchy | Contains |
| Equipment capability | Equipment class | Association (A) | Corresponds to |
| Equipment capability | Equipment | Association (C) | Corresponds to |
| Equipment capability property | Equipment class property | Dependency (B) | Maps to |
| Equipment capability property | Equipment property | Dependency (D) | Maps to |
| Physical asset capability | Physical asset capability | Aggregation hierarchy | Is made up of |
| Physical asset capability | Physical asset capability property | Composition whole | Has values of |
| Physical asset capability property | Physical asset capability property | Composition hierarchy | Contains |
| Physical asset capability | Physical asset class | Association (A) | Corresponds to |
| Physical asset capability | Physical asset | Association (C) | Corresponds to |
| Physical asset capability property | Physical asset class property | Dependency (B) | Maps to |
| Physical asset capability property | Physical asset property | Dependency (D) | Maps to |
| Material capability | Material capability | Aggregation hierarchy | Is assembled from |
| Material capability | Material capability property | Composition whole | Has values of |
| Material capability property | Material capability property | Composition hierarchy | Contains |
| Material capability | Material class | Association (A) | Corresponds to |
| Material capability | Material definition | Association (A) | Corresponds to |
| Material capability | Material lot | Association (C) | Corresponds to |
| Material capability | Material sublot | Association (C) | Corresponds to |
| Material capability property | Material class property | Dependency (B) | Maps to |
| Material capability property | Material definition property | Dependency (B) | Maps to |
| Material capability property | Material lot property | Dependency (D) | Maps to |

### Operations capability

A collection of *personnel capabilities, equipment capabilities, physical asset capabilities, material capabilities*, *process segment capabilities*, and *operations segment capabilities* for a given slice of time (past, current, or future), shall be presented as an *operations capability*.

Table 225 defines the relationship roles for the *operations capability*.

Table 226 defines the attributes for the *operations capability*.

Table 225 – Operations capability relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Process segment capability | Process segment capability | 0..\* | Is a collection of | The *process segment capability(s)* related to this *operations capability.* |
| Operations segment capability | Operations segment capability | 0..\* | Is a collection of | The *operations segment capability(s)* related to this *operations capability.* |
| Personnel capability | Personnel capability | 0..\* | Is a collection of | The *personnel capability* related to this *operations capability.* |
| Equipment capability | Equipment capability | 0..\* | Is a collection of | The *equipment capability* related to this *operations capability.* |
| Physical segment capability | Physical segment capability | 0..\* | Is a collection of | The *physical asset capability* related to this *operations capability.* |
| Material capability | Material capability | 0..\* | Is a collection of | The *material capability* related to this *operations capability.* |

Table 226 – Operations capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique instance of an *operations capability* for a specified element of the equipment hierarchy model (*enterprise, site, area, work center, or work unit*).  Required attribute. | 1999/12/30-HPC52 | 84818343DF | 4737845 | EDIDCUIUE |
| Description | Contains additional information and descriptions of the *operations capability* definition. | One day’s *operations capacity* for the Boston Widget Company. | Maintenance capability for one week | Test incoming material | Warehouse kit prep |
| Operations type | Describes the category of the activity.  Defined values are  production, maintenance, quality, inventory, or mixed.  “Mixed” can be used when the activity contains several categories of *process segments*. | Production | Maintenance | Quality | Inventory |
| Capability type | Defines the type of capability.  Defined values are   * committed: capacity that is committed for future productive use; * unattainable: capacity that is not attainable for future productive use given the equipment condition, equipment utilization, personnel availability or material availability; * available: capacity that is available for additional future productive use; * used: a historical value that defines the portion of the capacity with acceptable quality; * unused: a historical value that defines the portion of the capacity that was not used or had unacceptable quality; and * total: the sum of used and unused capability or the sum of available, unattainable and committed capability. | Available | Committed | Available | Unattainable |
| Reason | Defines the reason for the capability type.  EXAMPLE 1  If capability unused, then the reason for why the capability was unused is stated, such as a specific equipment failure or unacceptable product quality. | Available for Work | Scheduled calibration | Available for inspections | Down for inventory cycle count |
| Confidence factor | Measure of the confidence of the ability to obtain the capacity value.  EXAMPLE 2  A percentage value representing the confidence of the capacity. | 90% | 100% | Medium | 2 |
| Start time | The starting date and time of the *operations capability*. | 1999-12-29 11:59 | 10-28-2006 2:00 UTC | 10-28-2006 00:00 UTC | 10-28-2006 00:00 UTC |
| End time | The ending date and time of the *operations capability*. | 1999-12-30 12:00 | 10-28-2006 2:15 UTC | 10-28-2006 8:00 UTC | 10-29-2006 00:00 UTC |
| Published date | The date and time on which the *operations capability* was published or generated. | 1999-11-03 13:55 | 10-25-2006 00:00 UTC | 10-25-2006 00:00 UTC | 10-25-2006 00:00 UTC |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Zero or more as required to identify the specific scope of the *operations capability* definition. | Boston Widget Company | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |

Productive use occurs when a resource is used, or is planned to be used, to execute a type of operation which is aligned with the purpose for why the resource exists within the enterprise.

EXAMPLE 3 Productive use for a piece of production *equipment* takes place when it is used to execute production operations.

EXAMPLE 4 A piece of production *equipment* that is scheduled to be out of service whilst maintenance activities are undertaken on it is not considered productive use. The capability type of unattainable is therefore applicable in such a case.

EXAMPLE 5 Productive use for maintenance *personnel* takes place when they are performing maintenance activities. In some enterprises, this can be known as “tool time”.

EXAMPLE 6 Maintenance tools are productively used when they are used to execute maintenance activities.

EXAMPLE 7 Quality control *personnel* and *equipment* are productively used when they execute quality activities.

### Personnel capability

The capability of *persons* or *personnel classes* that is committed, available, or unattainable for a defined time shall be presented as a *personnel capability*. *Personnel capability* may contain references to either *persons* or *personnel classes*.

*Personnel capability* shall identify

1. the availability (available, unattainable, committed, used, unused, total) and
2. the time associated with the availability.

EXAMPLE 1 Third shift on a specific date.

Specific *personnel capabilities* shall be presented in *personnel capability properties*. The *personnel capability property* may include the quantity of the resource referenced.

EXAMPLE 2 3 horizontal drill press operators available for the third shift on 2000-02-29.

Table 227 defines the relationship roles for the *personnel capability*.

Table 228 defines the attributes for the *personnel capability*.

Table 227 – Personnel capability relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations capability | NA | 1 | Is a collection of | The *operations capability* defined in part by this *personnel capability.* |
| Personnel capability | Personnel capability child | 0..\* | Is made up of | The related object(s) makes up part of this *personnel capability* as the whole. |
| Personnel capability property | Personnel capability property | 0..\* | Has values of | The values in the *personnel capability property* are for this *personnel capability* |
| Personnel class | Personnel class | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *personnel class* of the capability. |
| Person | Person | 0..\* | Corresponds to | A cross-model association to element in the personnel model as explained in Clause 3.3.8.  Identifies the associated *person* of the capability. |

Table 228 – Personnel capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique instance of the *personnel capability* for a specified element of the equipment hierarchy model (*enterprise, site, area, work center, or work unit*).  Required attribute. | P-1999/12/30-HPC52-POM | P-84818343DF-MnTOM | P-737845-QOM | P-EDIDCUIUE-IOM |
| Description | Contains additional information and descriptions of the *personnel capability* definition. | Widget machine operator availability over the 2000 New Year boundary | Trained CNC operator | Quality personnel trained in stock inspections | (not applicable) |
| Capability type | Defines the type of capability.  Defined values are   * committed: capacity that is committed for future productive use; * unattainable: capacity that is not attainable for future productive use given the equipment condition, equipment utilization, personnel availability or material availability; * available: capacity that is available for additional future productive use; * used: a historical value that defines the portion of the capacity with acceptable quality; * unused: a historical value that defines the portion of the capacity that was not used or had unacceptable quality; and * total: the sum of used and unused capability or the sum of available, unattainable and committed capability. | Available | Committed | Available | (not applicable) |
| Reason | Defines the reason for the capability type.  EXAMPLE 3  If unused, then the reason for why the capability was unused, such as a specific *equipment* failure or unacceptable product quality. | Available for Work | Scheduled calibration | Available for incoming inspections | (not applicable) |
| Confidence factor | Measure of the confidence of the ability to obtain the capacity value. | 90 % | 100 % | 100 % | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  If omitted, then the capability is associated to the parent *operations capability* hierarchy scope.  Zero or more as required to identify the specific scope of the *operations capability* definition. | South Shore Work Plant | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | (not applicable) |
| Spatial definition | Spatially defines the personnel resource(s)specified by this *personnel capability* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the personnel resource(s) specified by this *personnel capability*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object, or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*; * description: operational location attribute contains a description of the operational location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Personnel use | Defines the expected use of the *personnel class* or *person* in the context of the *segment response*. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |
| Start time | The starting time associated with the *personnel capability*.  If omitted, then the capability is associated to the parent *operations capability* start time. | 1999-12-30 11:59 | 10-28-2006 2:00 UTC | 10-28-2006 00:00 UTC | (not applicable) |
| End time | The ending time associated with the *personnel capability*.  If omitted, then the capability is associated to the parent *operations capability* end time. | 2000-01-01 12:00 | 10-28-2006 2:15 UTC | 10-28-2006 8:00 UTC | (not applicable) |
| Quantity | Specifies the quantity of the *personnel capability* defined. | 48 | 1 | 1 | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours | Full Time Equivalent | Full Time Equivalent | (not applicable) |

NOTE A *personnel capability* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified *personnel* resource(s) within a given operational location.

Where *persons* are members of multiple *personnel classes* then the *personnel capability* information defined by *personnel class* should be used carefully because of possible double counts, and *personnel* resources should be managed at the instance level.

### Personnel capability property

Specific properties that are required for *personnel capabilities* shall be presented as *personnel capability properties*.

*Personnel capability properties* may contain nested *personnel capability properties*.

Table 229 defines the relationship roles for the *personnel capability property*.

Table 230 defines the attributes for the *personnel capability property*.

Table 229 – Personnel capability property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Personnel capability | NA | 1 | Has values of | The *personnel capability* defined in part by this *personnel capability property.* |
| Personnel capability property | Personnel capability property child | o..\* | Contains | The values in the child *personnel capability property* for this *personnel capability property.* |
| Personnel class property | Personnel class property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |
| Person property | Person property | 0..\* | Maps to | A cross-model dependency to element in the personnel model as explained in Clause 3.3.8. |

Table 230 – Personnel capability property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *person property* or *personnel class property*. | Packing Machine Certified | CNC daily maintenance certification | Stock receiving inspection certification | (not applicable) |
| Description | Contains additional information and descriptions of the *personnel capability property* definition. | Level of packing machine operator certification | Training level required | current certification | (not applicable) |
| Value | The value, set of values, or range of the property. | Journeyman | True | True | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | (not applicable) | Boolean | Boolean | (not applicable) |
| Quantity | Specifies the quantity of the *personnel capability* defined. | 16 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours | (not applicable) | (not applicable) | (not applicable) |

### Equipment capability

A representation of the capability of *equipment* or *equipment classes* that is committed, available, or unattainable for a specific time shall be presented as an *equipment capability*. *Equipment capability* may contain references to either *equipment* or *equipment classes.*

*Equipment capability* shall identify

1. the availability (available, unattainable, committed, used, unused, total) and
2. the time associated with the availability.

EXAMPLE 1 Third shift on a specific date.

Specific *equipment capabilities* may have *equipment capability properties*. The *equipment capability properties* may include the quantity of the resource referenced.

EXAMPLE 2 3 horizontal drill presses currently available.

Table 231 defines the relationship roles for the *equipment capability*.

Table 232 defines the attributes for the *equipment capability*.

Table 231 – Equipment capability relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations capability | NA | 1 | Is a collection of | The *operations capability* defined in part by this *equipment capability*. |
| Equipment capability | Equipment capability child | 0..\* | Is made up of | The related object(s) makes up part of this *equipment capability* as the whole. |
| Equipment capability property | Equipment capability property | 0..\* | Has values of | The values in the *equipment capability property* are for this *equipment capability.* |
| Equipment class | Equipment class | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment class* of the capability. |
| Equipment | Equipment | 0..\* | Corresponds to | A cross-model association to element in the equipment model as explained in Clause 3.3.8.  Identifies the associated *equipment* of the capability. |

Table 232 – Equipment capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique instance of the *equipment capability* for a specified element of the equipment hierarchy model  EXAMPLE 3  Enterprise, site, area, work center, or work unit.  Required attribute. | E-1999/12/30-HPC52-POM | E-84818343DF-MnTOM | E-4737845-QOM | E-EDIDCUIUE-IOM |
| Description | Contains additional information and descriptions of the *equipment capability* definition. | Widget Lathe availability over the 2000 New Year boundary | Automated drill press | Measurement tool | (not applicable) |
| Capability type | Defines the type of capability.  Defined values are   * committed: capacity that is committed for future productive use; * unattainable: capacity that is not attainable for future productive use given the equipment condition, equipment utilization, personnel availability or material availability: * available: capacity that is available for additional future productive use; * used: a historical value that defines the portion of the capacity with acceptable quality; * unused: a historical value that defines the portion of the capacity that was not used or had unacceptable quality; and * total: the sum of used and unused capability or the sum of available, unattainable and committed capability. | Unattainable | Committed | Available | (not applicable) |
| Reason | Defines the reason for the capability type.  EXAMPLE 4  If unused capability, then the reason for why the capability was unused, such as a specific equipment failure or unacceptable product quality. | Due to Y2K Non compliance | Schedule calibration | Available for measurement | (not applicable) |
| Confidence factor | Measure of the confidence of the ability to obtain the capacity value. | 90 % | 100 % | 100 % | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  If omitted, then the capability is associated to the parent *operations capability* hierarchy scope.  Zero or more as required to identify the specific scope of the *operations capability* definition. | South Shore Work Plant | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | (not applicable) |
| Spatial definition | Spatially defines the *equipment* specified by this *equipment capability* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Operational location | Identifies the operational location of the *equipment* specified by this *equipment capability*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Operational location type | Indicates whether the operational location attribute refers to an *operational* *location* object, or contains a description of the operational location.  Mandatory where an operational location attribute is specified.  Defined values are   * operational location: operational location attribute references an *operational* *location*. * description: operational location attribute contains a description of the operational location, such as a street address. | Operational location | Description | Operational location | Operational location |
| Equipment use | Defines the expected capability use of the *equipment class* or *equipment*. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |
| Start time | The starting time associated with the *equipment capability*.  If omitted, then the capability is associated to the parent *operations capability* start time. | 1999-12-30 11:59 | 10-28-2006 2:00 UTC | 10-28-2006 00:00 UTC | (not applicable) |
| End time | The ending time associated with the *equipment capability*.  If omitted, then the capability is associated to the parent *operations capability* end time. | 2000-01-01 12:00 | 10-28-2006 2:15 UTC | 10-28-2006 8:00 UTC | (not applicable) |
| Quantity | Specifies the quantity of the *equipment capability* defined. | 48 | 1 | 1 | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours | Machine | Tool | (not applicable) |

NOTE An *equipment capability* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified *equipment* within a given *operational location*.

Where *equipment* are members of multiple *equipment classes* then the *equipment capability* information defined by *equipment class* should be used carefully because of possible double counts and *equipment* resources should be managed at the instance level.

### Equipment capability property

Specific properties that are required for *equipment capabilities* shall be presented as *equipment capability properties*.

*Equipment capability properties* may contain nested *equipment capability properties*.

Table 233 defines the relationships for the *equipment capability property*.

Table 234 defines the attributes for the *equipment capability property*.

Table 233 – Equipment capability property relationships

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Equipment capability | NA | 1 | Has values of | The *equipment capability* defined in part by this *equipment capability property.* |
| Equipment capability property | Equipment capability property child | 0..\* | Contains | The values in the child *equipment capability property* for this *equipment capability property.* |
| Equipment class property | Equipment class property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |
| Equipment property | Equipment property | 0..\* | Maps to | A cross-model dependency to element in the equipment model as explained in Clause 3.3.8. |

Table 234 – Equipment capability property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *equipment property* or *equipment class property*.  Required attribute. | Volume | Spindle run-out | Scale definition | (not applicable) |
| Description | Contains additional information and descriptions of the *equipment capability property* definition. | Measure of the equipment volume. | Max allowed spindle runout | Units of measure | (not applicable) |
| Value | The value, set of values, or range of the property. | 10 000 | less than 0.000 08 | Metric | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | Liters | Inches | (not applicable) | (not applicable) |
| Quantity | Specifies the quantity of the *equipment capability* defined. | 12 | (not applicable) | 1 | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours | (not applicable) | Each | (not applicable) |

### Physical asset capability

A representation of the capability of a *physical asset* or *physical asset class* that is committed, available, or unattainable for a specific time shall be presented as a *physical asset capability*. *Physical asset capability* may contain references to either *physical asset* or *physical asset class*.

*Physical asset capability* shall identify

1. the availability (available, unattainable, committed, used, unused, total) and
2. the time associated with the availability.

EXAMPLE Third shift on a specific date.

Specific *physical asset capabilities* may contain *physical asset capability properties*. The *physical asset capability properties* may include the quantity of the resource referenced.

Table 235 defines the relationship roles for the *physical asset* *capability*.

Table 236 defines the attributes for the *physical asset* *capability*.

Table 235 – Physical asset capability relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations capability | NA | 1 | Is a collection of | The *operations capability* defined in part by this *physical asset capability.* |
| Physical asset capability | Physical asset capability child | 0..\* | Is made up of | The related object(s) makes up part of this *physical asset capability* as the whole. |
| Physical asset capability property | Physical asset capability property | 0..\* | Has values of | The values in the *physical asset capability property* are for this *physical asset capability.* |
| Physical asset class | Physical asset class | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset class* of the capability. |
| Physical asset | Physical asset | 0..\* | Corresponds to | A cross-model association to element in the physical asset model as explained in Clause 3.3.8.  Identifies the associated *physical asset* of the capability. |

Table 236 – Physical asset capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique instance of the *physical asset capability* for a specified element of the equipment hierarchy model  EXAMPLE 1  Enterprise, site, area, work center, or work unit.  Required attribute. | PA-1999/12/30-HPC52-POM | PA-84818343DF-MnTOM | PA-4737845-QOM | PA-EDIDCUIUE-IOM |
| Description | Contains additional information and descriptions of the *physical asset capability* definition. | Widget Lathe availability over the 2000 New Year boundary | Cameroon Drill Press | (not applicable) | (not applicable) |
| Capability type | Defines the type of capability.  Defined values are   * committed: capacity that is committed for future productive use; * Unattainable: capacity that is not attainable for future productive use given the equipment condition, equipment utilization, personnel availability or material availability; * available: capacity that is available for additional future productive use; * used: a historical value that defines the portion of the capacity with acceptable quality; * unused: a historical value that defines the portion of the capacity that was not used or had unacceptable quality; and * total: the sum of used and unused capability or the sum of available, unattainable and committed capability. | Unattainable | Committed | (not applicable) | (not applicable) |
| Reason | Defines the reason for the capability type.  EXAMPLE 2  If capability unused, then the reason for why the capability was unused, such as a specific equipment failure or unacceptable product quality. | Due to Y2K Non compliance | Scheduled calibration | (not applicable) | (not applicable) |
| Confidence factor | Measure of the confidence of the ability to obtain the capacity value. | 90 % | 100 % | (not applicable) | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  If omitted, then the capability is associated to the parent *operations capability* hierarchy scope.  Zero or more as required to identify the specific scope of the *operations capability* definition. | South Shore Work Plant | CNC Machine  Asset ID 13465 | (not applicable) | (not applicable) |
| Spatial definition | Spatially defines the *physical asset(s)* specified by this *physical asset capability* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Physical location | Identifies the physical location of the *physical asset(s)* specified by this *physical asset capability*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Physical location type | Indicates whether the physical location attribute refers to an *operational* *location* object, or contains a description of the physical location.  Mandatory where a physical location attribute is specified.  Defined values are   * operational location: physical location attribute references an *operational* *location*; * description: physical location attribute contains a description of the physical location, such as a street address. | Operational Location | Description | Operational Location | Operational Location |
| Physical asset use | Defines the expected capability use of the *physical asset class* or *physical asset*. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |
| Start time | The starting time associated with the *physical asset capability*.  If omitted, then the capability is associated to the parent *operations capability* start time. | 1999-12-30 11:59 | 10-28-2006 2:00 UTC | (not applicable) | (not applicable) |
| End Time | The ending time associated with the *physical asset capability*.  If omitted, then the capability is associated to the parent *operations capability* end time. | 2000-01-01 12:00 | 10-28-2006 2:15 UTC | (not applicable) | (not applicable) |
| Quantity | Specifies the quantity of the *physical asset capability* defined. | 48 | 1 | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours | Machine | (not applicable) | (not applicable) |

NOTE A *physical asset capability* can specify both a spatial definition and an operational location attributes where it is necessary to specify the spatial definition of the specified *physical asset(s)* within a given *operational location*.

### Physical asset capability property

Specific properties that are required for *physical asset capabilities* shall be presented as *physical asset capability properties*.

*Physical asset capability properties* may contain nested *physical asset capability properties*.

Table 237 defines the relationship roles for the *physical asset capability property*.

Table 238 defines the attributes for the *physical asset capability property*.

Table 237 – Physical asset capability property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Physical asset capability | NA | 1 | Has values of | The *physical asset capability* defined in part by this *physical asset capability property.* |
| Physical asset capability property | Physical asset capability property child | 0..\* | Contains | The values in the child *physical asset capability property* for this *physical asset capability property.* |
| Physical asset class property | Physical asset class property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |
| Physical asset property | Physical asset property | 0..\* | Maps to | A cross-model dependency to element in the physical asset model as explained in Clause 3.3.8. |

Table 238 – Physical asset capability property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *physical asset property* or *physical asset class*.  Required attribute. | Volume | Repeatability | (not applicable) | (not applicable) |
| Description | Contains additional information and descriptions of the *physical asset capability property* definition. | Measure of the equipment volume. | Drilling consistency | (not applicable) | (not applicable) |
| Value | The value, set of values, or range of the property. | 10 000 | 0.000 2 | (not applicable) | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | Liters | Inches | (not applicable) | (not applicable) |
| Quantity | Specifies the quantity of the *physical asset capability* defined. | 12 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | Hours | (not applicable) | (not applicable) | (not applicable) |

### Material capability

A representation of the capability of materialthat is committed, available, or unattainable for a specific time shall be presented as a *material capability*. *Material capability* is used for *material lots* and *material sublots*. This includes information that is associated with the functions of material and energy control and product inventory control. The currently available and committed *material capability* is the inventory. WIP (work in progress) is a *material capability* currently under the control of production.

*Material capability* shall identify

1. the availability (available, unattainable, committed, used, unused, total) and
2. the time associated with the availability.

EXAMPLE 1 Third shift on a specific date.

Specific *material capabilities* may have *material capability properties*. The *material capability properties* may include the quantity of the material referenced.

EXAMPLE 2 3 sublots in building 3 of material starch lot #12345 committed to production for 2000-02-29.

A *material capability* may be defined as containing an assembly of *material capabilities* and as part of an assembly of *material capability*.

1. A *material capability* may define an assembly of zero or more *material capabilities*.
2. *A material capability* may be an assembly element of zero or more *material capabilities*.
3. An assembly may be defined as a permanent or transient assembly of *material capabilities*.
4. An assembly may be defined as physical or a logical assembly of *material capabilities*.

Table 239 defines the relationship roles for the *material capability*.

Table 240 defines the attributes for the *material capability*.

Table 239 – Material capability relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations capability | NA | 1 | Is a collection of | The *operations capability* defined in part by this *material capability.* |
| Material capability | Material capability child | 0..\* | Is assembled from | The related object(s) makes up part of this *material capability* (lot or sublot) as the whole. |
| Material capability property | Material capability property | 0..\* | Has values of | The values in the *material capability property* are for this *material capability.* |
| Material class | Material class | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material class* or set of *material classes* of the capability |
| Material definition | Material definition | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material definition* or set of *material definition* of the capability. |
| Material lot | Material lot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material lot* or set of *material lot* of the capability  Typically, either a *material class* or *material definition* is specified. |
| Material sublot | Material sublot | 0..\* | Corresponds to | A cross-model association to element in the material model as explained in Clause 3.3.8.  Identifies the associated *material sublot* or set of *material sublot* of the capability.  Typically, either a *material class* or *material definition* is specified. |

Table 240 – Material capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique instance of the *material capability* for a specified element of the equipment hierarchy model.  EXAMPLE 3  Enterprise, site, area, work center, or work unit.  Required attribute. | M-1999/12/30-HPC52-POM | M-84818343DF-MnTOM | M-4737845-QOM | M-EDIDCUIUE-IOM |
| Description | Contains additional information and descriptions of the *material capability* definition. | Lubricant oil commitment over the 2000 New Year boundary | Blank sheet to run test on | (not applicable) | (not applicable) |
| Capability type | Defines the type of capability.  Defined values are   * committed: capacity that is committed for future productive use; * unattainable: capacity that is not attainable for future productive use given the equipment condition, equipment utilization, personnel availability or material availability; * available: capacity that is available for additional future productive use; * used: a historical value that defines the portion of the capacity with acceptable quality; * unused: a historical value that defines the portion of the capacity that was not used or had unacceptable quality; and * total: the sum of used and unused capability or the sum of available, unattainable and committed capability. | Committed | Committed | (not applicable) | (not applicable) |
| Reason | Defines the reason for the capability type.  EXAMPLE 4  If capability unused, then the reason for why the capability was unused, such as a specific equipment failure or unacceptable product quality. | Available for Work | Scheduled calibration | (not applicable) | (not applicable) |
| Confidence factor | Measure of the confidence of the ability to obtain the capacity value. | 90 % | 100 % | (not applicable) | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  If omitted, then the capability is associated to the parent *operations capability* hierarchy scope.  Zero or more as required to identify the specific scope of the *operations capability* definition. | Work Line 15 | CNC Machine  Asset ID 13465 | (not applicable) | (not applicable) |
| Spatial definition | Spatially defines the material resource(s) specified by this *material capability* as a 0-dimensional point, 1-dimensional line, or 2-dimensional shape or 3-dimensional solid. | 4326 / EPSG / GPX / lat="45.35" lon="24.15" | 5800 / EPSG / WKT / POINT ( -1000 463 ) | 4269 / EPSG / WKT / POINT ( 3848472 96789 ) | 6283 / EPSG / WKT / POLYGON ( ( -646.99 676.18, -645.14 683.09, -646.99 676.18 ) ) |
| Storage location | Describes the storage location of the material resource(s) specified by this *material capability*. | SST57 | Shed4S-8 | 3822 | WH1 |
| Storage location type | Indicates whether the storage location attribute refers to an *operational location*, *equipment* or *physical asset* object, or contains a description of the storage location.  Mandatory where a storage location is specified.  Defined values are   * operational location: storage location attribute references an *operational location*; * equipment: storage location attribute references an *equipment* object; * physical asset: storage location attribute references a *physical asset*; and * description: storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Material use | Defines the expected use of the *material class,* *material definition, material lot, or material sublot* in the context of the *operations capability*.  Defined values for production operations are  consumable, consumed, produced, by-product produced, co-product produced, and yield produced.  Defined values for maintenance operations are  consumable, material consumed, and material produced.  Defined values for quality test operations are  consumable, destructive sample, returned sample, and retained sample.  Defined values for inventory operations are  consumable, material consumed, material produced, and inventoried. | Consumed | Committed | (not applicable) | (not applicable) |
| Start time | The starting time associated with the *material capability*.  If omitted, then the capability is associated to the parent *operations capability* start time. | 1999-12-30 11:59 | 10-28-2006 2:00 UTC | (not applicable) | (not applicable) |
| End time | The ending time associated with the *material capability*.  If omitted, then the capability is associated to the parent *operations capability* end time. | 2000-01-01 12:00 | 10-28-2006 2:15 UTC | (not applicable) | (not applicable) |
| Quantity | Specifies the quantity of the *material capability* defined. | 155 | 1 | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the material quantity. | Liters | Sheet | (not applicable) | (not applicable) |
| Assembly type | Defines the type of the assembly.  Defined types are   * physical: the components of the assembly are physically connected or in the same area. * logical: the components of the assembly are not necessarily physically connected or in the same area. | Physical | Physical | Logical | Physical |
| Assembly relationship | Defines the type of the relationships.  Defined types are   * permanent: an assembly that is not intended to be split during the production process; * Transient: a temporary assembly using during production, such as a pallet of different materials or a batch kit. | Permanent | Transient | Permanent | Transient |
| \* Typically, either a *material class, material definition, material lot*, or *material sublot* is specified. | | | | | |

NOTE A *material capability* can specify a spatial definition attribute in addition to an operational location attribute where it is necessary to specify the spatial definition of the *material* resource(s) within the given *operational location*.

Where *materials* are members of multiple *material classes* then the *material capability* information defined by *material class* should be used carefully because of possible double counts, and *material* resources should be managed at the instance level.

### Material capability property

Specific properties that are required for *material capabilities* shall be presented as *material capability properties*.

*Material capability properties* may contain nested *material capability properties*.

Table 241 defines the relationship roles for the *material capability property*.

Table 242 defines the attributes for the *material capability property*.

Table 241 – Material capability property relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Material capability | NA | 1 | Has values of | The *material capability* defined in part by this *material capability property.* |
| Material capability property | Material capability property child | 0..\* | Contains | The values in the child *material capability property* for this *material capability property.* |
| Material class property | Material property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material definition property | Material property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |
| Material lot property | Material lot property | 0..\* | Maps to | A cross-model dependency to element in the material model as explained in Clause 3.3.8. |

Table 242 – Material capability property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a property of the associated *material property* or *equipment class property*.  Required attribute. | pH | Size | (not applicable) | (not applicable) |
| Description | Contains additional information and descriptions of the *material capability property* definition. | pH of active ingredient | Size required by calibration test | (not applicable) | (not applicable) |
| Value | The value, set of values, or range of the property. | 6.3 | 3 × 5 | (not applicable) | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value. | pH | Feet | (not applicable) | (not applicable) |
| Quantity | Specifies the quantity of the *material capability* defined. | 2 567 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity. | KiloLiters | (not applicable) | (not applicable) | (not applicable) |

## Process segment capability information

### Process segment capability model

A *process segment capability* is a representation of a logical grouping of personnel resources, equipment resources, physical asset resources, and material that is committed, available, or unavailable for a defined *process segment* for a specific time.

A *process segment capability* is related to a *process segment* that can occur during operations.

*Process segment capability* shall identify

1. the *capability type* (available, unattainable, committed, used, unused, total) and
2. the time associated with the capability.

EXAMPLE Third shift on a specific date.

*Process segment capabilities* shall be made up of

1. *personnel capabilities* and any specific properties required in *personnel segment capability properties*;
2. *equipment capabilities* and any specific properties required in *equipment capability properties*;
3. *physical asset capabilities* and any specific properties required in *physical asset capability properties*;
4. *material capabilities* and any specific properties required in *material capability properties.*

Figure 24 is the *process segment capability* model. Table 243 lists the relationships of the objects in the process segment capability model.

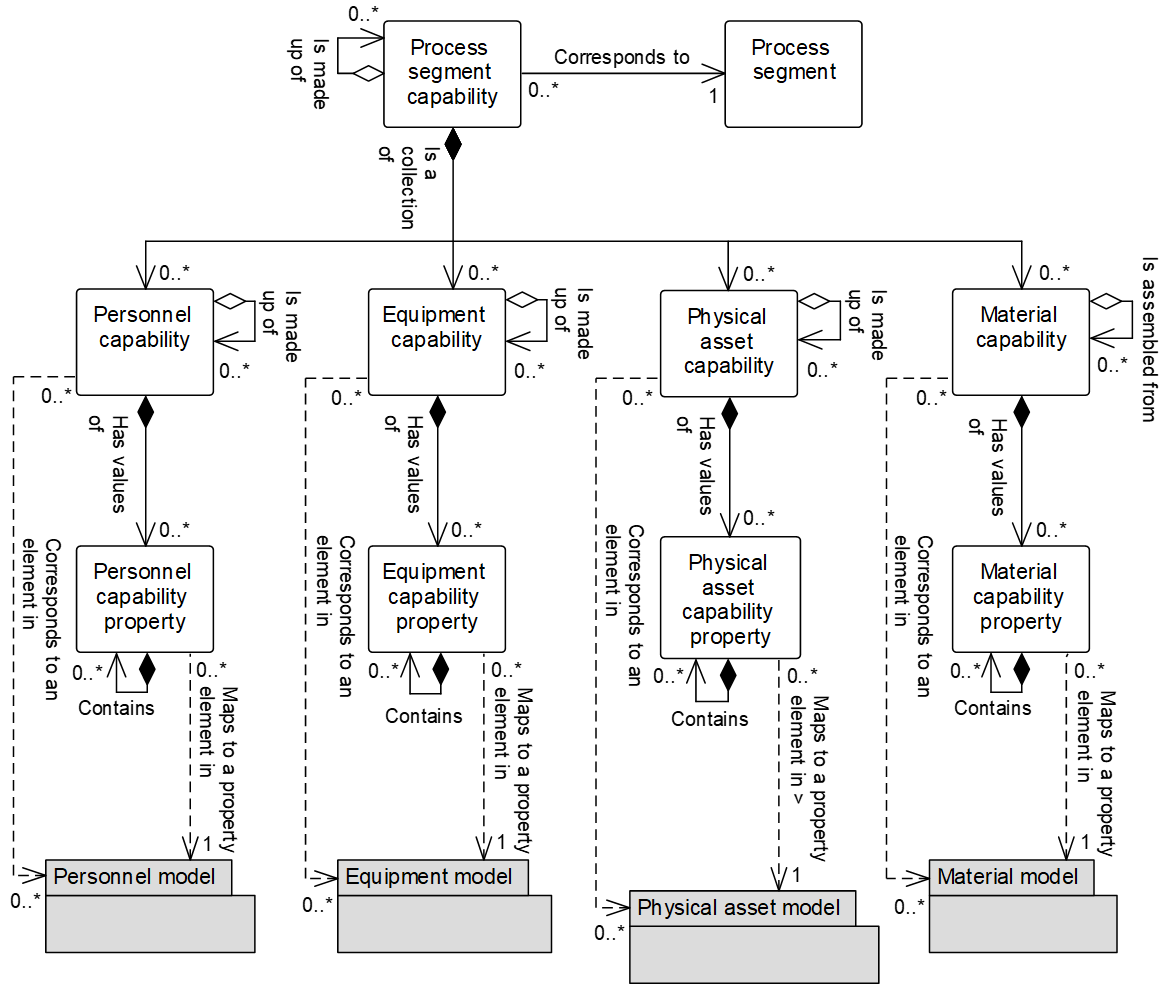


Figure 24 – Process segment capability object model

NOTE The object color convention used in the Part 2 and Part 4 UML diagrams for information models is as shown in Clause 3.3.3.

Table 243 – Process segment capability model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Process segment capability | Process segment | Association | Corresponds to |
| Process segment capability | Process segment capability | Aggregation hierarchy | Is made up of |
| Process segment capability | Personnel capability | Composition whole | Is a collection of |
| Process segment capability | Equipment capability | Composition whole | Is a collection of |
| Process segment capability | Physical asset capability | Composition whole | Is a collection of |
| Process segment capability | Material capability | Composition whole | Is a collection of |
| Personnel capability | Personnel capability | Aggregation hierarchy | Is made up of |
| Personnel capability | Personnel capability property | Composition whole | Has values of |
| Personnel capability property | Personnel capability property | Composition hierarchy | Contains |
| Personnel capability | Personnel class | Association (A) | Corresponds to |
| Personnel capability | Person | Association (C) | Corresponds to |
| Personnel capability property | Personnel class property | Dependency (B) | Maps to |
| Personnel capability property | Person property | Dependency (D) | Maps to |
| Equipment capability | Equipment capability | Aggregation hierarchy | Is made up of |
| Equipment capability | Equipment capability property | Composition whole | Has values of |
| Equipment capability property | Equipment capability property | Composition hierarchy | Contains |
| Equipment capability | Equipment class | Association (A) | Corresponds to |
| Equipment capability | Equipment | Association (C) | Corresponds to |
| Equipment capability property | Equipment class property | Dependency (B) | Maps to |
| Equipment capability property | Equipment property | Dependency (D) | Maps to |
| Physical asset capability | Physical asset capability | Aggregation hierarchy | Is made up of |
| Physical asset capability | Physical asset capability property | Composition whole | Has values of |
| Physical asset capability property | Physical asset capability property | Composition hierarchy | Contains |
| Physical asset capability | Physical asset class | Association (A) | Corresponds to |
| Physical asset capability | Physical asset | Association (C) | Corresponds to |
| Physical asset capability property | Physical asset class property | Dependency (B) | Maps to |
| Physical asset capability property | Physical asset property | Dependency (D) | Maps to |
| Material capability | Material capability | Aggregation hierarchy | Is assembled from |
| Material capability | Material capability property | Composition whole | Has values of |
| Material capability property | Material capability property | Composition hierarchy | Contains |
| Material capability | Material class | Association (A) | Corresponds to |
| Material capability | Material definition | Association (A) | Corresponds to |
| Material capability | Material lot | Association (C) | Corresponds to |
| Material capability | Material sublot | Association (C) | Corresponds to |
| Material capability property | Material class property | Dependency (B) | Maps to |
| Material capability property | Material definition property | Dependency (B) | Maps to |
| Material capability property | Material lot property | Dependency (D) | Maps to |

### Process segment capability

A representation of a logical grouping of personnel resources, equipment resources, physical asset resources, and material that is committed, available, or unavailable for a given process segment for a specific time shall be presented as a *process segment capability*.

*Process segment capability* has an equivalent structure to the *personnel, equipment and material* structure of *operations capability*, except the *process segment capability* is defined for a specific *process segment*.

Table 244 lists the relationship roles of the *process segment capability.*

Table 245 lists the attributes of the *process segment capability.*

Table 244 – Process segment capability relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Process segment | Process segment | 0..\* | Corresponds to | The *process segment* related to this *operations capability*. |
| Process segment capability | Process segment capability child | 0..\* | Is made up of | The nested *process segment capability(s)* makes up part of this *process segment capability* as the whole. |
| Personnel capability | Personnel capability | 0..\* | Is a collection of | The *personnel capability* related to this *process segment capability.* |
| Equipment capability | Equipment capability | 0..\* | Is a collection of | The *equipment capability* related to this *process segment capability*. |
| Physical segment capability | Physical segment capability | 0..\* | Is a collection of | The *physical asset capability* related to this *process segment capability.* |
| Material capability | Material capability | 0..\* | Is a collection of | The *material capability* related to this *process segment capability.* |

Table 245 – Process segment capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique instance of a *process segment capability* for a specified element of the equipment hierarchy model (*enterprise, site, area, work center, or work unit*).  Required attribute. | 1999/12/30-HPC52 | 84818343DF | 4737845 | EDIDCUIUE |
| Description | Contains additional information and descriptions of the *process segment capability* definition. | Defines the available capability for the Widget Assembly process segment | Calibration of CNC Drill Press | Incoming aluminum sheet thickness test | Kiting segment |
| Operations type | Describes the category of the activity.  Defined values are  production, maintenance, quality, inventory, or mixed.  “Mixed” can be used when the activity contains several categories of *process segments*. | Production | Maintenance | Quality | Inventory |
| Capability type | Defines the type of capability.  Defined values are   * committed: capacity that is committed for future productive use; * unattainable: capacity that is not attainable for future productive use given the equipment condition, equipment utilization, personnel availability or material availability; * available: capacity that is available for additional future productive use; * used: a historical value that defines the portion of the capacity with acceptable quality; * unused: a historical value that defines the portion of the capacity that was not used or had unacceptable quality; and * total: the sum of used and unused capability or the sum of available, unattainable and committed capability. | Available | Committed | Available | Unattainable |
| Reason | Defines the reason for the a.  EXAMPLE 1  If capacity unused, then the reason for why the capability was unused, such as a specific equipment failure or unacceptable product quality. | Available for Production | Scheduled calibration | Available for incoming inspection | Down for inventory cycle count |
| Confidence factor | Measure of the confidence of the ability to obtain the capacity value. | Good | 100% | bad | Uncertain |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  If omitted, then the capability is associated to the parent *process segment capability* hierarchy scope.  Zero or more as required to identify the specific scope of the *operations capability* definition. | Production Line #15 | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Start time | The starting time of the time span defining the capability type.  If omitted, then the capability is associated to the parent *process segment capability* start time. | 1999-12-30 11:59 | 10-28-2006 2:00 UTC | 10-28-2006 00:00 UTC | 10-28-2006 00:00 UTC |
| End time | The ending time of the time span defining the capability type.  If omitted, then the capability is associated to the parent *process segment capability* end time. | 2000-01-01 12:00 | 10-28-2006 2:15 UTC | 10-28-2006 8:00 UTC | 10-29-2006 00:00 UTC |

*Process segment capabilities* should be used carefully because of possible double counts of resources.

EXAMPLE 2 A resource can be shown as available in multiple *process segments*, but in fact can be available for use in only a single *process segment*.

## Operations segment capability information

### Operations segment capability model

An *operations segment capability* is a representation of a logical grouping of personnel resources, equipment resources, physical asset resources and material resources that is committed, available, or unavailable for a defined *operations segment* for a specific time.

An *operations segment capability* is related to an *operations segment* that can occur during operations.

*Operations segment capability* shall identify

1. the *capability type* (available, unattainable, committed, used, unused, total) and
2. the time associated with the capability.

EXAMPLE Third shift on a specific date.

*Operations segment capabilities* shall be made up of

1. *personnel capabilities* and any specific properties required in *personnel capability properties*;
2. *equipment capabilities* and any specific properties required in *equipment capability properties*;
3. *physical asset capabilities* and any specific properties required in *physical asset capability properties*; and
4. *material capabilities* and any specific properties required in *material capability properties.*

Figure 25 is the operations segment capability model. Table 246 lists the relationships of the objects in the operations segment capability model.

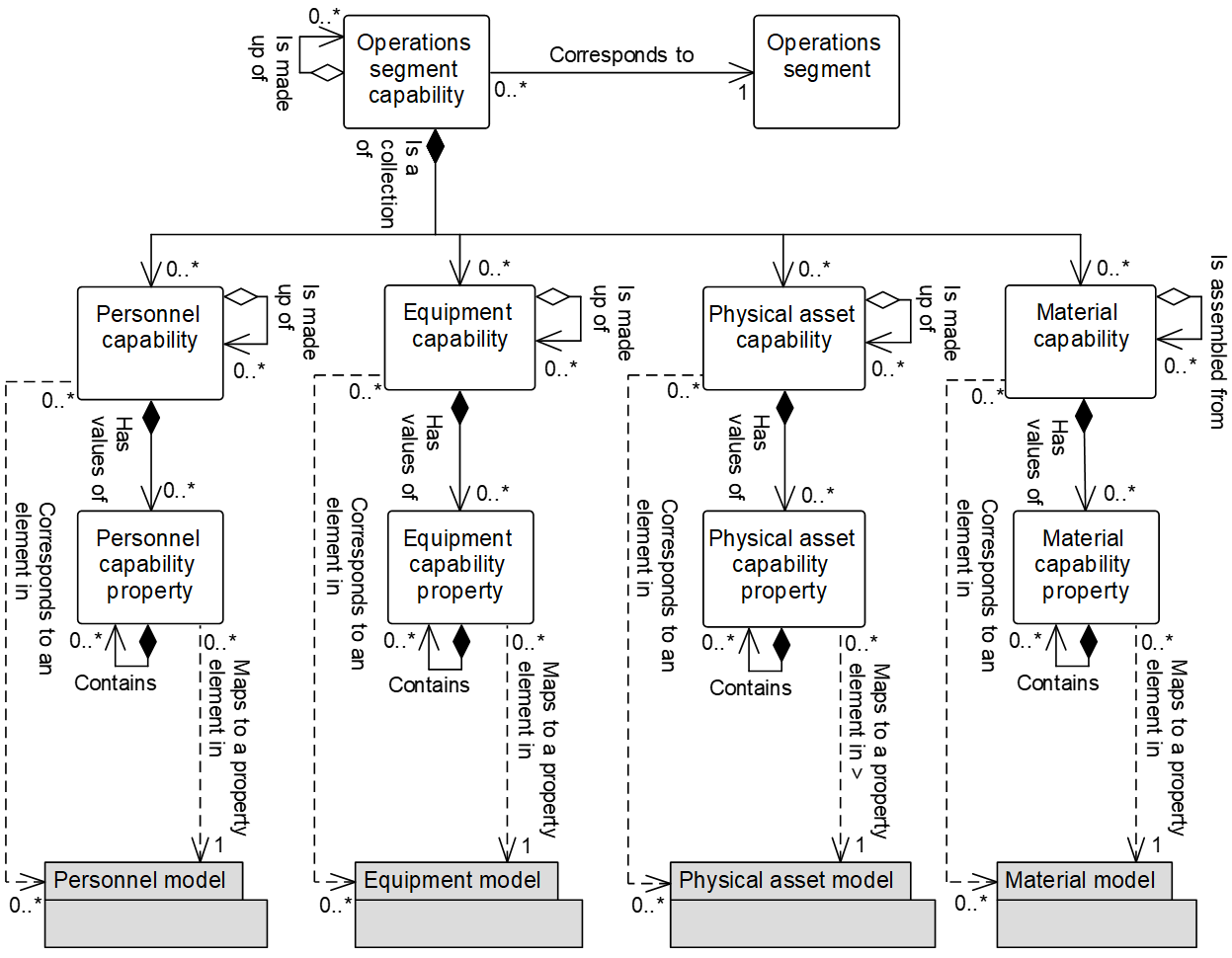


Figure 25 – Operations segment capability object model

NOTE The object color convention used in the Part 2 and Part 4 UML diagrams for information models is as shown below 3.3.3.

Table 246 – Operations segment capability model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations segment capability | Operations segment | Association | Corresponds to |
| Operations segment capability | Operations segment capability | Aggregation hierarchy | Is made up of |
| Operations segment capability | Personnel capability | Composition whole | Is a collection of |
| Operations segment capability | Equipment capability | Composition whole | Is a collection of |
| Operations segment capability | Physical asset capability | Composition whole | Is a collection of |
| Operations segment capability | Material capability | Composition whole | Is a collection of |
| Personnel capability | Personnel capability | Aggregation hierarchy | Is made up of |
| Personnel capability | Personnel capability property | Composition whole | Has values of |
| Personnel capability property | Personnel capability property | Composition hierarchy | Contains |
| Personnel capability | Personnel class | Association (A) | Corresponds to |
| Personnel capability | Person | Association (C) | Corresponds to |
| Personnel capability property | Personnel class property | Dependency (B) | Maps to |
| Personnel capability property | Person property | Dependency (D) | Maps to |
| Equipment capability | Equipment capability | Aggregation hierarchy | Is made up of |
| Equipment capability | Equipment capability property | Composition whole | Has values of |
| Equipment capability property | Equipment capability property | Composition hierarchy | Contains |
| Equipment capability | Equipment class | Association (A) | Corresponds to |
| Equipment capability | Equipment | Association (C) | Corresponds to |
| Equipment capability property | Equipment class property | Dependency (B) | Maps to |
| Equipment capability property | Equipment property | Dependency (D) | Maps to |
| Physical asset capability | Physical asset capability | Aggregation hierarchy | Is made up of |
| Physical asset capability | Physical asset capability property | Composition whole | Has values of |
| Physical asset capability property | Physical asset capability property | Composition hierarchy | Contains |
| Physical asset capability | Physical asset class | Association (A) | Corresponds to |
| Physical asset capability | Physical asset | Association (C) | Corresponds to |
| Physical asset capability property | Physical asset class property | Dependency (B) | Maps to |
| Physical asset capability property | Physical asset property | Dependency (D) | Maps to |
| Material capability | Material capability | Aggregation hierarchy | Is assembled from |
| Material capability | Material capability property | Composition whole | Has values of |
| Material capability property | Material capability property | Composition hierarchy | Contains |
| Material capability | Material class | Association (A) | Corresponds to |
| Material capability | Material definition | Association (A) | Corresponds to |
| Material capability | Material lot | Association (C) | Corresponds to |
| Material capability | Material sublot | Association (C) | Corresponds to |
| Material capability property | Material class property | Dependency (B) | Maps to |
| Material capability property | Material definition property | Dependency (B) | Maps to |
| Material capability property | Material lot property | Dependency (D) | Maps to |

### Operations segment capability

A representation of a logical grouping of *personnel* resources, *equipment* resources, *physical asset* resources, and *material* resources that is committed, available, or unavailable for a given *operations segment* for a specific time shall be presented as an *operations segment capability*.

*Operations segment capability* has an equivalent structure to the *personnel, equipment* and *material* structure of *operations capability*, except the *operations segment capability* is defined for a specific *operations segment*.

Table 247 lists the relationship roles of the *operations segment capability.*

Table 248 lists the attributes of the *operations segment capability.*

Table 247 – Operations segment capability relationship roles

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Operations segment | Operations segment | 0..\* | Corresponds to | The *operations segment* related to this *operations capability.* |
| Operations segment capability | Operations segment capability child | 0..\* | Is made up of | The nested *operations segment capability(s)* makes up part of this *operations segment capability* as the whole. |
| Personnel capability | Personnel capability | 0..\* | Is a collection of | The *personnel capability* related to this *process segment capability*. |
| Equipment capability | Equipment capability | 0..\* | Is a collection of | The *equipment capability* related to this *process segment capability.* |
| Physical segment capability | Physical segment capability | 0..\* | Is a collection of | The *physical asset capability* related to this *process segment capability.* |
| Material capability | Material capability | 0..\* | Is a collection of | The *material capability* related to this *process segment capability.* |

Table 248 – operations segment capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique instance of an *operations segment capability* for a specified *operations segment*.  Required attribute. | 1999/12/30-HPC52 | 84818343DF | 4737845 | EDIDCUIUE |
| Description | Contains additional information and descriptions of the *process segment capability* definition. | Defines the available capability for the Widget Assembly operations segment | Calibration of CNC Drill Press | Incoming aluminum sheet thickness test | Kiting segment |
| Operations type | Describes the category of the activity.  Defined values are  production, maintenance, quality, inventory, or mixed.  “Mixed” can be used when the activity contains several categories of *process segments*. | Production | Maintenance | Quality | Inventory |
| Operations segment | Identifies the *operations segment.* | Widget Assembly | Run X-Y test | RMT38283 | Kiting segment |
| Capability type | Defines the type of capability.  Defined values are   * committed: capacity that is committed for future productive use; * Unattainable: capacity that is not attainable for future productive use given the equipment condition, equipment utilization, personnel availability or material availability; * available: capacity that is available for additional future productive use; * used: a historical value that defines the portion of the capacity with acceptable quality; * unused: a historical value that defines the portion of the capacity that was not used or had unacceptable quality; and * total: the sum of used and unused capability or the sum of available, unattainable and committed capability. | Available | Committed | Available | Unattainable |
| Reason | Defines the reason for the capability type.  EXAMPLE 1  If capability unused, then the reason for why the capability was unused, such as a specific equipment failure or unacceptable product quality. | Available for Production | Scheduled calibration | Available for incoming inspection | Down for inventory cycle count |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  If omitted, then the capability is associated to the parent *operations segment capability* hierarchy scope.  Zero or more as required to identify the specific scope of the *operations segment capability*. | Production Line #15 | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Warehouse B |
| Start time | The starting time of the time span defining the capability type.  If omitted, then the capability is associated to the parent *operations segment capability* start time. | 1999-12-30 11:59 | 10-28-2006 2:00 UTC | 10-28-2006 00:00 UTC | 10-28-2006 00:00 UTC |
| End time | The ending time of the time span defining the capability type.  If omitted, then the capability is associated to the parent *operations segment capability* end time. | 2000-01-01 12:00 | 10-28-2006 2:15 UTC | 10-28-2006 8:00 UTC | 10-29-2006 00:00 UTC |

*Operations segment capabilities* should be used carefully because of possible double counts of resources.

EXAMPLE 2 A resource can be shown as available in multiple *operations segments*, but in actual fact can be available for use in only a single *operations segment.*

# Inter-relationships between object models

Figure 26 provides an informative illustration of how the object models inter-relate. The operations information presents what was made and what was used. Its elements correspond to information in *operations schedule* that listed what to make and what to use. The *operations schedule* elements correspond to information in the *operations definition*. The *operations definition* elements correspond to information in the *process segment* descriptions that present what can be performed with the resources. The *operations capability* contains what capacities exist for specified resources and for specific *process segments* for specific periods of time.

The slanted rectangles in Figure 26 represent any of the resources (*personnel, equipment, physical assets*, or *material*) and properties of the resources.

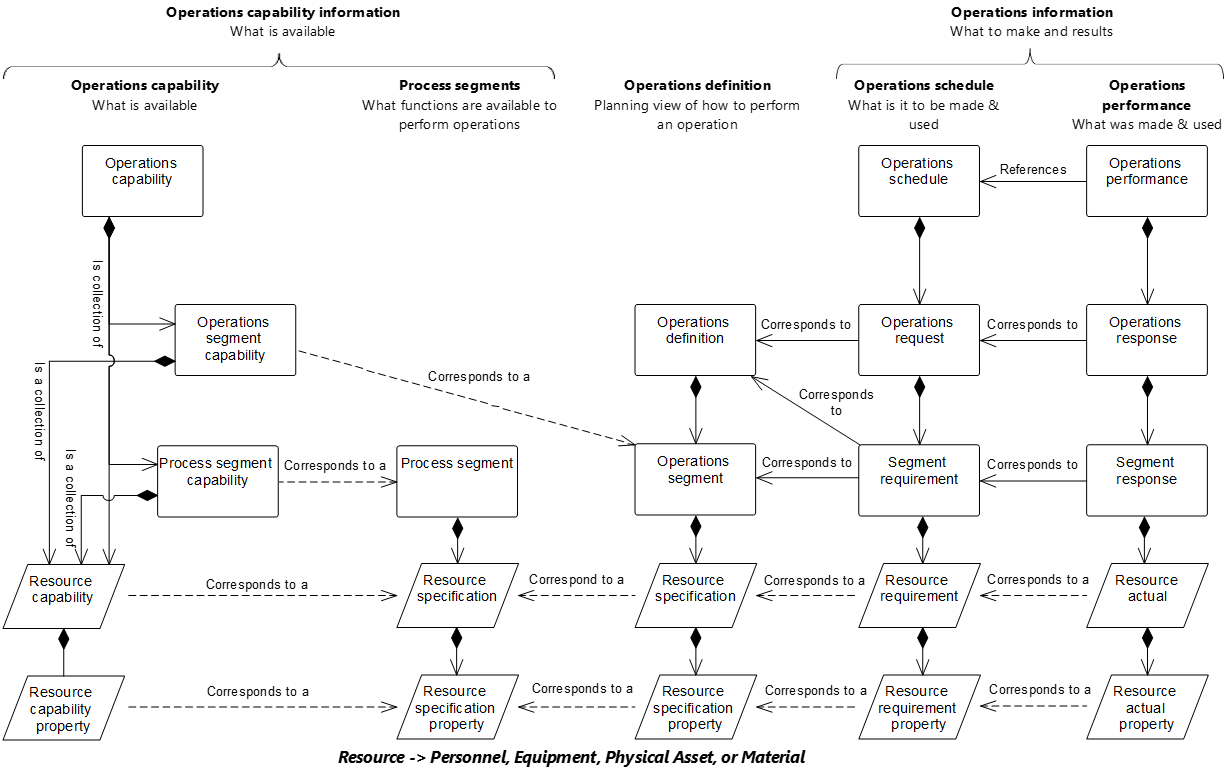


Figure 26 – Object model inter-relationships

NOTE Both resource capability properties and *operation segment*’s *operations specifications /properties* can map their properties to the *process segment*’s resource specification /properties. They can be subsets of the *process segment*’s resource specification /properties where capability properties are used to evaluate availability and *operations segment properties* can be used to determine requirement specifics for scheduling.

Table 249 lists the information models of this part that apply the simplified resource models to reference the resource models and defines the set of possible relationships to specific resource group and resource objects within each model.

Table 249 – List of information models and their resource object instances in cross-model relationships to resource models

| Information model | Resource reference object | Associated resource model | Associated resource group | Associated *resource* |
| --- | --- | --- | --- | --- |
| Process segment | Personnel segment specification | Personnel | Personnel class | Person |
| Equipment segment specification | Equipment | Equipment class | Equipment |
| Physical asset segment specification | Physical asset | Physical asset class | Physical asset |
| Material segment specification | Material | Material class, material definition | Material lot, material sublot |
| Operations definition | Personnel specification | Personnel | Personnel class | Person |
| Equipment specification | Equipment | Equipment class | Equipment |
| Physical asset specification | Physical asset | Physical asset class | Physical asset |
| Material specification | Material | Material class, material definition | Material lot, material sublot |
| Operations schedule | Personnel requirement | Personnel | Personnel class | Person |
| Equipment requirement | Equipment | Equipment class | Equipment |
| Physical asset requirement | Physical asset | Physical asset class | Physical asset |
| Material requirement | Material | Material class, material definition | Material lot, material sublot |
| Operations performance | Personnel actual | Personnel | Personnel class | Person |
| Equipment actual | Equipment | Equipment class | Equipment |
| Physical asset actual | Physical asset | Physical asset class | Physical asset |
| Material actual | Material | Material class, material definition | Material lot, material sublot |
| Operations capability | Personnel capability | Personnel | Personnel class | Person |
| Equipment capability | Equipment | Equipment class | Equipment |
| Physical asset capability | Physical asset | Physical asset class | Physical asset |
| Material capability | Material | Material class, material definition | Material lot, material sublot |
| Process segment capability | Personnel capability | Personnel | Personnel class | Person |
| Equipment capability | Equipment | Equipment class | Equipment |
| Physical asset capability | Physical asset | Physical asset class | Physical asset |
| Material capability | Material | Material class, material definition | Material lot, material sublot |

Table 250 provides a cross-reference between the elements of the information flows in the data flow model and the corresponding clause describing the object model.

Table 250 – Model cross-reference

| Part 1 - Data flow model information | Part 1 - From function | Part 1 - To function | Part 2 - Object model clause |
| --- | --- | --- | --- |
| 6.5.2 Schedule | Production scheduling | Production control | 6.2 and D.8 |
| 6.5.3 Production from plan | Production control | Production scheduling | 6.3, D.6, D.8, and D.9 |
| 6.5.4 Production capability | Production control | Production scheduling | 6.4, 6.5, 6.6, D,5, D.8, E.9, E.10, and E.11, |
| 6.5.5 Material and energy order requirements | Material and energy control | Procurement | Described in terms of the material model, 5.7, 5.9, 5.10, 5.11, 6.1, 6.2, D.7, D.9, E.6, and E.7 |
| 6.5.6 Incoming order confirmation | Material and energy control | Procurement | Described in terms of the material model, 5.7, 5.9, 5.10, 5.11, 6.1, and D.9 |
| 6.5.7 Long-term material and energy requirements | Production scheduling | Material and energy control | Described in terms of the material model, 5.7, 5.9, 5.10, 5.11, 6.1, 6.2, D.7, D.9, E.6, and E.7 |
| 6.5.8 Short-term material and energy requirements | Production control | Material and energy control | Described in terms of the material model, 5.7, 5.9, 5.10, 5.11, 6.1, 6.2, D.7, D.9, E.6, and E.7. |
| 6.5.9 Material and energy inventory | Material and energy control | Production control | Described in terms of the material model, 5.7. 5.3, 5.10, 5.11, 6.1, 6.3, 6.4, 6.5, 6.6, D.2, D.6, D.7, D.8, D.9, D.10, D.11, E.6, E.7, E.11, and E.13 |
| 6.5.10 Production cost objectives | Product cost accounting | Production control | 5.3, 5.8, 5.10, 5.11, 6.1, 6.2, D.8, E.10, and E.11 |
| 6.5.11 Production performance and costs | Production control | Product cost accounting | 5.3, 5.7, 5.8, 5.10, 5.11, 6.1, 6.2, 6.3, D.8, D.9, E.3, E.4, and E.11 |
| 6.5.12 Incoming material and energy receipt | Material and energy control | Product cost accounting | 5.3, 5.7, 5.8, 5.9, 5.10, 5.11, 6.1, 6.2, D.2, D.8, D.9, D.10, E.3, E.4, and E.11 |
| 6.5.13 Quality assurance results | Quality assurance | Production control, product inventory control functions, and material and energy control | 5.3, 5.7, 5.8, 5.9, 5.10, 5.11, 6.1, 6.2, 6.3, D.2, D.6, D.7, D.8, D.9, D.10, D.11, E.3, E.4, E.8, E.10, E.11, E.12, and E.13 |
| 6.5.14 Standards and customer requirements | Marketing and sales | Quality assurance | 5.3, 5.7, 5.8, 5.9, 5.10, 5.11, 6.1, 6.2, D.2, D.6, D.7, D.8, D.9, D.10, E.3, E.4, E.5, E.8, E.10, and E.11 |
| Quality assurance | Production control |
| 6.5.15 Product and process requirements | Research, development, and engineering | Quality assurance | 5.1 to 5.12; 6.1, 6.4, 6.5, 6.6, D.2, D.3, D.4, D.5, D.7, D.9, E.3, E.4, E.5, E.6, E.7, E.8, E.10, and E.11 |
| 6.5.16 Finished goods waiver | Order processing | Quality assurance | 5.1 to 5.12, 6.1, 6.3, D.2, D.7, D.8, D.9, D.11, E.3, E.4, E.5, E.6, E.7, E.8, E.10, and E.11  Typically, unstructured information handled on an *ad hoc* basis |
| 6.5.17 In-process waiver request | Production control | Quality assurance | 5.1, 5.2, 5.3, 5.7, 5.8, 5.9, 5.10, 5.11, 6.1, 6.3, D.2, D.6, D.7, D.8, D.9, D.11, E.3, E.4, E.5, E.6, E.7, E.8, E.10, and E.11 |
| 6.5.18 Finished goods inventory | Product inventory control | Production scheduling | 5.1, 5.2, 5.3, 5.7, 5.9, 5.10, 5.11, 6.3, D.2, D.6, D.7, D.8, D.9, D.10, E.3, E.4, E.5, E.6, E.7, E.8, E.10, and E.11 |
| 6.5.19 Process data | Production control | Quality assurance | 5.1, 5.2, 5.3, 5.7, 5.9, 5.10, 5.11, 6.3, D.2, D.6, D.7, D.8, D.9, D.10, E.3, E.4, E.5, E.6, E.7, E.8, E.10, and E.11 |
| 6.5.20 Pack-out schedule | Production scheduling | Product inventory control | 5.1 to 5.11, 6.1, 6.2, D.2, D.3, D.4, D.6, D.7, D.8, D.9, E.3, E.4, E.6, E.7, E.8, E.10, and E.11 |
| 6.5.21 Product and process information request | Production control | Research, development, and engineering | 5.1 to 5.11, 6.1, 6.2, D.2, D.3, D.4, D.7, D.8, D.9, E.3, E.4, E.6, E.7, E.8, E.10, and E.11 |
| 6.5.22 Maintenance requests | Production control | Maintenance management | 5.1 to 5.11, 6.1, 6.2, D.2, D.3, D.4, D.7, D.8, D.9, E.3, E.4, E.6, E.7, E.8, E.10, and E.11 |
| 6.5.23 Maintenance responses | Maintenance management | Production control | 5.1 to 5.11, 6.1, 6.3, 6.4, 6.5, 6.6, D.2, D.3, D.4, D.5, D.6, D.7, D.8, D.9, D.11, E.3, E.4, E.6, E.7, E.8, E.10, E.11, and E.12 |
| 6.5.24 Maintenance standards and methods | Production control | Maintenance management | 5.1 to 5.11, 6.1, 6.4, 6.5, 6.6, D.2, D.3, D.4, D.5, D.7, D.8, D.9, D.10, and E.3 to E.12 |
| 6.5.25 Maintenance technical feedback | Maintenance management | Production control | 5.1 to 5.11, 6.1, 6.3, 6.4, 6.5, 6.6, D.2, D.3, D.4, D.5, D.7, D.8, D.9, D.10, and E.3 to E.12 |
| 6.5.26 Product and process technical feedback | Production control | Research, development, and engineering | 5.1 to 5.11, 6.1, 6.3, 6.4, 6.5, 6.6, D.2, D.3, D.4, D.5, D.7, D.8, D.9, D.10, and E.3 to E.12 |
| 6.5.27 Maintenance purchase order requirements | Maintenance management | Procurement | 5.1, 5.2, 5.3, 5.5 to 5.11, 6.1, D.2, D.3, D.4, D.7, D.9, D.10, E.3, and E.7 |
| 6.5.28 Production order | Order processing | Production scheduling | 5.1 to 5.11, 6.1, 6.2, 6.3, D.2, D.3, D.4, D.6 to D.11, and E.3 to E.13 |
| 6.5.29 Availability | Production scheduling | Order processing | 5.1 to 5.11, 6.1, 6.2, 6.4, 6.5, 6.6, D.1 to D.11, E.3, E.4, and E.6 to E.12 |
| 6.5.30 Release to ship | Product shipping administration | Product inventory control | 5.1 to 5.11, 6.1, 6.3, D.2, D.6, D.7, D.8, D.9, and E.3, E.6, E.7, E.8, and E.13 |
| 6.5.31 Confirm to ship | Product inventory control | Product shipping administration | 5.1 to 5.11, 6.1, 6.3, D.2, D.6, D.7, D.8, D.9, and E.3, E.6, E.7, E.8, and E.13 |

# List of objects

Table 251 present a complete list of the objects discussed in this standard.

Table 251 – Common resource objects

| Object | Model |
| --- | --- |
| Hierarchy scope | Hierarchy scope |
| Operations location class | Operations location model |
| Operations location class property | Operations location model |
| Operations location | Operations location model |
| Operations location property | Operations location model |
| Personnel class | Personnel model |
| Personnel class property | Personnel model |
| Person | Personnel model |
| Person property | Personnel model |
| Equipment class | Equipment model |
| Equipment class property | Equipment model |
| Equipment | Equipment model |
| Equipment property | Equipment model |
| Physical asset | Physical asset model |
| Physical asset property | Physical asset model |
| Physical asset class | Physical asset model |
| Physical asset class property | Physical asset model |
| Equipment asset mapping | Physical asset model |
| Material class | Material model |
| Material class property | Material model |
| Material definition | Material model |
| Material definition property | Material model |
| Material lot | Material model |
| Material lot property | Material model |
| Material sublot | Material model |
| Process segment | Process segment model |
| Process segment parameter | Process segment model |
| Personnel segment specification | Process segment model |
| Personnel segment specification property | Process segment model |
| Equipment segment specification | Process segment model |
| Equipment segment specification property | Process segment model |
| Physical asset segment specification | Process segment model |
| Physical asset segment specification property | Process segment model |
| Material segment specification | Process segment model |
| Material segment specification property | Process segment model |
| Segment dependency | Process segment model |
| Test specification | Operations test model |
| Test specification property | Operations test model |
| Test specification criteria | Operations test model |
| Evaluated property | Operations test model |
| Test result | Operations test model |
| Property measurement | Operations test model |
| Operations record specification template | Operations record model |
| Operations record template | Operations record model |
| Operations record entry template | Operations record model |
| Operations event class | Operations event model |
| Operations event class property | Operations event model |
| Operations event class record specification | Operations event model |
| Operations event definition | Operations event model |
| Operations event definition property | Operations event model |
| Operations event definition record specification | Operations event model |
| Operations event | Operations event model |
| Operations event property | Operations event model |
| Operations event record | Operations event model |
| Operations event record entry | Operations event model |
| Operations definition | Operations definition model |
| Operations material bill | Operations definition model |
| Operations material bill item | Operations definition model |
| Operations segment | Operations definition model |
| Parameter specification | Operations definition model |
| Personnel specification | Operations definition model |
| Personnel specification property | Operations definition model |
| Equipment specification | Operations definition model |
| Equipment specification property | Operations definition model |
| Physical asset specification | Operations definition model |
| Physical asset specification property | Operations definition model |
| Material specification | Operations definition model |
| Material specification property | Operations definition model |
| Segment dependency | Operations definition model |
| Operations schedule | Operations schedule model |
| Operations request | Operations schedule model |
| Requested segment response | Operations schedule model |
| Segment requirement | Operations schedule model |
| Segment parameter | Operations schedule model |
| Personnel requirement | Operations schedule model |
| Personnel requirement property | Operations schedule model |
| Equipment requirement | Operations schedule model |
| Equipment requirement property | Operations schedule model |
| Physical asset requirement | Operations schedule model |
| Physical asset requirement property | Operations schedule model |
| Material requirement | Operations schedule model |
| Material requirement property | Operations schedule model |
| Operations performance | Operations performance model |
| Operations response | Operations performance model |
| Segment response | Operations performance model |
| Segment data | Operations performance model |
| Personnel actual | Operations performance model |
| Personnel actual property | Operations performance model |
| Equipment actual | Operations performance model |
| Equipment actual property | Operations performance model |
| Physical asset actual | Operations performance model |
| Physical asset actual property | Operations performance model |
| Material actual | Operations performance model |
| Material actual property | Operations performance model |
| Operations capability | Operations capability model |
| Personnel capability | Operations capability model, process segment capability model, operations capability segment model |
| Personnel capability property | Operations capability model, process segment capability model, operations capability segment model |
| Equipment capability | Operations capability model, process segment capability model, operations capability segment model |
| Equipment capability property | Operations capability model, process segment capability model, operations capability segment model |
| Physical asset capability | Operations capability model, process segment capability model, operations capability segment model |
| Physical asset capability property | Operations capability model, process segment capability model, operations capability segment model |
| Material capability | Operations capability model, process segment capability model, operations capability segment model |
| Material capability property | Operations capability model, process segment capability model, operations capability segment model |
| Process segment capability | Operations capability model, process segment capability model |
| Operations segment capability | Operations capability model, operations capability segment model |

# Compliance

Any assessment of compliance of a specification shall be qualified by the following:

a) the use of the terminology defined in this part;

b) support of the object models defined in this part;

c) support the use of objects listed in Clause 8;

d) support the use of the attributes for each supported object;

e) support the defined relationships between the supported objects:

f) a statement of the total compliance concerning definitions, objects, attributes, and relationships or, in case of partial compliance, a statement identifying explicitly the areas of noncompliance.

g) a list of additional relationships and roles not covered in this part

h) a list of additional attributes not covered in this part

i) support for the use of values in enumerations

j) a list of additional values in enumerations

1. (Informative)  
   Implementation naming convention for object relationships
   1. Naming strategies

Implementation models may use the following naming strategies when producing an implementation model.

An example of the derivation of implementation models from the abstract model of this standard is represented in Annex G (Informative) abstract to implementation examples.

1. The relationship type conveys semantics of object lifetimes and navigation. Implementations use this information in conjunction with this annex to determine the appropriate implementation model and object naming convention that is aligned with this standard.
2. Object lifetime and relationship navigation for a specific implementation is represented in the associated documentation of the implementation.

EXAMPLE 1 Manufacturing information exchange profile, template, or specification.

1. The relationship roles from abstract UML models of this standard are represented within the objects or elements of an implementation. Implemented objects may the following role naming convention.
   1. In each object’s role table, a related object is represented by the name defined in the UML model relationships table of this standard.
   2. The role name for the related object in an object role table is a logical name and may convey semantics of the related object in some implementations.
2. Implementation names are typically represented without spaces and have the first letter of each word capitalized.

EXAMPLE 2 Object name = *Material lot*; Implementation name = MaterialLot

1. Object type representation: The structure (type) of an object is represented by an object name without spaces and ‘Type’ suffix.

EXAMPLE 3 Object name = *Material lot*; Object type = MaterialLotType.

1. A contained object: The object’s attribute name is the object name. The object type is the object name with ‘Type’ suffix.

EXAMPLE 4 Object name = *Material lot*; Object type = MaterialLotType.

1. A referenced object (not contained physically in the object): Object name has an ‘ID’ appended to the object name. The object type is the object name with ‘Type’ suffix.

EXAMPLE 5 Object name = *Material lot ID*; Object type = MaterialLotIDType

1. A related object, single occurrence: The relationship related object name is the name of the object. The object type is the object name with ‘Type’ suffix.

EXAMPLE 6 Object name = *Material lot*; Object type = MaterialLotType

1. A related object, multiple occurrences: Each occurrence is the object name when the message format allows (e.g. XML) or within a collection object with the object name as the plural of the object name.

EXAMPLE 7 *Material lot* is the attribute name for a collection of *material lot* entries

NOTE *Equipment* is a special case for plurality in that the object name is used in both contexts, singular and plural. In many implementations, the representation of *equipment* is a hierarchy, which allows the use of parent *equipment* and child *equipment* as presented below.

1. A relate object, multiple occurrences with different semantic meaning: The relationship object name is used as prefix to distinguish the two entries.

EXAMPLE 8 *Equipment parent, equipment child.*

1. Entry points to an intermediate object relationship (UML N-ary/Ternary relationship association class): The implementation represents an intermediary object containing the identifiers of the multiple objects participating in the relationship.
2. In a composite element part, the multiplicity value is one: In an implementation that uses containment (the part is physically contained in the whole, not represented as a reference), the containment infers the multiplicity of one representation. The whole object is still represented as an attribute of the part in implementation models where navigation from part to whole explicitly is required.

EXAMPLE 9 *Equipment asset mapping*. *Equipment* is an *equipment asset mapping type* which contains the identifiers and other attributes defining the relationship between objects.

1. (Informative)  
   Value syntax

The format for values in value attributes is not defined in this part of this standard and will be defined by implementations of the standard.

EXAMPLE The following syntax, defined in an EBNF (Extended Backus–Naur Form) notation from ISO 14977, can be used to represent single element values, range specifications, arrays of values, and a set of allowed values as delimited text strings.

<value> ::= <simpleValue>

| <arrayValue>

| <rangeValue>

| <seriesValue>

<arrayValue> ::= “[“ <arrayElement> \*( “,” <arrayElement> ) “]”

<rangeValue> ::= “{“ <rangeElement> \*( “,” <rangeElement> “}”

<seriesValue> ::= “<” <simpleValue> \*( “,” <simpleValue> ) “>”

<arrayElement> ::= <simpleValue> | <arrayValue>

<rangeElement> ::= <simpleValue> “..” <simpleValue>

<simpleValue> ::= string

1. (Informative)  
   Use and examples
   1. Use and examples

This standard is expected to be used in the specification of interfaces (at Level 3 and Level 4) between new applications, between legacy applications, or between new applications and legacy applications. This can facilitate the usage of packaged software in a legacy application context, which can be the most powerful initial use of the standard.

Through the use of this standard the definition of the interface content can be provided faster and more accurately. In addition, the specification of interface content can be easily reused. This will be facilitated by the correct use of compliance assessments that identify which object models are supported by the interface content specification.

Part 1 of this standard defines the categories of information that should be exchanged between business systems and manufacturing operations and control systems. Four (4) categories are defined as

* *operations definition,*
* *operations capability,*

Operations information

* *operations schedule,*
* *operations performance*

Each of these four (4) categories relies on the following five (5) resources also defined in Part 1 of this standard:

* *personnel,*
* *equipment,*
* *physical asset,*
* *material, and*
* *process segment*

Part 2 presents the corresponding UML models and attributes for the objects contained in the UML models. The UML models are software independent descriptions of the data exchange between business systems and the manufacturing operations and control systems.

UML relies on object-oriented methodology. Very briefly, this means that there are classes, subclasses and instances (objects).

EXAMPLE 1 A class can be Car, and the instances can be “Mrs Mine’s car” or “My car”. A class has attributes, and the instances have values on the attributes.

EXAMPLE 2 The class Car has an attribute “License plate” whereas the Instance “Mrs. Mine’s car” has the attribute “license plate= ABC 123”.

EXAMPLE 3 Figure C.1 shows the UML model for personnel information.

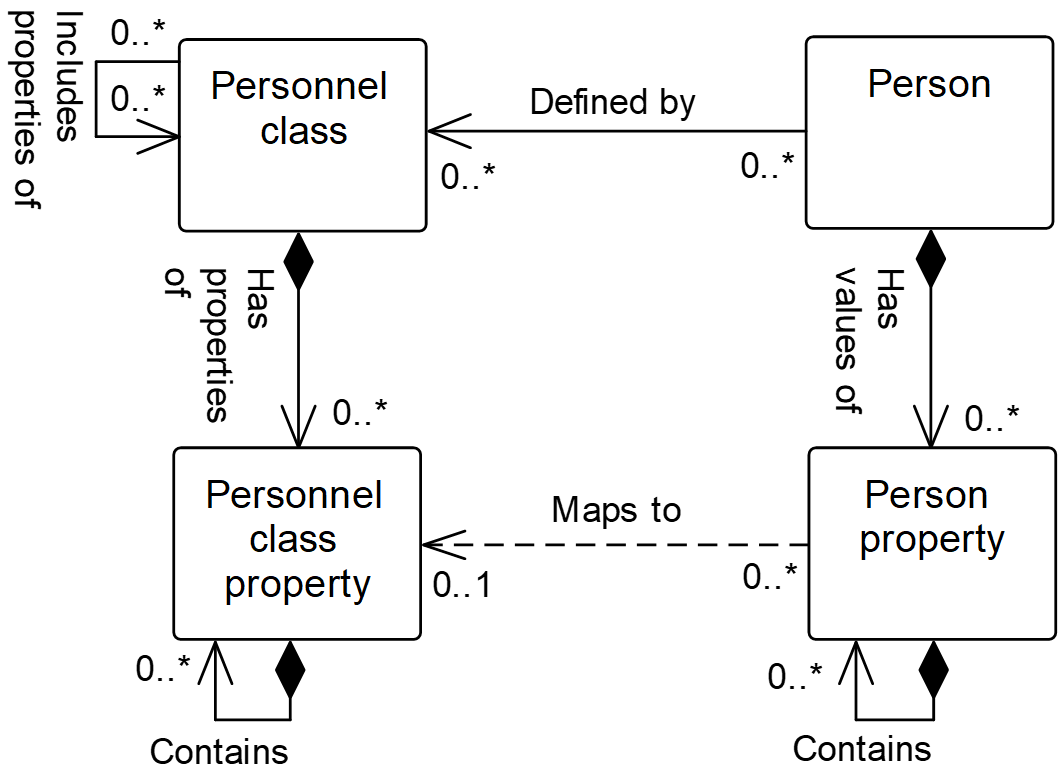


Figure C.1 – Personnel model

The model shown in Figure C.1, a copy of Figure 8, defines six (6) classes: *person, personnel class, person property, personnel class property, qualification test specification* and *qualification test results*.

Table C.1 (copy of Table 29) lists the relationships of the objects in the personnel model.

Table C.1 – Personnel model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Personnel class | Personnel class property | Composition | Has properties of |
| Personnel class | Personnel class | Association | Includes properties of |
| Person | Personnel class | Association | Defined by |
| Person | Person property | Composition | Has values of |
| Person property | Personnel class property | Dependency | Maps to |
| Person property | Person property | Composition hierarchy | Contains |
| Personnel class property | Personnel class property | Composition hierarchy | Contains |
| Testable object <<Interface>> | Test specification | Association | Specifies |
| Test specification | Testable object <<Interface>> | Association | Specifies test for |
| Test result | Testable object <<interface>> | Association | Records test results for |
| Evaluated property | Testable object property <<interface>> | Association | Corresponds to |
| Property measurement | Testable object property <<interface>> | Association | Records measurement of |

Table C.2 shows the attributes for *person* (a copy of Table 35).

Table C.2 – Person attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific person, within the scope of the information exchanged (*operations capability, operations schedule, operations performance*, …)  The ID is used in other parts of the model when the *person* needs to be identified, such as the *operations capability* for this person, or an *operations response* identifying the person. | Employee 23 | 22828 | 999-123-4567 | 007 |
| Description | Additional information about the resource. | Person Information | Maintenance Tech | Lab Tech | Driver |
| Name | The name of the individual.  This is meant as an additional identification of the resource, but only as information and not as a unique value. | Jane | Jim | John | James |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy. | East Wing(AREA)/ Manufacturing Line #2(WORK CENTER) | CNC Machine  Asset ID 13465 | Test Cell 4  Receiving | Ware-house B |

This means that the class *person* should have ID, description and name as attributes.

Figure C.2 shows the class *person* with the attributes and two instances.

EXAMPLE 4 John Smith and Lou Brown.

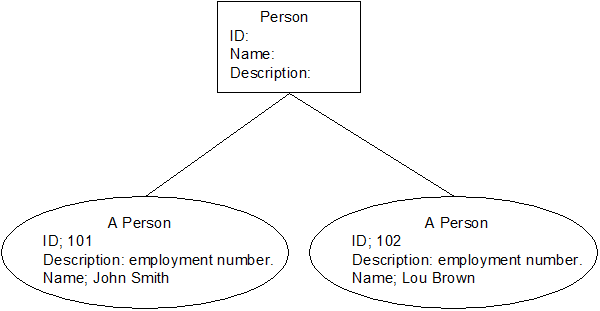


Figure C.2 – Instances of a person class

In the same manner, there is a class for *personnel class* (*personnel class* should be thought of as *personnel* group/category), the instances used depends on the application.

EXAMPLE 5 Engineers, night-shift workers, drilling-machine-operators etc.

Of course, certain attributes for classes will depend on the application. To support application, specific attributes of the property should be used. The instances of the properties will define the attributes for the corresponding class. The UML model says that there can be none, one or many properties linked to the corresponding class as shown in Figure C.3.

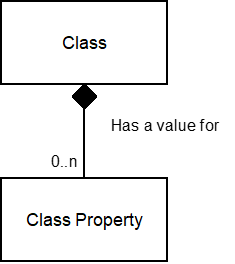


Figure C.3 – UML model for class and class properties

This means that all the instances of property will effectively describe attributes to the class. Each instance of the class will contain values for the attributes.

Certain attributes for *person* as well as for *personnel class* depend on the application.

EXAMPLE 6 Useful to exchange info about a person’s date-of-birth in one application but not in another.

To support application specific attributes, the *person property* or *personnel class property* should be used. The instances of the properties will define the attributes for the *person/personnel class*. The UML model says that there can be none, one or many properties linked to *person/personnel class*.

There is a class called *person property*. Each property is uniquely defined by its ID, description, valueand *value unit of measure,* as shown in Figure C.4.

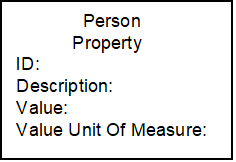


Figure C.4 – Class property

The class can have four instances, two for the date of birth, one for John and one for Lou, and two for shoe sizes, one for John and one for Lou, as shown in Figure C.5.

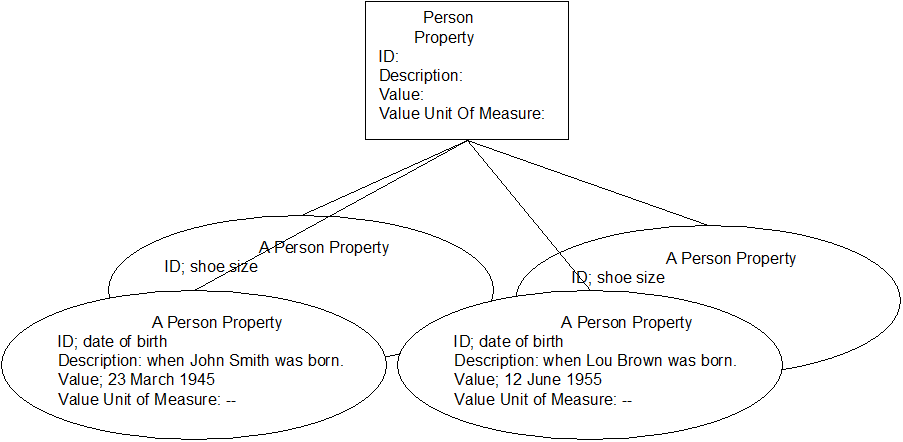


Figure C.5 – Instances of a person properties

This means that each *person* (instance) will have info about its properties as shown in   
Figure C.6.

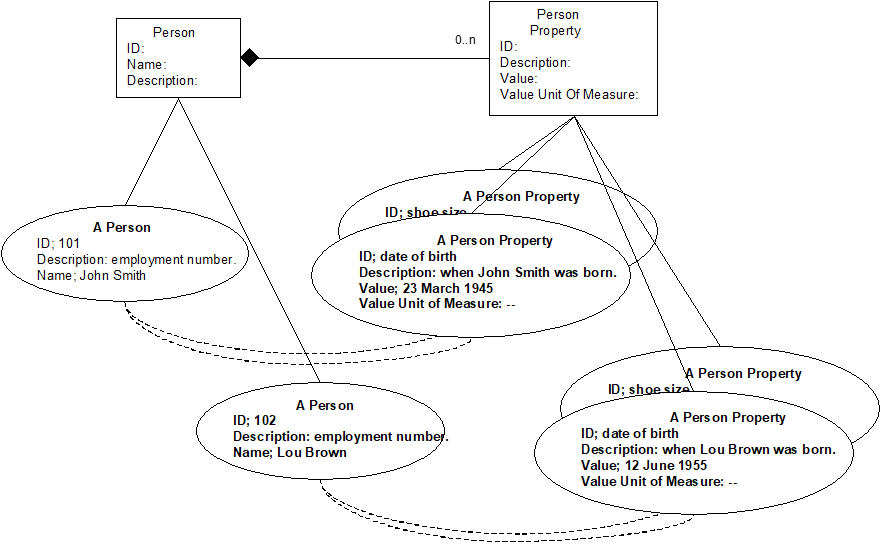


Figure C.6 – Instances of person and person properties

It is important to note that the classes will have to be defined within a product as well as support within a product to create and manipulate instances. However, the specific instances created will depend on the application.

* 1. Application of the standard

When designing or creating a system that implements the standard, one will need to make sure that the system supports the classes needed.

EXAMPLE 1 *Person, personnel class, person property, personnel class property*, etc.

To completely comply with the standard, all classes defined in the standard should be supported in the system.

Before the systems are put in execution mode it has to be decided what properties the classes should have.

EXAMPLE 2 What instances the property class should have.

Of course, only the properties that need to be exchanged between the systems have to be decided. The reasons this has to be decided include.

Due to the internal structure of databases, some databases cannot be enlarged during execution mode, and therefore it needs to know in advance what properties should be supported.

Different systems might have different constraints on the naming of the properties

EXAMPLE 3 A maximum length of property-name, the usage of upper and lower-case letters.

Different systems might be developed in different languages,

EXAMPLE 4 In one system all properties are presented in French, whereas in another one, the properties are presented in English.

During execution, data regarding the instances can be exchanged. The data exchanged can be implemented in many different forms. One possibility is through databases, another possibility is through XML and XML schemas that have been developed in accordance with the models of this standard.

* 1. Database mapping of the models

If a database is used for data exchange, then there are many different ways of structuring the database. Tables C.3 and C.4 are included as examples of a data base structure that can be used to contain the data. The key attribute indicates a unique value that can be required for relational integrity.

Table C.3 – Database structure for person

|  |  |  |
| --- | --- | --- |
| TABLE: *Person* | | |
| ID | Description | Name |
|  |  |  |
|  |  |  |

Table C.4 – Database structure for person property

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| TABLE: *Person property* | | | | |
| ID | Description | Value | Value unit of measure | Key |
|  |  |  |  |  |
|  |  |  |  |  |

When the system is in execution, the database could contain the information shown in   
Table C.5 and Table C.6.

Table C.5 – Database for person with data

|  |  |  |
| --- | --- | --- |
| TABLE: *Person* | | |
| ID | Description | Name |
| 101 | The employment number | John Smith |
| 102 | The employment number | Lou Brown |
| 103 | The employment number | Jane Mine |

Table C.6 – Database for person property with data

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| TABLE: *Person property* | | | | |
| ID | Description | Value | Value unit of measure | Key |
| Date of Birth | Indicates when a person is born | 1945-03-23 | YYYY-MM-DD | 101 |
| Shoe size | Indicates the shoe size of a person | 43 |  | 101 |
| Date of Birth | Indicates when a person was born | 1955-06-12 | YYYY-MM-DD | 102 |
| Shoe size | Indicates the shoe size of a person | 45 |  | 102 |
| Date of Birth | Indicates when a person is born | 1969-12-24 | YYYY-MM-DD | 103 |
| Shoe size | Indicates the shoe size of a person | 38 |  | 103 |

* 1. XML usage

If XML documents are used for data exchange, then there are many different ways of structuring the documents. The structure for an XML document is defined in a “schema”. A schema is the equivalent of a data base table definition.

Figure C.7 illustrates a possible XML schema for *“Person*”. The schema defines a place for ID, Description, Name, the *person properties*, and a place to contain the list of *Personnel Classes* the *person* belongs to. A *person* (instance) is defined by its ID, Description, Name, PersonProperty, and PersonnelClassID. The ID, Description and Name correspond to the attributes ID, description and name defined in this part of this standard.

PersonnelClassID is defined as the ID of a *personnel class*. PersonnelClassID (there can be many) contains a link to instances of *PersonnelClass*.

*PersonProperty* is defined as a complex type that contains the property ID, description, and value.

<xsd:complexType name = "**PersonType**">

<xsd:sequence>

<xsd:element name = "**ID**" type = "xsd:string"/>

<xsd:element name = "**Description**" type = "xsd:string"

minOccurs = "0"

maxOccurs = "unbounded"/>

<xsd:element name = "**Name**" type = "xsd:string"/>

<xsd:element name = "**PersonProperty**"

type = "PersonPropertyType"

minOccurs = "0"

maxOccurs = "unbounded"/>

<xsd:element name = "**PersonnelClassID**"

type = "PersonnelClassIDType"

minOccurs = "0"

maxOccurs = "unbounded"/>

</xsd:sequence>

</xsd:complexType>

<xsd:simpleType name="**PersonnelClassIDType**">

<xsd:restriction base="xsd:string">

</xsd:restriction>

</xsd:simpleType>

Figure C.7 – XML schema for a person object

*PersonProperty* contains the instances of *PersonProperty* (there can be many). A *PersonProperty* (instance) is defined by its ID, Description, Value, and Value Unit of Measure. The ID, Description and Value and Value Unit of Measure correspond to the attributes ID, description and name defined in this part of this standard.

A *PersonProperty* (instance) could be defined in the schema shown in Figure C.8

<xsd:complexType name = "**PersonPropertyType**">

<xsd:sequence>

<xsd:element name = "**ID**" type = "IDType"/>

<xsd:element name = "**Description**" type = "DescriptionType"

minOccurs = "0" maxOccurs = "unbounded"/>

<xsd:element name = "**Value**" type = "ValueType"

minOccurs = "0" maxOccurs = "unbounded"/>

<xsd:element name = "**ValueUnitOfMeasure**" type = "ValueUOMType"

minOccurs = "0" maxOccurs = "unbounded"/>

<xsd:element name = "**QualificationTestSpecificationID**"

type = "QualificationTestSpecificationIDType"

minOccurs = "0" maxOccurs = "unbounded"/>

<xsd:element name = "**TestResult**" type = "TestResultType"

minOccurs = "0" maxOccurs = " unbounded"/>

</xsd:sequence>

</xsd:complexType>

Figure C.8 – XML schema for person properties

During execution, an XML document is created and the values of the attributes are filled in and exchanged between the systems. Figure C.9 illustrates a sample XML document, matching the schema above that contains *person* and *person property* information.

<PersonType>

<ID> **101**</ID>

<Description>**Employment Number**</Description>

<Name>**John Smith**</Name >

<PersonProperty>

<ID>**date-of-birth**</ID>

<Description>**indicates when a person is born**

</Description>

<Value>**1945-03-23**</Value>

<Value Unit of Measure> **YYYY-MM-DD**

</Value Unit of Measure>

<ID>**Shoe size**</ID>

<Description>**indicates the shoe size** </Description>

<Value>**43**</Value>

**</** PersonProperty >

<PersonnelClassID>{**night-shift-operator, engineer**}

</PersonnelClassID>

</PersonType>

Figure C.9 – Example of person and person property

The information about an instance (e.g., Product manager or Engineer) of *PersonnelClass* could be exchanged in a separate XML schema, as shown in Figure C.10.

<PersonClassType>

<ID>**Engineer**</ID>

<Description> **a registered professional engineer**</Description>

<PersonnelClassPropertyType>

<ID>**Engineer’s License Number**</ID>

<Description>”**The official engineer’s license number”**

</Description>

</PersonnelClassPropertyType>

</PersonClassType>

Figure C.10 – Example of person class information

Since the XML schemas or the objects and their attributes might not be implemented or called the same thing inside different systems, it might be required to have an “adapter/translator” inside the systems. This “adapter/translator” translates from the Part 1 of this standard terminology to the terminology used within the different systems. Figure C.11 illustrates an adaptor that maps *property ID*s and property types (date formats).



Figure C.11 – Adaptor to map different property IDs and values

1. (Informative)  
   Example data sets
   1. General

The following clauses contain example data sets, based on the Part 2 models and attributes.

* 1. Material model example

EXAMPLE This is a simplified example of material information that can be used in the food processing industry. The example presents shared information about a *material class* (Pork), a *material definition* (Pork 80 % Lean), a *material lot*, and a *material sublot*. In a full example, there can be multiple *material classes* and *material description* information sets that are shared with lot and sublot dynamically shared. Indentation of objects is used to illustrate the relationship between the objects.

*Material class*

ID - Pork

Description -

*Material class property*

ID - Lethal Heat

Description - Temperature to kill bacteria

Value - 160

Units of Measure - Degrees F

ID - Receiving Temperature Target

Description -

Value - 32

Units of Measure - Degrees F

ID - Receiving Temperature Max

Description -

Value - 36

Units of Measure - Degrees F

ID - Receiving Temperature Min

Description -

Value - 28

Units of Measure - Degrees F

ID - Maximum Allowable Cut Time

Description - Time since cut

Value - 3

Units of Measure - Days

*Material definition*

ID - Pork 80

Description - Boneless pork cut up with a target lean percentage of 80

Value -

Unit of Measure -

*Test specification*

ID - JackSpratTest1

Description - Test to determine percent of fat.

Version - 1997-04-02

*Evaluated property*

ID - JackSpratTest1\_Percentage Lean

De Version scription - Test to determine percent of fat.

- 1997-04-02.1

*Material definition property*

ID - Percentage Lean

Description -

Value - 80

Units of Measure – Percentage

ID - Percentage Fat

Description -

Value - 20

Units of Measure - Percentage

*Material lot (Testable object)*

ID - 20000115091345

Description -

Status - approved

*Material lot property*

ID - Delivery Temperature

Description - Temperature at delivery

Value - 37.5

Units of Measure - Degrees F

ID - Cut

Description - Cut Date

Value - 2000-01-14

Units of Measure -

ID - Expiration

Description - Expiration Date

Value - 2000-01-17

Units of Measure -

ID - Fat

Description - Actual Percent Fat

Value - 20

Units of Measure – Percent

ID - Lean

Description - Actual Percent Lean

Value - 80

Units of Measure – Percent

*Material sublot*

ID - 20000115091345-1

Description -

Storage Location - Tote 392, Level 3, Rack 49

Value - 200

Value Unit of Measure - Pounds

ID - 20000115091345-2

Description -

Storage Location - Tote 852, Level 3, Rack 50

Value - 300

Value Unit of Measure – Pounds

*Test result*

ID - 2000-01-16-4930-TEMP

Description - Internal temperature of pork

Date - 2000-01-16

Expiration – None

Test criteria result – approved

*Material lot (Testable object)*

ID - 20000115091345

Description -

*Test specification*

ID –

Description-

*Test specification criteria* –

ID -

*Evaluated property* –

ID –

*Property measurement*

ID - 2000-01-16-4930-TEMP

Description - Internal temperature of pork

Measurement date - 2000-01-16

Value – 37.5

Units of Measure – Degrees F

*Material lot property*

ID - Delivery Temperature

Description - Temperature at delivery

Value - 37.5

Units of Measure - Degrees F

ID - 2000-01-16-4930-SPRAT

Description – FAT Percent

Measurement date - 2000-01-16

Value – 30

Units of Measure – Percent Fat

*Material lot property*

ID - Fat

Description - Actual Percent Fat

Value - 30

Units of Measure – Percent Fat

* 1. Equipment model examples

EXAMPLE 1 Pulp and paper

Table D.1 – Pulp and paper equipment model example

| Enterprise | Site | Area | Work center | | | Work unit | Equipment | Notes |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| paper producer | |  |  | | |  |  |  |
|  | deep woods river site | |  | | |  |  | integrated paper mill complex |
|  |  | wood preparation plant |  | | |  |  |  |
|  |  |  | rail yard | | |  |  | storage |
|  |  |  | saw mill | | |  |  | continuous |
|  |  |  |  | | | slasher deck |  |  |
|  |  |  |  | | | splitting |  |  |
|  |  |  |  | | | conveyor |  |  |
|  |  |  | wood room | | |  |  |  |
|  |  |  |  | | | debarking |  |  |
|  |  |  |  | | | chippers |  |  |
|  |  |  |  | | | screend |  |  |
|  |  |  |  | | | chip conveyors |  |  |
|  |  |  |  | | | chip bins/silos |  | storage |
|  |  |  |  | | | grinders |  |  |
|  |  |  | wood yard | |  | |  | storage |
|  |  |  |  | | | pile a |  |  |
|  |  |  |  | | | pile b |  |  |
|  |  |  |  | | | pile c |  |  |
|  |  | steam plant |  | | |  |  |  |
|  |  |  | boiler room | | |  |  |  |
|  |  |  |  | | | furnace #1 |  |  |
|  |  |  |  | | |  | stack |  |
|  |  |  |  | | |  | esp | environmental controls - electrostatic precipitator |
|  |  |  | |  | | boiler #1 |  |  |
|  |  |  | |  | |  | gauges & instruments |  |
|  |  | pulp mill -- chemical pulp -- kraft process | |  | |  |  | batch (product) / continuous (machine operation) |
|  |  |  | cooking & washing -- wood chips | |  | |  |  |
|  |  |  |  | | | chip storage |  | storage |
|  |  |  |  | | | white liquor storage |  | storage |
|  |  |  |  | | | digester |  |  |
|  |  |  |  | | | blow tank |  |  |
|  |  |  |  | | | washers |  |  |
|  |  |  | acid plant | | |  |  | chemical recovery system |
|  |  |  |  | | | black liquor storage |  | storage |
|  |  |  |  | | | evaporators |  |  |
|  |  |  |  | | | recovery furnace |  |  |
|  |  |  |  | | | dissolving tank |  |  |
|  |  |  |  | | | green liquor storage |  | storage |
|  |  |  |  | | | slaker |  |  |
|  |  |  |  | | | clarifier |  |  |
|  |  |  |  | | | lime mud washer |  |  |
|  |  |  |  | | | white liquor storage |  | storage |
|  |  |  |  | | | lime kiln |  |  |
|  |  |  | steam plant | | |  |  |  |
|  |  |  |  | | | refuse boilers |  |  |
|  |  |  | by-products | | |  |  | storage |
|  |  |  | pulp processing | | | |  |  |
|  |  |  |  | | | bleaching |  |  |
|  |  |  |  | | | washer vacuum |  |  |
|  |  |  |  | | | centrifugal screening |  |  |
|  |  |  |  | | | pressure screening |  |  |
|  |  |  |  | | | pulp press |  |  |
|  |  | paper mill |  | | |  |  | batch (product) / continuous (machine operation) |
|  |  |  | beater room | | |  |  |  |
|  |  |  |  | | | beating engine #1 |  |  |
|  |  |  | machine room | | |  |  |  |
|  |  |  |  | | | paper machine #2 |  | west end |
|  |  |  |  | | |  | screens |  |
|  |  |  |  | | |  | head box |  |
|  |  |  |  | | |  | wire pit |  |
|  |  |  |  | | |  | press |  |
|  |  |  |  | | |  |  |  |
|  |  |  | wet end | | |  |  |  |
|  |  |  |  | | | paper machine #2 |  | dry end |
|  |  |  |  | | |  | drying section |  |
|  |  |  |  | | |  | calendar stack #1 |  |
|  |  |  |  | | |  | calendar stack #2 |  |
|  |  |  |  | | |  | reeler |  |
|  |  |  |  | | |  | winder |  |
|  |  |  |  | | | machine drive |  |  |
|  |  |  |  | | | roll handler/conveyor |  |  |
|  |  |  |  | | | roll storage |  | storage |
|  |  | finishing |  | | |  |  | discrete |
|  |  |  | coating | | |  |  |  |
|  |  |  |  | | | coater # 1 |  |  |
|  |  |  |  | | |  | coater mix |  |
|  |  |  |  | | |  | coater |  |
|  |  |  |  | | |  | dryer |  |
|  |  |  |  | | | supercalendar # 1 |  |  |
|  |  |  |  | | | coater # 2 |  |  |
|  |  |  |  | | | supercalendar # 2 |  |  |
|  |  |  | slitting -- reels | | | |  |  |
|  |  |  |  | | | slitter # 1 |  |  |
|  |  |  |  | | |  | knife set |  |
|  |  |  |  | | |  | kickup |  |
|  |  |  |  | | | conveyor |  |  |
|  |  |  | sheeting | | |  |  |  |
|  |  |  |  | | | sheeter |  |  |
|  |  |  |  | | | Stacker |  |  |
|  |  |  |  | | | bundler |  |  |
|  |  | shipping warehouse | | | |  |  | storage |
|  |  | lumber mill | | | |  |  | lumber / board |

EXAMPLE 2 Semiconductor manufacturing

Table D.2 – Semiconductor manufacturing equipment model example

| Site | Area | Work center/ work cell | Work unit | Equipment | Notes |
| --- | --- | --- | --- | --- | --- |
|  |  |  |  |  | Assumption process starts with SOI wafers (Silicone on Insulation) that were purchased. |
| FAB 1 |  |  |  |  |  |
|  | front end |  |  |  |  |
|  |  | deposition |  |  |  |
|  |  |  | CVD | deposition tools | CVD Chemical Vapor Deposition |
|  |  |  |  | thickness tool |  |
|  |  |  | PVD |  | PVD (Physical Vapor Deposition) |
|  |  | metrology |  | thickness tool | thickness defect |
|  |  |  |  | defect tool |  |
|  |  |  |  | characteristics |  |
|  |  | polishing | CMP |  | CMP Chemical Mechanical Polishing (Wafer is ready for the next step.) |
|  |  | lithography |  | tools | electrical circuit mask |
|  |  |  |  |  |  |
|  |  | etch |  | tools |  |
|  |  |  |  |  |  |
|  |  | furnace |  | tools |  |
|  |  |  |  |  | Repeat the above steps over and over until the wafer of devices is built. |
|  | back end |  |  |  |  |
|  |  | passivation |  |  | Preparation for pad bonding. |
|  |  | Bonding |  |  |  |
|  |  | Dicing |  |  |  |
|  |  | Packaging |  |  |  |
|  |  | Test |  |  |  |

* 1. Personnel model example

EXAMPLE This is a simplified example of personnel information that might be used in the petrochemical processing industry. The example lists shared information about *personnel classes* and *persons*, including qualification test information.

*Personnel class*

ID - Operator Level A

Description - Top level operator certification for petrochemical plant

ID - Operator Level B

Description - Basic level operator certification for petrochemical plant

ID - Operator

Description - Operators for petrochemical plant

*Test specification*

ID - PC-MTBE-992828

Description - Test to determine level of MTBE certification.

Version - 1997-04-02

ID - PC- PO-Refining -992828

Description - Test to determine level of PO Refining certification.

Version - 1997-04-02

*Personnel class property*

ID - MTBE Process Certification

Description - Each completed level of certification test

Value - TRUE, FALSE

Units of Measure -

ID - PO Refining Process Certification

Description - Each completed level of certification test

Value - TRUE, FALSE

Units of Measure –

ID - Push-Up Certification

Description - Operator is temporarily able to perform the higher up function

Value - TRUE, FALSE

Units of Measure -

*Person*

ID - 999-63-8161

Description -

Name - John Doe

*Person property*

ID - MTBE Process Certification

Description - Each completed level of certification test

Value - TRUE,

Units of Measure -

ID - PO Refining Process Certification

Description - Each completed level of certification test

Value - FALSE

Units of Measure –

ID - Fire Team Qualified

Description - Operator has been trained to aid in fire-fighting

Value – TRUE

Units of Measure -

*Personnel classes*

ID - Operator

ID - Operator Level B

ID - Fire Team Qualified

*Test results*

ID - PC-MTBE-992828-2000-10-12

Description - Test to determine level of MTBE certification

*Person*

ID - 999-63-8161

Description -

Name - John Doe

*Test specification*

ID - PC-MTBE-992828

Description - Test to determine level of MTBE certification.

Version - 1997-04-02

Test specification criteria result – Passed

Expiration - 2000-12-15

* 1. Operations capability example

EXAMPLE This is a simplified example of *operations capability* information for a crude oil pipeline shipment system. This example illustrates the future committed definition of the capability of a crude oil pipeline segment, using a specific segment of time.

*Operations capability*

ID - Caspian Crude Oil Pipeline

Location - Tengiz-Atyrau Pipeline Segment

Element Type - Area

Start Time - August 1, 2011

End Time - August 31, 2011

*Material capability*

Description - Segment Throughput

Material Class - Crude Oil - Type A

Capability Type - Committed

Start Time - August 1, 2001 6:00

End Time - August 2, 2001 6:00

*Material capability property*

ID - Viscosity

Value - 104

Value Unit of Measure - cp (centipoise)

*Material capability property*

ID - Entry Temperature

Value - 30

Unit of Measure - Deg C

*Material capability property*

ID - Ground Temperature

Value - 18

Value Unit of Measure - Deg C

* 1. Operations performance example

EXAMPLE This is a simplified example of operations performance information for a crude oil pipeline shipment system. This example illustrates an example of a day of production for crude oil pipeline segment.

*Operations performance*

ID - Caspian Crude Oil Pipeline

Start Time - August 1, 2011

End Time - August 2, 2011

Hierarchy Scope - Tengiz-Atyrau Pipeline Segment

Operations type - Production

*Operations response*

ID - Daily Production

Start Time - August 1, 2011 - 6:00

End Time - August 2, 2011 - 6:00

*Segment response*

ID - Daily Production

*Segment data*

Name - Total Pipeline Throughput

Value - 126,000

Value Unit of Measure - Metric Tons / Day

*Material actual*

Description- Crude Shipped, Shipper A

Material Lot - SampleNumber 28883992021

Quantity - 63,000

Unit of Measure - Metric Tons / Day

*Material actual property*

ID - Average Viscosity

Value - 103

Value Unit of Measure - cp (centipoise)

ID - Entry Temperature

Value - 32.3

Value Unit of Measure - Deg C

* 1. Operations test model use case examples

EXAMPLE 1 Quality test: Exchange quality test results by *material lot ID* (or other resource types)

NOTE 1 The *test result* can be exchanged as a first order object or contained in the *operations event record,* *work record, job response, work alert,* *segment response* or *operations performance* objects.

1. Use *test result* with *testable object* (object ID) that has a specified *test specification ID*.

*Test result*

ID – QO12

Description –

Evaluation date – 2015-07-25 13:59 UTC

Evaluated criterion result – Pass

*Material lot* (*Testable object)*

ID – 20000115091345

*Property measurement*

ID - Delivery Temperature

Description - Temperature at delivery

Measurement date - 2015-07-25 13:59 UTC

Value - 37.5

Value unit of measure - Degrees F

*Material lot property (Testable object property*)

ID - DeliveryTemp 123

NOTE 2 Material lot ID references the following *material lot* elements

*Test specification*

ID - JackSpratTest1

Description – Temperature test

Version – 1997-04-02

*Evaluated property*

ID - Delivery Temperature

Description - Temperature at delivery

Value - 37.5

Value unit of measure - Degrees F

*Test specification criteria*

ID - DeliverTempID123

*Material lot property (Testable object property*)

ID – DeliveryTemp123

Description - Temperature at delivery

Value - 37.5

Value unit of measure - Degrees F

1. Use *test result* with *operations test requirement* (object ID) that has a specified *test specification ID*.

*Test result*

ID – QO12

Description –

Evaluation date – 2015-07-25 13:59 UTC

Evaluated criterion result – Pass

*Operations segment ID (Operations test requirement*)

ID – 20000115091345

*Property measurement*

ID - Delivery Temperature

Description - Temperature at delivery

Measurement date - 2015-07-25 13:59 UTC

Value - 37.5

Value unit of Measure - Degrees F

*Material lot property (Testable object property*)

ID -

NOTE 3 Operations segment ID references the following *material lot* elements

*Material requirement ID*

ID - 20000115091345

*Material lot* (*Testable object*)

ID-

*Test specification*

ID - JackSpratTest1

Description – Fat Temperature test

Version - 1997-04-02

*Test specification criteria*

ID –

*Evaluated property*

ID –

EXAMPLE 2 Maintenance checkout tests run on the equipment.

NOTE 4 The *test result* can be exchanged as a first order object or contained in the *operations event record,* *work record, job response, work alert*, *segment response* or *operations performance* objects.

1. Use *test result* with *testable object* (object ID) that has a specified *test specification ID*.

*Test result*

ID – QO12

Description –

Evaluation date – 2015-07-25 13:59 UTC

Evaluated criterion result – Pass

*Physical Asset (Testable object)*

ID – 20000115091345

*Property measurement*

ID – High RPM Temperature

Description - Temperature at high RPM

Measurement date - 2015-07-25 13:59 UTC

Value - 37.5

Value unit of measure - Degrees F

Physical asset property *(Testable object property)*

ID – 20000115091345-1

NOTE 5 Physical asset ID references the following *physical asset* elements

*Test specification*

ID – RPMTest1

Description – RPM Test.

Version – 1997-04-02

*Evaluated property*

ID – RPMTemp032

Description - RPM Temperature

Value - 37.5

Value unit of measure - RPM

*Test specification criteria*

ID - HighRPM Temp ID123

*Physical asset property* (*Testable object property)*

ID – HighRPMTemp

Description – High RPM Temperature

Value - 37.5

Units of Measure - RPM

1. Use *test result* with *operations test requirement* (object ID) that has a specified *test specification ID*.

*Test result*

ID – QO12

Description –

Evaluation date – 2015-07-25 13:59 UTC

Evaluated criterion result – Pass

*Operations segment* (*Operations test requirement)*

ID – 20000115091345

*Property measurement*

ID – High RPM Temperature

Description - Temperature at high RPM

Measurement date - 2015-07-25 13:59 UTC

Value - 37.5

Value unit of Measure - Degrees F

Physical asset property *(Testable object property*)

ID – 20000115091345-1

NOTE 6 Operations segment ID references the following *physical asset* elements

*Physical asset requirement ID*

ID - 20000115091345

*Physical asset (Testable Object*)

ID-

*Test specification*

ID - JackSpratTest1

Description – Fat Temperature test

Version - 1997-04-02

*Test specification criteria*

ID –

*Evaluated property*

ID –

EXAMPLE 3 Material test request: Identify the material and reference the test method

Use *operations request (Quality) with operations requirement* (object ID) that has a specified *test specification ID* that references the pre-specified *evaluated property ID* with a pre-specified *work master ID*.

*Operations request*

ID – QO12

Description –

*Segment requirement*

ID -

*Material requirement*

ID - 20000115091345

Description – Fat content

*Test specification*

ID - FatTest1

Description - Test to Fat content min

Version - 1997-04-02

*Test specification criteria*

ID – Fat Test1\_EP1 Criteria

Description - Test to Fat min

Version - 1997-04-02

Result – Pass, Fail

*Evaluated property*

ID – Fat Test1\_EP1

Description - Test to Fat min

Version - 1997-04-02

*Work Master*

ID –FatTestMethod 1.1

EXAMPLE 4 Find *material* produced to a given *test specification*.

Query *material actual ID* with *material ID, operations request ID, operations test requirement (object ID)* and a specified *test specification ID.*

*Material actuals*

ID – QO12

Description –

*Material lot*

ID -

*Segment response*

ID –

Description –

*Segment requirement*

ID –

*Operations request*

ID -

*Material requirement*

ID - 20000115091345

Description – Fat content

*Test specification*

ID – FatTest1.2

Description - Test to Fat content min

Version - 1997-04-02

*Test specification criteria*

ID – Fat Test1\_EP1 Criteria

Description - Test to Fat min

Version - 1997-04-02

Result – Pass, Fail

*Evaluated property*

ID – Fat Test1\_EP1

Description - Test to Fat min

Version - 1997-04-02

EXAMPLE 5 Send test sample plan (operations definition) for a final product (operation definition) in a source system. ERP publishes sample plan to execution systems (quality management system (QMS) /laboratory execution system (LES) /batch execution system (BES) /manufacturing execution system (MES)) for production of a product.

Use an *operations event,* NewSamplePlanRelease, with the *operations event record* containing an *operations definition* that list of intermediate materials and final produced materials with associated test specifications and a list of *operations segments* that produce each material and executes each quality test specification for a requested batch.

*Operation event*

ID – SPR01

Description – NewSamplePlanRelease

*Operations event record*

ID –

Description -

*Operations event record entry*

ID –

Description –

*Information Object*

ID –

Description –

*Operations definition*

ID-SPB1

Description – Sample Plan B1

*Operations segment*

ID-

Description –

*Material specification*

ID –

Description –

*Test specification*

ID –

Description –

*Test specification criteria*

ID –

Description –

*Evaluation property*

ID –

Description –

*Work master*

ID –

Description –

EXAMPLE 6 Test information for a welder safety check in the mechanical workshop hierarchy scope.

Maintenance tests evaluated using this example generate a Pass or Fail result. A two-level hierarchy of test specifications has been applied. When *test specifications* are used in a hierarchy, the parent object applies the worst-case result of its children. In this case, the wldr\_check *test specification* will therefore return a Fail result if any of its children return a Fail result. The three children equipment *test specifications* check for:

1. condition of electrical leads;
2. expiry date of safety tag; and
3. the work lead is firmly attached.

This example is structured to be suitable for application as a checklist, where each of the children *test specifications* relates to a checklist item. The checklist can exist in either hard copy or electronic form. The example can be applied during execution management tasks by a welder immediately prior to commencing use of the welding machine.

*Test specification*

ID - wldr\_check

Description - Welder Safety Check

Version - 2.3

Effective start date - 2015-11-01 08:00 UTC

Effective end date - 2020-11-01 08:00 UTC

Published date -2015-10-30 15:45 UTC

Hierarchy scope - Mechanical workshop

Equipment class ID - Arc\_welders

*Test specification*

ID - wldr\_check\_1

Description - Welder Safety Checklist Item 1. Visual inspection of electrical leads.

*Test specification criteria*

ID: 001

Description: All electrical leads in good condition

Sequence: 1

Expression: Are leads in good condition?

Result: Pass

ID: 002

Description: Leads in poor condition

Sequence: 2

Expression:

Result: Fail

ID: wldr\_check\_2

Description: Welder Safety Checklist Item 2. Check safety tag expiration date.

*Test specification criteria*

ID: 001

Description: Safety tag expiry date is in the future.

Sequence: 1

Expression: Is safety tag expiry date in the future?

Result: Pass

ID: 002

Description: Safety tag-nonexistent or expired.

Sequence: 2

Expression:

Result: Fail

ID: wldr\_check\_3

Description: Welder Safety Checklist Item 2. Check work lead connection.

*Test specification criteria*

ID: 001

Description: Work lead is firmly attached to the work.

Sequence: 1

Expression: Is work lead firmly attached to the work?

Result: Pass

ID: 002

Description: Work lead is not firmly attached to the work.

Sequence: 2

Expression:

Result: Fail

EXAMPLE 7 *Test specifications* evaluated generate an result of Pass or Fail to confirm if a *person* is fit to operate the fork truck in the Warehouse B hierarchy scope.

The test sample size of 1 *person* specifies that the *test specification* is evaluated for 1 *person*. A *test specification property* object has been applied to indicate the enforcement level of the *test specification*. The *test specification* has an enforcement level of conditional, which means that determination as to when to execute tests in accordance with the *test specification* is based on an acceptable quality limit (AQL) sampling plan.

Two conditions are specified that must be met in order to achieve a Pass result. The *person* being evaluated must have a fork truck certification expiry date in the future and must have completed their last shift more than 12 hours prior. In all other situations, an result of Fail will be returned.

The truck certification expiry date is maintained in a *person property* object with an ID of “Fork Truck certification expiry date” and the finish time of the last shift worked is maintained in a *person property* object with an ID of “last\_shift\_finish\_time”. The 12 hour minimum break time is maintained in a *personnel class property* object with an ID of “min\_break\_time”.

The *test specification* can be applied during processes such as dispatching or execution management to check that the *person* assigned to a job order is certified to drive the fork truck and that they have had a minimum break of 12 hours since working their last shift.

This example demonstrates a use-case of the *evaluated property* object where the values of the properties being evaluated in the *test specification criteria* have already been determined by prior processes. In this case, the time when the driver last clocked-off was populated automatically when the driver scanned his/her ID card when leaving the workplace. The expiry date for the fork truck driver certification was populated when the driver successfully completed an internally run fork truck driver training course.

NOTE 7 This use of a *test specification property* value highlights how alignment with the OAGIS Quality schema can be achieved. The OAGIS quality schema contains a specific attribute for *test specification* enforcement level.

*Personnel class*

ID: 10045

Description: truck drivers

Hierarchy scope: Warehouse

*Personnel class property*

ID: 001

Description: Minimum inter-shift break time

Property type: Class type

Value: 12

Value unit of measure: hours

ID: 002

Description: Fork truck certification expiry date

Property type: Instance type

ID: 003

Description: Time clocked off

Property type: Instance type

*Person*

ID: 28065

Description: Driver

Hierarchy scope: Warehouse B

Name: James Johnson

Personnel class ID: 10045

*Person property*

ID: 001

Description: Fork truck certification expiry date

Value: 2018-10-12 00:00 UTC

ID: 002

Description: Time clocked off

Value: 2017-04-21 16:00 UTC

*Test specification*

ID: Fork Truck Pre-Drive Test

Description: Specifies the test to check fitness to operate the fork truck

Hierarchy scope: Warehouse B

Test sample size: 1 person

Personnel class ID: 10045

*Test specification property*

ID: Enforcement level

Description: Defines if a test is required, optional (subjective) or conditional (based on an AQL-based sampling plan)

Value: conditional

*Test specification criteria*

ID: 001

Description: Qualified and fit for work.

Sequence: 1

Expression: today() < fork truck certification expiry date AND (now() – last\_shift\_finish\_time) > min\_break\_time

Result: Pass

ID: 002

Description: Unfit to operate

Result: Fail

*Evaluated property*

ID: fork truck certification expiry date

Description: The date of expiry of the certification to operate the fork truck

Personnel class property ID: 10045.002

ID: last\_shift\_finish\_time

Description: The time when the driver being tested last clocked off.

Personnel class property ID: 10045.003

ID: min\_break\_time

Description: The minimum shift break before driver is fit to operate the fork truck

Personnel class property ID: 10045.001

*Test result*

ID: 300567

Description: Result of fork truck pre-drive test

Hierarchy scope: Warehouse B

Evaluation date: 2017-04-22 08:00 UTC

Evaluated criterion result: Pass

Person ID: 28065 (Testable object)

(Contains Test specification ID: Fork Truck Pre-Drive Test)

* 1. Example of planning and response state attributes and defined values

End users of this standard are able to implement specific data exchanges supporting the integrated processes for planning/detailed scheduling, job order execution and multi-level performance reporting. Across Level 3 and between Level 3 and 4, these data exchanges can be modelled to a single state model for planning and job order execution with a single reporting name space. The Part 2 and Part 4 information models of this standard define a list of common process states across plant resource planning to detailed scheduling/dispatching and then throughout job order execution. The information models of this standard do not define a method to exchange the state transitions or transition rules between process states; but as system-specific process states are exchanged between systems, they are much more easily derived and mapped across systems by applying the list of process states and their defined values of this standard. This is a good business benefit since system design is seeded with pre-defined common states and values as starting template for designing the common user-specific planning and job order execution models for integration and reporting. This positive benefit includes reducing risk of data corruption, change management and cost associated with implementing and maintaining the integrated business processes and their support systems.

Solution providers and plant-specific MOM architectures are able to be aligned on the single planning-job order-response state model with aligned data exchanges with an aligned standard state definitions for a planning, job order, and work response states.

The plant planning-job order-response state models use the Part 2 operations and Part 4 work information models and objects which include aligned end-to-end lifecycle process state attributes and defined values. Information models of this standard support the design of a planning-job order state models. The exchanges between Level 4 and Level 3 (L4-L3) and Level 3 to Level 3 (L3-L3) covered are

1. from start of Level 4 *operations request* process with the transfer of operations schedule/request from L4-L3 to plant controllers;
2. to creation and dispatch of the L3-L3 *work schedule* and *work request* to the plant floor;
3. to the L3-L3 *job order* dispatch and execution; and
4. to the reporting response processes with the transfer of *work response* and *job response* from L3-L3 and *operations response* from L3- L4 with the in-process and completion of *operations performance* to the *operations schedule*.

The process states are consistent and inherently support common use cases. End users of this standard are able to implement common integrated scheduling, execution and performance reporting processes without only limited extensions and/or customisation of their state models.

NOTE 1 The information exchanges for a plant’s process and resource capability state model (capability type) or *material lot* state model (material lot disposition) can cover different aspects of operations management compared to the planning and job order execution state models.

Table D.3 provides a summary of the Part 2 and Part 4 state attributes for each object in this standard in the exchanges supporting scheduling, execution and performance reporting processes across L4 and L3 and within L3.

Table D.3 – Planning and job order execution states and defined values of this standard

|  |  |  |
| --- | --- | --- |
| Object | State attribute | Defined values |
| **Level 4 to Level 3 exchanges** | | |
| *Operations schedule* | Schedule state | Forecast, released, cancelled, waiting, ready, running, completed, aborted, held, suspended, closed |
| *Operations request* | Request state | Forecast, released, cancelled, waiting, ready, running, completed, aborted, held, suspended, closed |
| *Segment requirement* | Segment state | Forecast, released, cancelled, waiting, ready, running, completed, aborted, held, suspended, closed |
| **Level 3 to Level 3 exchanges** | | |
| *Work schedule* | Schedule state | Released, cancelled, waiting, ready, running, completed, aborted, held, suspended, closed |
| *Work request* | Request state | Released, cancelled, waiting, ready, running, completed, aborted, held, suspended, closed |
| *Job order* | Dispatch status | Waiting, cancelled, dispatched, ready, running, completed, aborted, held, suspended, closed |
| *Job response* | Job state | Waiting, ready, running, completed, aborted, held, suspended, closed |
| *Work response* | Response state | Waiting, ready, running, completed, aborted, held, suspended, closed |
| *Work performance* | Work state | Waiting, ready, running, completed, aborted, held, suspended, closed |
| **Level 4 to Level 3 exchanges** | | |
| *Segment response* | Segment state | Waiting, ready, running, completed, aborted, held, suspended, closed |
| *Operations response* | Response state | Waiting, ready, running, completed, aborted, held, suspended, closed |
| *Operations performance* | Performance state | Waiting, ready, running, completed, aborted, held, suspended, closed |

In Figure D.1, a simplified example of a job order execution state model that commonly exists for job order management. This state model is not a normative part of the standard and is included to provide an example of how the job order dispatch status and it defined values could be implemented.

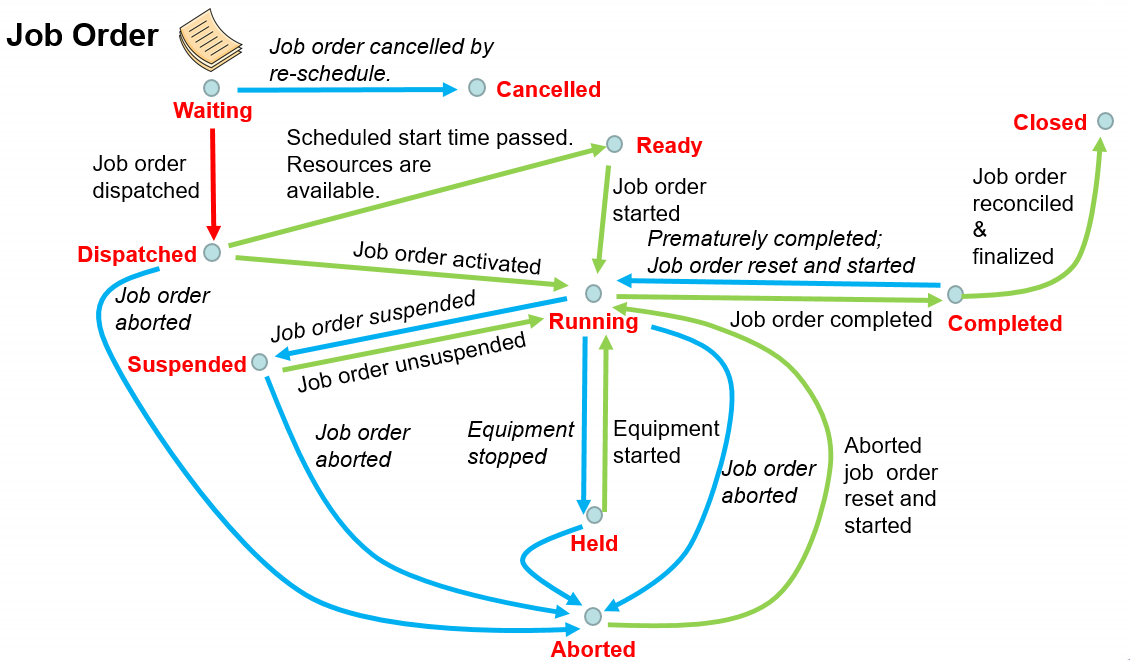


Figure D.1 – Example of simplified job order state model

NOTE 2 In Figure D.1, the states are shown in red, the transition rules/triggers are shown in black on transition line. Active job order transitions are shown with a green line with un-italicized rule while inactive job order transitions are shown with a blue line with italicized rule.

End users who do not apply this common process state approach of this standard have no option but to implement specific extensions or customizations to support common use cases. This detracts from the stated goals in Part 1 of this standard, which “are to increase uniformity and consistency of interface terminology and reduce the risk, cost, and errors associated with implementing these interfaces.”

* 1. Operations event definition record specification example

The operations event model is constructed to provide explicit specification of an operation event *operations event* instance (occurrence) using the *operations event definition record specification* to specifies the allowable content. An *operations event* instance consists of a collection of information objects that are specified with action attribute for an individual or collection of information objects. The examples below illustrate the flexibility of the operations event model’s specification method and the ability to define a number of scenarios. The specification method can be applied in simple form by specifying only information objects which may occur through a detailed specification of a range(s) for mandatory information objects and/or specific mandatory information object sets.

The *operations event definition* is typically documented as part of the system messaging specification where messages are specified in schema (XSD etc.) with validation logic for message construction and validation. Other validation logic for *information object* value contents and message envelopes are not considered in this example.

Validation logic in this example is interpreted by reading down the table where each row or merged row represents one set of testable logic for validating the *operations event* content.

The *operations event* validation must match all of the mandatory entries in the table to be considered a valid *operations event*.

Mandatory logic entries are represented in either the information object or action multiplicity columns.

EXAMPLE A *operations event definition* (specification) that specifies *Object A* with a multiplicity of 1 and an action attribute of Created with the action multiplicity attribute of 1 must have in an *operation event* instance only one *Object A* that has one action attribute of Created. Alternatively, there could be *Object A* and *Object B* specified with different multiplicities and different action attributes with different action multiplicity attributes.

If objects are present in the message that do not match any row / merged row entries, the out of specification objects must be reported as part of the message error response.

* 1. Resource acquired example

The *operations event*, *resource acquired,* notifies the subscribing functions of the acquisition of new physical resources. The physical resource(s) may have been acquired through processes such as procurement, personnel management, or production processes producing *material lots / sublots*. Figure D.2 shows an example of the MOM functions subscribing to the resource management function that is publishing the *operations event,* *resource acquired*.



Figure D.2 –Typical MOM functions subscribing to the *ResourceAcquired* event

Table D.4 shows the *operations event definition* entries for the *operations event*, *ResourceAcquired*.

Table D.4 – Operations event definition for the operations event, *ResourceAcquired*

| Attribute name | Value |
| --- | --- |
| ID | ResourceAcquired |
| Description | Notifies the acquisition of new physical resources |
| Hierarchy scope | Cincinnati Line 2 |
| Priority | Medium |
| Operations event type | Event |
| Operations event level | 3 |
| Operations type | Production |
| Function | Resource Management |
| Category | Production status |
| Source | Work Unit 42 |
| Acknowledgment | Nil |

Table D.5 defines entry set 1 for the *operations event definition record specification* for the possible scenario 1.

Scenario 1: An *operations event* occurrence can be defined as any combination of the information objects specified with any number of action attribute entries represented for each *information object*. The corresponding *operations event definition specification* is represented in Table D.5.

Table D.5 – Entry set 1 for an operations event definition record specification

|  |  |  |  |
| --- | --- | --- | --- |
| Information object | Object multiplicity | Action | Action Multiplicity |
| *Person* | Min 0 | Added | Min 0 |
| *Physical asset* | Min 0 | Added | Min 0 |
| *Equipment* | Min 0 | Added | Min 0 |
| *Material lot* | Min 0 | Added | Min 0 |
| *Material sublot* | Min 0 | Added | Min 0 |
| *Resource relationship network* | Min 0 | Added | Min 0 |
| Min 0 | Deleted | Min 0 |
| Min 0 | Changed | Min 0 |

Table D.6 defines minimum values for entry set 2 for the *operations event definition record specification* as scenario 2.

Scenario 2: Unconstrained multiplicity is the default representation in this example so there is no need to represent the multiplicity column. The definition for entry set 2 of the *operations event definition record specification* is represented.

Table D.6 – Entry set 2 for minimal operations event definition record specification

|  |  |
| --- | --- |
| Information object | Action |
| *Person* | Added |
| *Physical asset* | Added |
| *Equipment* | Added |
| *Material lot* | Added |
| *Material sublot* | Added |
| *Resource relationship network* | Added |
| Deleted |
| Changed |

Table D.7 defines possible scenario 3 for the entry set 3 in the *operations event definition record specification*.

Scenario 3: If the *operations event definition* required either *equipment* or the *physical asset* to be represented in an *operations event* but not together, the action multiplicity attribute is required to specify the logic for use and validation of the *operations event* instance.

Table D.7 – Entry set 3 for an operations event definition record specification

|  |  |  |  |
| --- | --- | --- | --- |
| Information object | Object multiplicity | Action | Action Multiplicity |
| *Person* | 0..n | Added | Min 0 |
| *Physical asset* | Min 0 | Added | Min 0 |
| ***Equipment*** | **Max 0** | Added |
| ***Physical asset*** | **Max 0** | Added | Min 0 |
| *Equipment* | Min 0 | Added |
| *Material lot* | Min 0 | Added | Min 0 |
| *Material sublot* | Min 0 | Added | Min 0 |
| *Resource relationship network* | Min 0 | Added | Min 0 |
| Min 0 | Deleted | Min 0 |
| Min 0 | Changed | Min 0 |

Table D.8 defines entry set 4 for the *operations event definition record specification* for possible scenario 4.

Scenario 4: If one of the resources must be present in a given message (a mandatory requirement), the object multiplicity entries are combined where any combination of the *information object* and *resource relationship network,* can be applied (an optional requirement).

Table D.8 – Entry set 4 for operations event definition record specification 4

|  |  |  |
| --- | --- | --- |
| Information object | Object multiplicity | Action |
| *Person* | Min 1 | Added |
| *Physical asset* | Added |
| *Equipment* | Added |
| *Material lot* | Added |
| *Material sublot* | Added |
| *Resource relationship network* | Min 0 | Added |
| Min 0 | Deleted |
| Min 0 | Changed |

* 1. Work commenced /redirected /completed / aborted example

The operations events of *WorkCommenced, WorkRedirected, WorkCompleted and WorkAborted* provide the ability for Level 3 execution management function to provide published notification of the key state changes to work in progress under the control of execution management. Figure D.3 provides a typical set of subscribers to the *WorkCommenced, WorkRedirected, WorkCompleted* and *WorkAborted* events.

The *WorkCommenced* event is a published notification when new work commences and includes a new *job order* with *work directive(s)* and new *job response* information as well as any relevant *material lot/sublot* information.

The *WorkRedirected* event is a published notification when existing work-in-process is changed. This may take the form of changing one or more existing *work directives* or may also result in replacing *work directives* with new ones. It also includes one or more *job responses* as well as any relevant *material lot/sublot* information.

The *WorkCompleted* and *WorkAborted* events are published notification when work is completed or aborted, respectively, and include job response information, change to *work directive* information, and any relevant *material lot/sublot* information.



Figure D.3 – Typical MOM functions subscribing to the *WorkCommenced, WorkRedirected, WorkCompleted* and *WorkAborted* events

The entry sets for *operations event definition* are not reported in this example. The *WorkCommenced* and *WorkRedirected* have the same *operations event definition specification*. The *WorkCompleted* and *WorkAborted* have the same *operations event definition specification*.

Table D.9 defines the entry set for the *operations event definition record specification* for *WorkCommenced* and *WorkRedirected*.

1. The *job response* and *work directive* must occur together; this is represented by combining them into one action multiplicity attribute entry.
2. The *material lot* and *material sublot* objects have no entry as they are unconstrained (the default).

Table D.9 – Operations event definition record specification for *WorkCommenced* and *WorkRedirected*

|  |  |  |  |
| --- | --- | --- | --- |
| Information object | Object multiplicity | Action | Action multiplicity |
| *Job response* | 1 | Added | Min 1, Max 1 |
| *Work directive* | 1 | Added |
| *Material lot* |  | Added |  |
| *Material lot* |  | Changed |  |
| *Material lot* |  | Deleted |  |
| *Material sublot* |  | Added |  |
| *Material sublot* |  | Changed |  |
| *Material sublot* |  | Deleted |  |

Table D.10 defines the entries for the *operations event definition record specification* for *WorkCompleted* and *WorkAborted*.

1. The *job response* and *work directive* must occur together; this is represented by combining them into one entry for the action multiplicity attribute.
2. The *job response* must have an action attribute, Added.
3. The *work directive* can have either an action attribute of Changed or Deleted in the object pair.
4. The *material lot* and *material sublot* have no entry as they are unconstrained (the default).

Table D.10 – Operations event definition record specification for *WorkCompleted* and *WorkAborted*

|  |  |  |  |
| --- | --- | --- | --- |
| Information object | Object multiplicity | Action | Action multiplicity |
| Job response | 1 | Added | Min 1, Max 1 |
| Work directive | 1 | Changed |
| Deleted |
| Material lot |  | Added |  |
| Material lot |  | Changed |  |
| Material lot |  | Deleted |  |
| Material sublot |  | Added |  |
| Material sublot |  | Changed |  |
| Material sublot |  | Deleted |  |

1. (Informative)  
   Questions and answers about object use
   1. General

This annex contains notes about the expected use of the object models, basically recorded as notes between committee members.

* 1. Inflow materials

**Question:**

In many continuous production facilities, the material inflow into the process is an important element of shared information. Does the *operations segment* present the material inflow into production or can it be presented in the *operations definition*?

**Answer:**

There are no attributes in the *operations segment - material specification*, or the *process segment - material segment specification* that detail if the *material* is produced or consumed.

To be consistent with the rest of the models we should be able to specify the inflow (consumed) *material* in either the *process segment,*

EXAMPLE Running a distillation segment consumes a *material.*

or in the *operations segment* (producing a *material* also consumes a *material*). This information is needed for scheduling, so it should be included in the exchanged information. The information should probably be recorded as a property of either the *operations segment - material specification* or of the *process segment - material segment specification*, depending on the industry needs.

* 1. Multiple products per process segment

**Question:**

In many continuous and batch industries, a single *process segment* can produce multiple products. What describes the whole picture that multiple *operations segments* are associated with a certain *process segment*?

EXAMPLE In a system where materials A, B and C are used to produce products X and Y at a certain equipment in a single batch, where Y could be a by-product.

There is only one *process segment*.

There are two *operations segments* for X and Y.

The *operations definition* describes that X is made from A, B and C, and Y is made from A, B and C.

Then, what describes that the X and Y are “brother” products?

Is it a parent *operations segment*, which contains *operations segment* X and Y?

**Answer:**

Part 2 of this standard does not model the object relationships in Part 1, so this is a matter of implementation. The most common approach to this problem seems to be to list a *process* segment for the process of consuming (A,B,C) and generating (X,Y).

The *process segment - material segment specifications* would contain the appropriate ratios (assuming they are constant), such as [50 % A, 30 % B, 20 % C] to produce [75 % X, 25 % Y]. There would be *operations segments* for X and Y, but they would not maintain the inflow (consumed) information in the *operations segments*.

Since the exact relationship between the amounts of material can also be equipment specific, the most common approach would be to create multiple *process segments* that show the consumed and produced materials in the ratios appropriate for each set of unique *equipment*.

In petrochemical refining and chemical production, it is even more complicated, since the ratio of produced material can vary based on production parameters (such as temperatures of trays in distillation columns) and on the specific properties of the consumed materials (such as the sulfur content of the oil). In those cases, if the information needed to be exchanged on a regular basis, the most common approach would be to extend the *process segment - material segment specifications* to include the mathematical relationships, such as an equation, tables, or LP, or a reference to an LP, equation, or table.

* 1. Process segments vs. operations segments

**Question:**

What is the difference between *process segments* and *operations segments*?

**Answer:**

A *process segment* presents a production activity and what resources are needed to execute the activity, at the level of detail required for business processes, such as planning or costing. business segment is a synonym for *process segment*.

EXAMPLE 1 Making a bicycle frame necessitates the use of an assembly jig, a bending machine, and an assembler for 30 min.

The same resources can be associated with more than one *process segment*.

A *operations segment* lists what resources are needed to make a specific product, at the level of detail required for planning or costing.

EXAMPLE 2 What is needed to make a 27-inch bicycle; 2 27-inch wheels, 1 27-inch frame, 1 seat, 15 screws, 1 h of a tall test cyclist, etc.

A product and support tasks are defined by one or more *operations segments*.

Any specific implementation can require more than one *operations segment*, more than one *process segment*, or a combination of both to fully describe a planning or costing view of production.

The concept of “*process segment*” is a planning view of operations describing the resources needed for operations. In the continuous industries, this usually corresponds to scheduled/planned operations within operations units.

EXAMPLE 3 A *process segment* in an oil refinery would be the material flowing through a catalytic cracker. The “segment” of production would be the use of the catalytic cracker. The scheduled element would be either the flow rate through the cracker, or the total amount of *material* through the cracker during a period of time.

In addition, when multiple products are produced from the same process, then *process segments* are generally considered a better description of production.

EXAMPLE 4 A distillation *process segment* (associated with a distillation column) could process many o*perations segments* (one per outflow).

The “*operations segment*” is a planning view of production where the *operations definition* is more descriptive than the *process segment* definition.

EXAMPLE 5 There can be many products made using a “semiconductor chip insertion process”, but the *operations definition* is the key determination of the product produced, not the process itself.

*Process segments* are generally considered a sufficient description when the processes are relatively generic and do not themselves define products. *Operations segments* are important in flexible-discrete and batch manufacturing, where the ability to include specific characteristics for each product is possible.

Table E.1 – Definition of segment types

|  |  |  |
| --- | --- | --- |
| Description | *Process segment* | *Operations segment* |
| Category of Information | Operations information | *Operations definition* /description |
| Definition | Planning view of operations | Product or task view of operation planning |
| Dependence | Usually independent of product or operations task | Usually dependent on product or operations task |

* 1. Segment parameter references

**Question:**

Is a *operations request - segment request - segment parameter* a reference to a parameter of the associated *operations segment* or the *process segment*?

**Answer:**

Either, and this ambiguity was used on purpose, because the specifying committee had examples for both cases.

EXAMPLE A *operations parameter* can be a paint color to be used, this could be defined as being in either the *operations segment* (if each product can be painted a different color in the same production step) or in the *process segment* (if all products going through the production step are painted the same color).

* 1. Use of hierarchy scope in parameter objects

**Question:**

What is the purpose of including the hierarchy scope attribute in the following objects?

* *Process segment parameter* (process segment model);
* *Parameter specification* (operations definition model); and
* *Segment parameter* (operations schedule model).

**Answer:**

The equipment hierarchy can be as broad or as deep as is required for any supply chain. However, certain key pieces of *equipment* in the hierarchy are singled out to be used in information exchanges to represent supply chain scope – the locations in which work is performed and where *material, equipment* and *personnel* are located. This supply chain scope is known as a *hierarchy scope.*

EXAMPLE 1 A scope within the overall equipment hierarchy.

The *hierarchy scope* is organized into a five-level hierarchy

The hierarchy scope attribute identifies where the exchanged information sits within the role based equipment hierarchy. It defines the scope of the exchanged information, such as a site or area for which the information is relevant at the time of the exchange.

The use of the hierarchy scope attribute in the *parameter* objects provides for the ability to restrict the applicability of individual *parameter* instances to a specific *hierarchy scope* at the time of the exchange.

EXAMPLE 2 The *process segment* for a milling production process assumes the *process segment* is specified for a site (South Shore) and area (Work Line) which contains two milling work centers (Milling 1 and Milling 2). The range of acceptable milling times for the Milling 1 work center is 5-10 minutes and for the Milling 2 work center is 10-15 minutes. This information can be exchanged in a single *process segment* exchange that has two *process segment parameters* for milling time – one for each of the relevant work centers. If the hierarchy scope attribute was not available in the *process segment parameter* object, the information would be required to be exchanged in two *process segments* exchanges. This would increase volume of data exchanged and potentially increase complexity associated with managing integrity of master data records.

* 1. Use of spatial definition in personnel objects

**Question:**

What is the purpose of including the spatial definition attribute in the following objects?

* *personnel specification;*
* *personnel requirement;*
* *personnel actual; and*
* *personnel capability*.

**Answer:**

The spatial definition attribute has been introduced into the resource models to provide a means to specify a combination of the geospatial location and 2-dimensional or 3-dimensional shape applicable to the resources. It is an optional attribute as all attributes that is intended to be used when it is relevant to geospatially specify a location and its shape for the resource.

There are a broad range of possible use cases associated with the spatial definition attribute.

In the case of *personnel* resource related objects, it could be used to geospatially specify:

* where people are required to be in order to perform a specified operation via the operations definition model;
* where people are permitted access at various times via the operations capability model;
* where people are scheduled to be via operations schedule model; and
* where people actually were via the operations performance model.
  1. How class name and property IDs are used to identify elements

**Question:**

The object models all follow the same pattern of class name with an optional property ID. How is that used to identify elements?

**Answer:**

While properties can be used to contain information about resources, they can also be used to identify subsets of resources.

Resources can sometimes be described using a class name, such as “Operators,” or as class names plus some differencing property, such as “Operators” with ranking of “Master,” “Standard” or “Junior.” In the models where a “quantity” is needed, the models all follow the same pattern. There is always a reference to a class (such as *personnel capability*) that can have an optional quantity.

EXAMPLE 1 It can need 10 man-hours of operator time available for a shift. If the element described is a subset of the class, such as only “Master” operators, then a property object is used to contain the discriminating information, and the quantity information.

EXAMPLE 2 *Personnel property capability* would define 4 man-hours of “Master” operator time available for a shift.

This model allows significant flexibility by allowing a single class definition (e.g., operators), without a quantity listing, and multiple property descriptions (e.g., Master, Standard, and Junior operators) each with their own property definition. The left part of Figure E.1 illustrates how a *personnel capability* would describe a capability of 8 operators. The right part illustrates how the capability of different ranking of operators would be defined. The *personnel capability property*, Ranking, is used to differentiate the capability of different types of operators.



Figure E.1 – Class and property IDs used to identify elements

This concept applies to the following objects:

* *personnel capability ⎯ equipment capability*
* *material capability ⎯ personnel segment capability*
* *physical asset capability ⎯ physical asset segment capability*
* *equipment segment capability ⎯ material segment capability*
* *personnel segment specification ⎯ equipment segment specification*
* *material segment specification ⎯ personnel specification*
* *equipment specification ⎯ material specification*
* *physical asset specification ⎯ physical asset requirement*
* *personnel requirement ⎯ equipment requirement*
* *material produced requirement ⎯ material consumed requirement*
* *consumable expected ⎯ personnel actual*
* *equipment actual ⎯ material produced actual*
* *material consumed actual ⎯ consumable actual*
* *physical asset actual*
  1. Possible capability over-counts

**Question:**

What does the statement about over-counts in capabilities mean?

**Answer:**

The statements, such as: Where *persons* are members of multiple *personnel classes*, then the personnel capability information presented by *personnel class* should be used carefully because of possible double counts, and personnel resources should be managed at the instance level, are given because when a property is used to show overlapping subsets of a capability, then the same capability can be double scheduled unless this situation is recognized. Figure E.2 shows an example where a property of ReactorType presents how many reactors are available. The total amount of capability is 5, but the sum of all reactors subsets is 6, because 1 reactor can be qualified as a heating and a mixing type. In this situation, the mixing and heating resources should be scheduled at the instance level in order not to overuse the available resources.



Figure E.2 – A property defining overlapping subsets of the capability

* 1. Routing and process capability

**Question:**

How are routing information and processing capabilities represented in the models?

**Answer:**

Routing information can be represented in *operations segment dependencies*, in *process segment dependencies*, or in both.

In some industries, the routing is product specific, such as the route shown in Figure E.3. The left side of the figure illustrates the assembly of a specific electronic product, with multiple assembly operations (at G and H). The routing, for a single product (or class of products), is represented by the *operations segment dependencies* illustrated in the center of Figure E.3. The capability of the system, for a specific product, can be represented in a set of *operations segment dependencies*, as illustrated on the right side of Figure E.3.

In this example, there could be multiple product routings given, one for each class of products. A scheduling system would use the product demand, product routing, and *process segment capabilities* to generate *operations schedules*.



Figure E.3 – Routing for a product

In some industries, such as continuous production with byproducts, the routing can be dependent on the processes. In Figure E.4 the routing contains material dependencies information. The routing information is then used for scheduling. The route in the left side of Figure E.4 can be represented in a set of *process segment* definitions (center table in   
Figure E.4) and *process segment dependency* definitions (right table in Figure E.4). The *process segment* definitions contain the material operations and consumption information. The consumption and operations information within the *process segments* present additional constraints and dependencies required for scheduling of material B1, C1, and F1.



Figure E.4 – Routing with co-products and material dependencies

* 1. Product and process capability dependencies

**Question:**

How is the information represented for complex scheduling problems, such as where there is a complex relationship between equipment and products? An example of this is a paint plant, where particular products can only be manufactured on specific equipment and yield varies based on product and equipment.

**Answer:**

There can be a mapping of equipment to *process segments*. The example shown in   
Figure E.5 shows sets of equipment A, B, C, and D that correspond to *process segments*. There might be multiple elements of *equipment* (process cells, production lines, production units) associated with each *process segment*, or it could correspond to a single piece of *equipment*.

In this example, there can be specific rules for each product, or rules for classes of products. The *operations segments* for each product would show which *process segments* are valid. The capability of each *process segment* and product combination can be represented in *process segment capability* objects. This information can then be used to fill in the information needed by a scheduling system, such as in a cost/throughput matrix illustrated in the lower right of Figure E.5. The costing information, and demand information required to determine the optimal throughput, do not cross the boundary addressed by this standard, but the capacity information does.

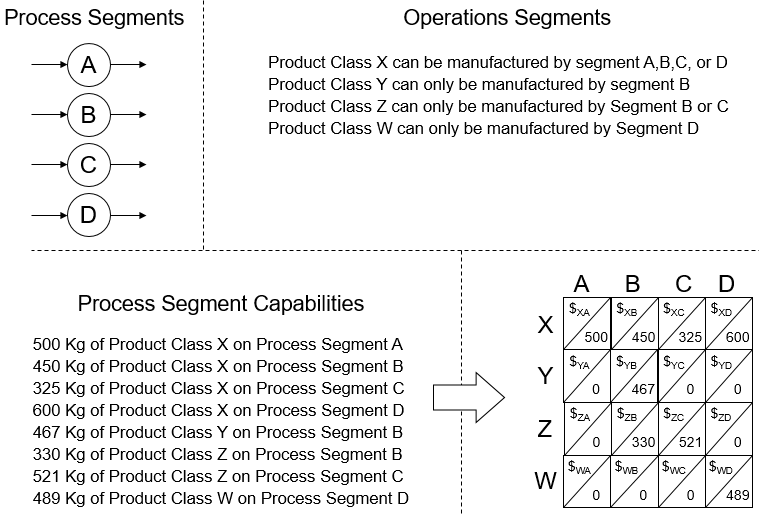


Figure E.5 – Product and process capability relationships

* 1. Representation of dependencies

**Question:**

How are process or operations dependencies represented?

**Answer:**

The dependency typeattribute in the *process segment dependency* and the *operations segment dependency* objects can be used to show the dependency. These can be simple dependencies, such as:

1. one segment follows another segment;
2. one segment cannot follow another segment;
3. two segments can run in parallel;
4. one segment starts when another segment starts;
5. one segment starts when another segment ends;
6. one segment starts any time after another segment starts;
7. one segment starts any time after another segment ends.
8. one segment is an alternative to another segment.

These dependencies can include physical constraints (because of production line layout), or constraints based on safety (such as prohibiting a “water add” after an “acid fill”), or constraints based on the chemical or physical processing required to make a product (bicycle wheels have to be assembled before the bicycle final assembly).

More complicated constraints based on timing or other dependencies can also be defined using the dependency factor attribute.

EXAMPLE 1 The longer a semiconductor wafer is kept unprocessed the more defects are introduced, so there is a maximum delay allowed between segments of production.

EXAMPLE 2 A material (like cheese or wine) ages between processing segments so there is a minimum time allowed between segments of production.

Figure E.6 illustrates some of the possible dependencies using timing constraints associated with *operations segment dependencies* or *process segment dependencies*. The left side of Figure E.6 illustrates possible dependencies where overlapped execution of the segment is allowed or required. The right side of Figure E.6 illustrates dependencies where non-overlapped execution is allowed or required



Figure E.6 – Time-based dependencies

The dependency type cannot only be related to time, but also to other unit of measures.

EXAMPLE 3 In Discrete Industry it can be common to specify a dependency between two work task segments that is based on the amount of product produced rather than on the time elapsed.

The idea is to be able to express a dependency like “Start B after A has started and at least 50 % of product quantity has been produced".

* 1. How a material transfer is handled?

**Question:**

How is a material transfer handled? It is not a request for operations, just a request to move material from one location to another.

**Answer:**

A *material* transfer can be handled using the operations schedule and operations performance models. There are multiple methods; one is to have a *process segment* defined for a “TRANSFER.” The *material* to be transferred could be identified in the *material requirement* object. The actual amount of *material* transferred could be identified in a *material produced actual* object. In some processes, the two amounts can differ due to losses during transfer. The *material* locations for the movements could be identified in the consumed *material sublot* and produced *material sublot* information.

If the movement of *material* is initiated from the manufacturing operations level but has to be known by the logistics level, then a *operations response* could be generated that defined a “TRANSFER” segment. There is no requirement in this standard that there is an *operations request* for a *operations response*, but corresponding business processes have to be in place to support the exchange of information.

* 1. How to extend the standard when properties cannot be used

Properties are the standard method for extensions, however, where required information cannot be added using the property model, additional information, including industry- and application-specific information, can have to be added as non-standard attributes and objects. However, in order to achieve integration, these extensions have to be documented and explicitly shared among interoperating partners. A documentation method should be to define a new industry or application specific standard, referencing this part of this standard and documenting the extensions.

* 1. Modeling of tools

**Question:**

Are tools modeled as *equipment* or *material*?

**Answer:**

Depending on the purpose of the tool, a tool can be modelled as either *equipment* or as *material*. Tools can be used in different ways.

EXAMPLE Tools used in the process of manufacturing versus tools included in the assembly of the product.

Tools that can be consumed or need to be lot traceable would be modelled as *material*. Other tools could be modelled as *equipment*. Some examples are shown in Table E.2:

Table E.2 – Examples of materials and equipment

|  |  |
| --- | --- |
| Equipment | Material |
| Electric drill | Bit |
| Sanding machine | Sandpaper |
| Screw driver | Screw |
| Hammer | Nail |

* 1. What is equipment and what is a physical asset?

**Question:**

Does there need to be a one-to-one relationship between *physical asset* and *equipment*?

**Answer:**

There are cases of one-to-one relationships, and one-to-many relationships in each direction. One item that is scheduled as a single piece of *equipment* can be tracked as multiple *physical assets* for maintenance purposes. Likewise, a single *physical asset* can be scheduled as multiple pieces of *equipment*. The relationship with these many to many roles is accomplished using the mapping of the role based equipment hierarchy to the physical asset hierarchy. One element in the equipment role hierarchy is a collection of assets in the physical asset hierarchy. Examples are shown in Table E.3.

Table E.3 – Equipment and physical assets

| Equipment | Physical asset | Relationship |
| --- | --- | --- |
| TT-101 (temperature sensor) | 1212-RTD-R21 (temperature probe) | 1 to 1 |
| P-1000 (palletizer) | Robot  Labeler  Bar code verifier / scanner  Conveyer  Servo Motor | 1 to 4 |
| CP-1001 (capper)  F-1001 (sanitary filter) | 453212-121-09FEB2006 (capper machine) | 2 to 1 |

* 1. How should dependencies in the operations schedule and operations response be handled?

**Question:**

How should dependencies in the *operations schedule* and *operations response* be handled?

**Answer:**

There are different types of dependencies (resource availability, customer priority, process dependency, and other).

Real applications need to model different types of dependencies between *operations requests*.

EXAMPLE An MRP/ERP at level 4 can generate separate requests for subassemblies or a single request for the final assembly of a given finished product and for the manufacturing of the intermediate *materials* that are the subassemblies to be assembled. Of course, there is a work process dependency relationship and final assembly can start only after all subassemblies have been manufactured. This is handled in an implementation where an *operations request* or *work request* states the start time and/or end time and then the associated segment requests specify the earliest start time, latest end time and duration for each segment. The algorithm for the actual dispatching of work can be implemented at level 4 or level 3, but represented in the *operations schedule* or *operations request*.

* 1. How are “mixed” operations types used?

**Question:**

How are “mixed” operations types to be used?

**Answer:**

The operation schedule model can handle mixed types of operations. The *operation schedule, operation request* and *segment requirement* can be specialized or mixed.

1. a “mixed” *operation schedule* can hold mixed or specialized *operation requests*,
2. a “mixed” *operation request* can hold mixed or specialized *segment requirements*,
3. a “mixed” *segment requirement* can handle multiple resource specifications that would normally appear in specialized segment.

In the figure, the *segment requirement* specifies

* the material movements needed to fulfill the corresponding operation (inventory operation category);
* the resources for the production;
* the material information that should include the dispensed material and other material those transfer would not need to be specified (liquid substance available from fixed pipes);
* the quality related resources that are involved during or at the end of the production operation.



Figure E.7 – Mixed operation example

* 1. What is the relationship between this standard and MESA’s B2MML?

**Question:**

What is the relationship between this standard and MESA’s B2MML?

**Answer:**

B2MML is an implementation of the standard that is based on XML technology and was developed by and is the property of MESA (ref: www.mesa.org). B2MML includes a compliance statement (as defined in Clause 9.)

The B2MML implementation includes additional information (elements) than are defined in this standard, usually for consistency of type definitions or to make use of the implementation easier when using standard programming languages.

B2MML is not the only way to implement this standard, but B2MML can be used as a reference implementation of the standard.

The committee developing the B2MML standard also sends comments on this standard to the committee developing this standard.

1. (informative)  
   Logical information flows

The personnel model, equipment model, physical asset model, material model, and process segment model are collectively referred to as the resource models.

Systems communicating using the operations capability, operations definition, operations schedule, and operations performance models must agree on the meaning of data values.

EXAMPLE 1 *Property IDs*.

The objects in the resource models document the agreed upon values.

The assumption is that the resource model information is shared among communicating systems. The resource model information can be embedded as part of an information flow for other objects, can be exchanged as separate objects, or can be part of a common or distributed data store.

The Part 1 of this standard object model does not assume a one-to-one relationship between enterprise systems and manufacturing control systems. These can be one-to-many, many-to-one, or many-to-many relationships.

EXAMPLE 2 Examples of the exchanges include contract manufacturing being performed for multiple customers (many-to-one), and a single company with multiple different manufacturing control systems (one-to-many). Figure F.1 illustrates some possible abstract information flows between enterprise systems and manufacturing control systems.



Figure F.1 – Enterprise to manufacturing system abstract information flows

The information in this part of this standard is independent of any communication protocol. Part 2 of this standard makes no assumption about the agents that create the information and the agents that use the information. Different implementations of the information model can describe different communication protocols and will often require additional attributes and objects.

EXAMPLE 3 An SQL implementation will have to identify primary keys and can identify index attributes.

Additionally, the information model does not assume a one-to-one relationship between external systems and manufacturing control systems. There can be one-to-many, many-to-one, or many-to-many relationships.

EXAMPLE 4 Examples of the many-to-many exchanges include multiple maintenance systems or quality systems. Figure F.2 illustrates examples of manufacturing control system connections.



Figure F.2 – Abstract information flows among multiple systems

1. (Informative)  
   Abstract model to implementation model transformations

The data shown in the abstract UML models in this standard may be implemented as a subset, specialization or extension of those models. The relationship between the abstract UML models of this standard and associated implementation models is expressed through a transformation process which may be a combination of text and transformation / constraint rules.

The data shown in an implementation model may include the following as well as additional entries depending on the requirements of the implementation:

* 1. cardinality,
  2. navigability,
  3. definitions,
  4. key attributes, and

EXAMPLE 1 Primary keys, secondary keys.

* 1. intermediate objects / link objects.

EXAMPLE 2 Many to many tables.

NOTE 1 Implementation models can be generic models that support a broad implementation scope in a specific exchange technology which can further refined by other implementation models that have a tighter scope.

NOTE 2 Different implementation models of the abstract objects in this standard and UML models can apply various technical methods to represent the object relationships presented in the abstract model in this standard.

EXAMPLE 3 Object relationships in this standard can be represented as additional attributes in a database implementation; The same object relationships can also be represented as in a containment in an XML document implementation.

EXAMPLE 4 An implementation model of this standard is the Business-to-manufacturing-markup-language (B2MML) from MESA International.

The abstract to implementation model transformation process from abstract models in this standard or a more generic implementation model is achieved by the application of rules and processing steps over the objects, relationships, and attributes of the source model to produce the implementation model.

Implementation models may constrain abstract model object relationships in this standard by applying additional constraints to the abstract models in this standard. The abstract models in this standard and associated relationship and role tables present information which may not be relevant to specific implementation models.

The object lifetime and navigation information are typically required in a persistent store but is not required for a specific information exchange interpretation. Navigation constraints are defined and applied for undefined navigations in this standard. Even though individual message payloads have no navigation and lifetime semantics applied, the information models in this standard can be used to represent a canonical information model that references all endpoints. In this case, the object relationships influence the message representation. The implementation of the abstract model relationships in standard vary depending on the implementation technology applied and implementation requirements. The related object naming conventions and relationship types in object relationship tables in standard allow implementation models to be constructed from the abstract models in the standard in a common manner.

The implementation model can be visualized using the same UML, attribute table and relationship table formats as used in this standard. The implementation model is documented in a standard message profile which describes the compliant and specialized custom objects. The user of the implementation model shall be able to understand the difference between the source of abstract model to the end result in the implementation model.

Annex A shows a typical related object naming convention for the mapping for the abstract model in this standard to an implementation model. Annex G shows typical implementation model examples. Annex H shows descriptions of typical implementation technologies.

NOTE 3 In the message payloads, the object relationship can be either as contained objects or external references using reference ID values. The reference ID values can be directly reference the ID of an external object or an intermediate associative ID to link tables that connect the objects and add attributes to the link.

NOTE 4 If the transaction processing logic within the sender and receiver applications require navigation persistence, the message payload can require relationship attributes for the object relationships to aid in message processing.

Abstract UML models in standard are independent of the implementation models. Implementation models are classified by the following two categories representing application of information models of this standard. Further specializations on these categories can be developed depending on implementation requirements.

1. Information model persistence: information is retained in a persistent store closely aligned with the information models of this standard, which can be part of messaging infrastructure or at application level in systems. This category of system receives and generate transactions based on this standard with minimal additional translation between the message and the store’s meta data. Objects in this standard are created, updated and deleted with transactions based on this standard. The persistence technology uses a storage model to implement the relationship rules.

EXAMPLE 5 Storage maybe modeled as relational, associative, object, semantic, graph, triple store.

In a message or information exchange, object lifetimes and navigation are defined by the model relationship and role tables represented in this standard. The details of processing of the relationship are managed by the implementation method.

1. Message structure definition: messages between applications construct data objects from each application’s information models by serializing their content into a message payload in a form validated against the information models of this standard. As message payloads are constructed and interpreted as a whole, there are no navigation and lifetime semantics applied to the content in message payloads. Each message is a partial snapshot of the sender’s information model at the time of the data exchange.

EXAMPLE 6

* Hierarchical (Nested XML)
* Flat (Flat buffers, flat XML, csv)
* Object (OMG - IDL), JSON

The related object naming conventions and relationship types in this standard allow implementation models to be constructed following a standard process. The implementation of the abstract relationships of this standard vary depending on the implementation technology applied.

The following historical example list of the implementation methods have applied abstract models of this standard. Future advances in implementation methods will expand this limited list.

1. hierarchical: related objects in UML models of this standard are represented directly as relationship attributes within the parent object. A combination of contained and referenced objects.

EXAMPLE 7 XML Hierarchical form - XML Schema (XSD) of the Business-to-manufacturing-markup-language (B2MML)

1. associative / link tables / column databases: object relationship attributes are represented as individual records with unique identifiers / reference identifiers for each record. All related objects in UML models of this standard are represented in link / association tables that correspond to source and target identifiers and verb /role indication of the association between objects. Objects are typically defined with attributes while their relationships to external and contained objects are represented as external links with the ID suffix indicating the external reference.

EXAMPLE 8

1. Topic maps (ISO 13250)
2. Relational database
3. NoSQL database
4. XML flat (objects stored in single level of XML)
5. Graph database
6. Triple store

Object attributes and relationships in object UML models in this standard are represented as individual triple entries. Instances represent class membership and values with individual triple entries.

EXAMPLE 9

1. Web ontology language (OWL)
2. Resource description framework (RDF)
3. Binary

A binary wire protocol specified by a definition which generates interfaces to allow applications to interact with the binary wire protocol.

EXAMPLE 10

1. OMG data distribution service (DDS), OMG Common Data Representation (CDR) binary wire protocol specified by OMG interface definition language (IDL)
2. Flat Buffers binary specification specified by Google interface definition language (IDL)

A binary protocol that is specified in a document and implemented by add on tools

EXAMPLE 11

1. OPC Binary specifications
2. OASIS AMQP specification

A binary protocol that allows implementation to specify their own message payload content.

EXAMPLE 12

1. OASIS MQTT
2. OASIS – AMQP
3. OMG RTPS – DDS - CDR
4. (informative)   
   Abstract to implementation model examples

In examples of this annex, an *person* object defined in this standard is used for each implementation model example for a number of implementation technologies applied in manufacturing, industrial internet of things, smart manufacturing, military and space craft systems.

Each implementation has its own representation of transaction objects; only the noun component is depicted in the examples where the personnel model has been simplified to allow presentation of the basic transformations that are performed between the abstract model and its implementation model counterpart.

The examples are informative of the type of implementation model performed and may not be indicative of the best practice applied in each environment. Some examples provided are taken from existing works that are cited appropriately while others are examples created by this committee and are not intended to represent a completed implementation. An explanation of how to apply each implementation technology is not provided to keep the annex brief for illustration purposes only. The reader is directed to research implementation technology of interest for details on how to build the implementation.

As transactions based on this standard are specifications of exchanged information, many of the implementation models focus on the generation of application interfaces that allow generation of the messages in a controlled manner. XML/XSD interfaces can be generated from the message schema; however, in many cases, an intermediate type definition language is used to generate the interfaces and generate message validation logic.

* 1. Personnel abstract UML model

This example represents parts of the *person* object as represented in the Personnel model presented in Figure 8. A formal description of the personnel model is presented in Clause 5.



Figure H.1 – Abstract UML Model Example: Personnel model

The *person* object has the following relationship and object attributes.

There is no multiplicity value present on *person* object attributes. The ID attribute is required (multiplicity of 1) which is represented in the example of implementation models.

Table H.1 – Example: Personnel class relationships

| Related Object | Role | Multiplicity | Relationship Name | Description |
| --- | --- | --- | --- | --- |
| Personnel class | Personnel class parent type | 0..\* | Includes properties of | This *personnel class(s)* include properties of the *personnel class*. |
| Personnel class property | Personnel class property | 0..\* | Has properties of | The *personnel class property(s)* of this *personnel class*. |
| Person | NA | 0..\* | Defined by | The *person* support this *personnel class.*  The *person* objects support the *personnel class property(s)* associated with this *personnel class.* |

Table H.2 – Example, Personnel class attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *personnel class*.  These are not necessarily job titles, but identify classes that are referenced in other parts of the model. | Widget assembly operator | Maintenance Technician Grade 1 | Senior Lab Assistant | Warehouse Manager |
| Description | Additional information and description about the *personnel class*. | General information about widget assembly operators. | Highest grade for maintenance technician | Highest level of lab assistants | Person responsible for the warehouse |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally, hierarchy scope defines the scope of the *personnel class* definition, such as the site or area where it is defined. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |

* 1. MESA – B2MML 6.0 (XSD) implementation model

B2MML 6.0 (Copyright © 2013 MESA International) represents its types using optional elements since all attributes are optional.

EXAMPLE The common identifierType and its derived types such as EquipmentIDType allows optional elements in structure in addition to its base string representation and the DescriptionType is based on a Text type. Whilst these values are possible, these entries are typically applied with the base string / text type matching the ISA-95 representation.

<xsd:complexType name = "PersonType">

<xsd:sequence>

<xsd:element name = "ID" type = "IdentifierType"/>

<xsd:element name = "Description" type = "DescriptionType" minOccurs = "0" maxOccurs = "unbounded"/>

<xsd:element name = "HierarchyScope" type = "HierarchyScopeType" minOccurs = "0" />

<xsd:element name = "PersonProperty" type = "PersonPropertyType" minOccurs = "0" maxOccurs = unbounded"/>

…

<xsd:group ref = "Extended:Person" minOccurs = "0" maxOccurs = "1"/>

</xsd:sequence>

</xsd:complexType>

<xsd:complexType name="HierarchyScopeType">

<xsd:sequence>

<xsd:element name="EquipmentID" type="EquipmentIDType"/>

<xsd:element name="EquipmentElementLevel" type="EquipmentElementLevelType"/>

<xsd:element name="HierarchyScope" type="HierarchyScopeType" minOccurs="0"/>

<xsd:group ref="Extended:HierarchyScope" minOccurs="0" maxOccurs="1"/>

</xsd:sequence>

</xsd:complexType>

<xsd:complexType name="EquipmentElementLevel1Type">

<xsd:simpleContent>

<xsd:restriction base="CodeType">

<xsd:enumeration value="Enterprise"/>

…

<xsd:enumeration value="ControlModule"/>

</xsd:restriction>

</xsd:simpleContent>

</xsd:complexType>

* 1. Simplified XSD implementation model

This implementation is utilized in internet and manufacturing applications. This simplified representation of XML validation represents the most common application of XML based information exchanges defined in this standard where string values are exchanged for each element.

<xsd:complexType name = "PersonType">

<xsd:sequence>

<xsd:element name = "ID" type = "xsd:string"/>

<xsd:element name = "Description" type = "xsd:string"/>

<xsd:element name = "HierarchyScope" type = "HierarchyScopeType"/>

…

<xsd:element name = "PersonProperty" type = "xsd:string"/>

</xsd:sequence>

</xsd:complexType>

<xsd:complexType name="HierarchyScopeType">

<xsd:sequence>

<xsd:element name="EquipmentID" type="EquipmentIDType"/>

<xsd:element name="EquipmentElementLevel" type="xsd:string"/>

<xsd:element name="HierarchyScope" type="HierarchyScopeType"/>

</xsd:sequence>

</xsd:complexType>

<xsd:complexType name="EquipmentElementLevel1Type">

<xsd:simpleContent>

<xsd:restriction base="CodeType">

<xsd:enumeration value="Enterprise"/>

…

<xsd:enumeration value="ControlModule"/>

<xsd:enumeration value="Other"/>

</xsd:restriction>

</xsd:simpleContent>

</xsd:complexType>

* 1. Object Management Group (OMG) – Interface Definition Language (IDL) – Common Data Representation (CDR) implementation model

The IDL CDR standard is utilized in military, manufacturing, space craft, and Industrial Internet of things (IIoT) systems.

The type definitions represented in IDL are used to generate application interfaces which generate a common binary representation of either CDR or a custom representation. Wire messages can be processed with decodes based on the IDL or by defining a debug format that is human readable.

Module ISA95vX

{

struct PersonType

{

string ID;

string Description;

HierarchyScopeType HierarchyScope;

…

Sequence<PersonPropertyType> PersonProperties;

}

struct HierarchyScopeType

{

string EquipmentID;

EquipmentElementLevelEnum EquipmentElementLevel;

HierarchyScopeType HierarchyScope;

}

enum EquipmentElementLevelEnum

{

Enterprise,

…

ControlModule,

Other

}

}

* 1. OPC Unified Architecture (UA) implementation model

The OPC Foundation has published the OPC Unified Architecture (OPC UA) specification to allow the formal specification of implementation models across a variety of applications. The example is based on OPC UA for ISA-95 Common Object Model, Companion Specification, Release 1.0.3, December 20, 2015. Copyright © 2006-2013, OPC Foundation, Inc.

As an open standard, OPC UA is based on standard Internet technologies: TCP/IP, HTTP, Ethernet, and XML.

As an extensible standard, OPC UA provides a set of services (defined OPC UA Part 4 specification) and a basic information model framework. This framework provides an easy manner for creating and exposing vendor defined information in a standard way. More importantly, all OPC UA clients are expected to be able to discover and use vendor defined information. This means OPC UA users can benefit from the economies of scale that come with generic visualization and historian applications. This specification is an example of an OPC UA information model designed to meet the needs of developers and users.

OPC UA provides a framework that can be used to represent complex information as *Objects* in an address space which can be accessed with standard transports (TCP, HTTP, AMQP, and others). These *Objects* consist of *Nodes* connected by *References*. Different classes of *Nodes* convey different semantics. For example, a *Variable* *Node* represents a value that can be read or written. The *Variable* *Node* has an associated *DataType* that can define the actual value, such as a string, float, structure etc. It can also describe the variable value as a variant. A *Method* *Node* represents a function that can be called. Every Node has a number of attributes including a unique identifier called a *NodeId* and non-localized name called as *BrowseName*. . The notation developed for the OPC UA specification is summarized in Figure H.1. UML representations can also be used; however, the OPC UA notation is less ambiguous because there is a direct mapping from the elements in the figures to Nodes in the address space of an OPC UA server.

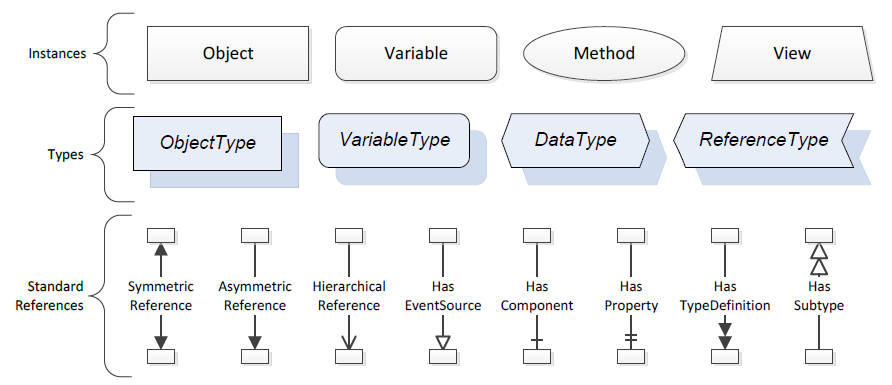


Figure H.2 – OPC UA Specification Notation

OPC UA specification defines a very wide range of functionality in its basic information model. All clients or servers are not expected to support all functionality in the OPC UA specifications. OPC UA includes the concept of profiles which segment the functionality into testable certifiable units. This allows the development of companion specification (such as OPC UA for ISA-95) that can describe the subset of functionality that is expected to be implemented. The profiles do not restrict functionality but generate requirements for a minimum set of functionalities.

The modelling approach for generating an OPC UA model from an ISA-95 UML Models follows the following general concepts / suggestions.

1. Map all ISA-95 properties to *OPC UA Variables* and *OPC UA VariableTypes*, creating OPC UA *VariableTypes* as needed. Create a subtype of a *VariableType* whenever the item will be reused multiple times; otherwise, create an instance of the appropriate OPC UA *VariableType* (*Equipment Property Type* or *PhysicalAssetPropertyType* ….).
2. Map all ISA-95 resource class objects and instance objects to OPC UA *ObjectTypes*, creating OPC UA *ObjectTypes* as needed. Again, *ObjectType* need only be created for *Objects* where multiple instance of the *Object* will exist; otherwise, simply create an instance of the appropriate *ObjectType* (*EquipmentType*, *PhysicalAssetType*).
3. Create all types as part of a hierarchical set of types to allow for easier implementation and maintenance.
4. Convert IDs used to indicate a relationship between ISA-95 objects to OPC UA *References*. Use the *References* defined in this specification as needed. Generate *Custom References* only if an existing *Reference* does not exist and the *Reference* provides some unique semantic information.
5. Reuse existing OPC UA concepts wherever possible, such as Descriptions, Names, Engineering Units etc. These items should not be duplicated as additional ISA-95 properties.

As an example of modeling, Figure H.3 illustrates the OPC UA representation of the ISA-95 personnel model. Figure H.6 illustrates a personnel model which consists of specific *persons*, *ISA95Classes* of *personnel class*, and associated properties. The example shows a subtype that illustrates creating customized subtype of *PersonnelClass*. Also, actual instance of the individual types is created to illustrate how multiple classes can be combined into a single instance.

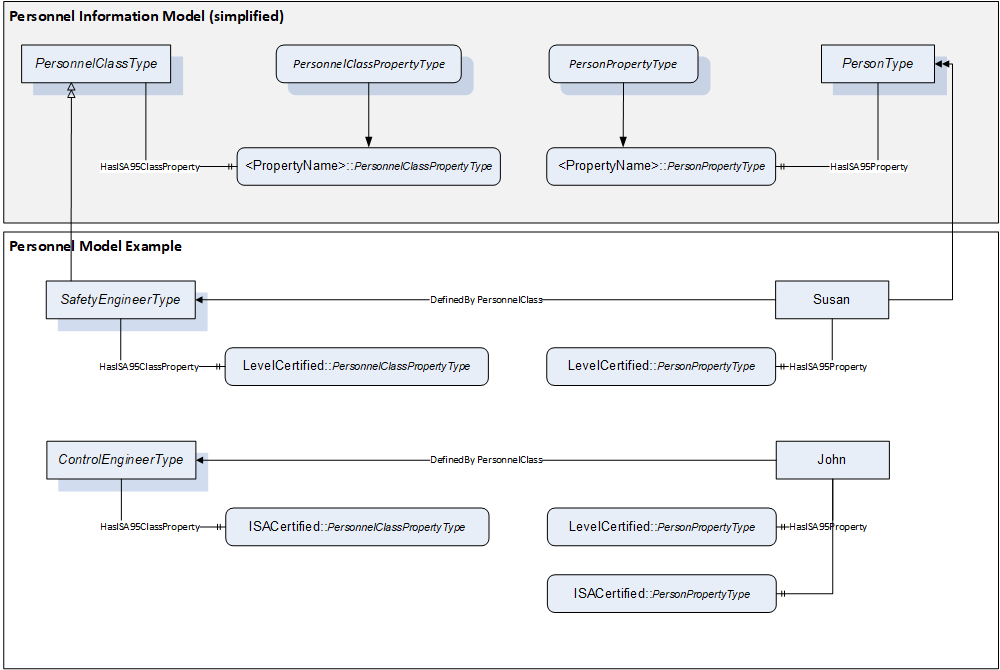


Figure H.3 – OPC UA representation of the personnel model

* 1. Flat buffers – Interactive Data Language (IDL) implementation model

The IDL standard is utilized in internet, Internet of Things, and future Industrial Internet of things. The type definitions represented are used to generate application interfaces which generate a common binary representation. The type definitions are used to generate decodes for the binary wire protocol.

Table:PersonType

{

ID:string(required);

Description:string;

HierarchyScope: HierarchyScopeType;

PersonProperty[PersonPropertyType];

}

Table HiearchyScopeType

{

EquipmentID:string(required);

EquipmentLevel:EquipmentLevelEnum;

HierarchyScopeType string;

}

enum EquipmentLevelEnum:byte

* 1. Internet Engineering Task Force (IETF) – JavaScript Object Notation (JSON) – Schema implementation model

This implementation is used in internet-based manufacturing applications, (JavaScript object notation) JSON is an object notation applied as a lightweight message representation compared to XML but has limited structure validation when compared to other message formats. Javascript and other application / language API’s validate the message before exchanging in JSON format. Formal schema definitions such as the Internet Engineering Task Force (IETF) JSON-Schema (json-schema.org) provide specific implementation model validation capabilities that can be used for an implementation model specification based on this standard.

Message validation is performed using one of JSON schema specifications. The following example illustrates a JSON-Schema schema which retains a similar format to the transmitted message. The transmitted message has the values in place of the validation specification.

{  
 "Person"{  
 "ID":{“type”:“string”},  
 "Description":{“type”:“string”},  
 "HierarchyScope":{“type”:“HierarchyScopeType”},  
 …  
 "PersonProperty":{“type”:“array”, “minItems”:0, “items”: {“type”:”PersonProperty”}, “uniqueItems”: true}  
 }  
 HierachyScopeType

{

“EquipmentID”:{“type”:”string”},

“HierarchyScopeLevel”: {“enum”:[“Enterprise”, … ,”ControlModule”, “Other”]},

“HierarchyScope”:{“type”:”HieararchyScopeType””}

}

}

* 1. Open Source Robotics Foundation (OSRF) as so known as Open Robotics, Robot Operating System (ROS) message description specifications (MDS)

The Open Source Robotics Foundation (OSRF) as so known as Open Robotics (www.openrobotics.org) produces the Robot Operating System (ROS) which defines messaging platforms for robots and smart machines in manufacturing, defense, research and space craft systems. The ROS2 version contains DDS/RTPS as are core component for information exchange. The messages are defined message description specifications (MDS) which generate the configurations and messaging API for the underlying RTPS layer along with extended capabilities.

PersonType.msg

string ID

string Description

…

HierarchyScopeType HierarchyScope

PersonPropertyType [] PersonProperties

HierarchyScopeType.msg

string EquipmentID

HierarchyScopeLevelType HierarchyScopeLevel

HiearchyScopeType HierarchyScope

HierarchyScopeLevelType.msg

HierarchyScopeLevel\_Enterprise = “Enterprise”

…

HierarchyScopeLevel\_ControlModule=”ControlModule”

HierarchyScopeLevel\_Other=”Other”

* 1. World Wide Web Consortium (W3C) Resource Description Framework (RDF) schema

RDF implementation is adopted for a number or formats that can be used to represent RDF triples. The implementation model of this standard in this environment defines the format of the RDF Descriptions to be used.

The following uses standard turtle syntax.

@prefix PersonType

@prefix HierarchyScopeType

@prefix HierarchyScopeEnumType

< http://…/Object#me>

rdf:type PersonType:Person

attribute#Description

…

attribute#HierarchScopeType

attribute#PersonProperty

<< need to confirm the correct representation of RDF / RDFS

* 1. SQL database model

The SQL database itself acts as an implementation model schema. It is constructed with its linkages of related tables. The related tables can be represented in many forms depending on business rules, the following is one of them represented in pseudo SQL statements that would construct the database. Any data manipulation of these tables will generate errors if the relational rules are broken.

CreateTable PersonType ( ID varchar(255) Primary Key

Description varchar (255), …, HierarchyScope varchar(255), Foreign Key (HierarchyScopeType) )

CreateTable PersonPropertyType ( ID varchar(255) Primary Key …)

CreateTable PersonProperties (PersonTypeID varchar(255) Foreign key (PersonType[ID]),

PersonPropertyType varchar(255) Foreigh Key (PersonPropertyType[ID])

CreateTable HierarchyScopeType ( EquipmentID varchar(255) Primary Key,

HierarchyScopeLevel varchar(255) Foreign Key (HierarchyScopeLevelEnum[Level]),

HierarchyScope varchar(255) Foreign Key(Hierarchy Scope Type[EquipmentID]));

CreateTable HierarchyScopeLevelEnum ( Level varchar(255) Primary Key);

Insert into HierarchyScopeLevel Level “Enterprise” … , “Control Module”, “Other”

* 1. Transport Protocols

There are several standards that are used to transfer information models in ISA 95, such as OASIS – MQ Telemetry Transport (MQTT) and OASIS – Advanced Message Queuing Protocol (AMQP) and other communications standards (TCP/IP, UDP/IP, RS485, Message Queues, named pipes …). Implementations can use these messaging infrastructure platforms with their own message payload specification which may include the validation examples presented in this part.

The MQTT implementation is utilized in applications where lightweight messaging is required including Industrial Internet of Things and Enterprise to smart device integration. The payload of a message is a variable length byte stream. MQTT does not provide a validation capability in its specification. A validation technique specified for other implementation model validation may be used in conjunction with the MQTT as a transport. The object structure is defined at the application level which may be validated by the messaging infrastructure that generates the byte stream for transfer. The following example is for a ‘C’ language implementation for the in-memory representation of the object, any language implementation can be used so long as the byte stream serialization functions support the agreed byte stream format.

Struct PersonType

{

char[MAX\_FIELD\_TYPE] ID, Description;

EquipmentElementLevel HiearchyScopeType;

PersonPropertyType[MAX\_PERSON\_PROPERTIES] PersonProperty;

…

};

typedef enum EquipmentElementLevel

{

Enterprise,

…

ControlModule

};

This OASIS AMQP standard is utilized in finance, manufacturing, enterprise systems and Industrial Internet of things. There are a number of application interfaces that apply this wire level protocol. The actual wire structure of the message is binary following the type definition presented. The representation of contained objects on the wire is still unclear at the time of writing. The message type is used to decode wire level binary messages.

<type name ="PersonType" class=”composite” source=”list” provides=”frame”>

     <field name = "ID" type = "string"/>

     <field name = "Description"  type = " string"/>

     <field name = "HierarchyScope" type = "HierarchyScopeType"/>

…

     <field name = "PersonProperty" type = "PersonProperty" category “List” />

</ type>

<type name="HierarchyScopeType" class=”composite” source=”list” provides=”frame”>

           <field name="EquipmentID" type="EquipmentIDType"/>

            <field name="EquipmentElementLevel" type="xsd:string"/>

            <field name="HierarchyScope" type="xsd:string"/>

</type>

<type name=”EquipmentElementLevelType” class=”restricted” source=”string”>

     <choice name=”Enterprise” value=”Enterprise”/>

     …

     <choice name=”ControlModule” value=”ControlModule”/>

     <choice name=”Other” value=”Other”/>

</type>

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