**AMERICAN NATIONAL STANDARD**

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**Enterprise-Control System Integration**

**− Part 2: Object Model Attributes**

ANSI/ISA-95.00.02-ed3 CD01 (ISA-95.00.02 ed2Mod)

Enterprise-Control System Integration − Part 2: Object Model Attributes

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CONTENTS

FOREWORD 14

INTRODUCTION 16

1 Scope 18

2 The scope of ISA-95.00.02 is limited to the definition of object models and attributes of the exchanged information defined in ISA-95.00.01.Normative references 18

3 Terms, definitions and abbreviations 19

3.1 Terms and definitions 19

3.2 Abbreviations 20

4 Production operations models and generic operations models 20

4.1 Information models 20

4.2 Relationship of exchange information models to operations management activity categories 21

4.3 General information model characteristics 22

4.4 Information object model structure 22

4.5 Value types 35

4.6 Expression of measurement uncertainty 37

5 Common object models 38

5.1 Hierarchy scope 38

5.2 Spatial definition 39

5.3 Operational location model 41

5.4 Personnel information 46

5.5 Role based equipment information 50

5.6 Physical asset information 56

5.7 Material information 63

5.8 Process segment information 77

5.9 Test information 95

5.10 Operations record information 102

5.11 Operations event information 107

5.12 Containers, tools and software 124

6 Operations management information 125

6.1 Operations definition information 125

6.2 Operations schedule information 147

6.3 Operations performance information 169

6.4 Operations capability information 188

6.5 Process segment capability information 207

6.6 Operations segment capability information 212

7 Object model inter-relationships 216

8 List of objects 219

9 Compliance 221

Annex A (Informative) Implementation naming convention for object relationships 222

A.1 Naming strategies 222

Annex B Value syntax 224

B.1 Value Syntax 224

Annex C (informative) Use and examples 225

C.1 Use and examples 225

C.2 Application of the standard 229

C.3 Database mapping of the models 229

C.4 XML usage 230

Annex D (informative) Example data sets 233

D.1 General 233

D.2 Material model example 233

D.3 Equipment model examples 235

D.4 Personnel model example 238

D.5 Operations capability example 239

D.6 Operations performance example 240

Annex E (informative) Questions and answers about object use 241

E.1 General 241

E.2 Inflow materials 241

E.3 Multiple products per process segment 241

E.4 Process segments vs. operations segments 242

E.5 Segment parameter references 243

E.6 Use of hierarchy scope in parameter objects 243

E.7 Use of spatial definition in personnel objects 244

E.8 How class name and property IDs are used to identify elements 245

E.9 Possible capability over-counts 246

E.10 Routing and process capability 248

E.11 Product and process capability dependencies 249

E.12 Representation of dependencies 250

E.13 Representation of material produced and consumed 251

E.14 Material produced and the capability model 251

E.15 How a material transfer is handled? 252

E.16 How to extend the standard when properties cannot be used 252

E.17 Modeling of tools 252

E.18 What is equipment and what is a physical asset? 253

E.19 How should dependencies in the operations schedule and operations response be handled? 253

E.20 How are “mixed” operations types used? 254

E.21 What is the relationship between this standard and MESA’s B2MML? 254

Annex F (informative) Abstract information flows 256

Annex G (informative)Implementation models 258

Annex H (informative) Abstract to implementation model examples 260

H.1 Personnel abstract model 260

H.2 MESA – B2MML (XSD) implementation model 261

H.3 Simplified XSD implementation model 262

H.4 Object Management Group (OMG) – Interface Definition Language (IDL) – Common Data Representation (CDR) implementation model 262

H.5 OPC Unified Architecture (UA) implementation model 263

H.6 Organization for the Advancement of Structured Information Standards (OASIS) – Advanced Message Queuing Protocol (AMQP) implementation model 263

H.7 Flat buffers – Interactive Data Language (IDL) implementation model 263

H.8 Internet Engineering Task Force (IETF) – JavaScript Object Notation (JSON) – Schema implementation model 264

H.9 Open Source Robotics Foundation (OSRF), Robot Operating System (ROS) message description specifications (MDS) 264

H.10 OASIS - MQ Telemetry Transport (MQTT) 265

H.11 World Wide Web Consortium (W3C) Resource Description Framework (RDF) schema 265

H.12 SQL database model 265

Annex I (informative) Test Examples 266

I.1 Personnel model – qualification test specification examples 266

I.2 Role based equipment model – equipment capability test specification examples 266

I.3 Physical asset model – physical asset capability test specification examples 266

I.4 Material model – material test specification examples 266

Bibliography 268

Tables

Table 1 – UML notation used 23

Table 2 – Example: Relationship table for an information model, Personnel model relationships 28

Table 3 – Example: Relationship role table, Personnel class relationship roles 28

Table 4 – Example: Object attribute table 29

Table 5 – Detailed UML model relationships in Figure 4 31

Table 6 – Four possible cross-model relationships for a *resource task* instance 31

Table 7 – List of ISA-95 models and their permitted resource object instances in cross-model relationships to resource models 31

Table 8 – Resource task cross-model relationship roles 32

Table 9 – Resource task property cross-model relationship roles 33

Table 10 – Resource group cross-model relationship roles 33

Table 11 – Resource group property cross-model relationship roles 34

Table 12 – Resource cross-model relationship roles 34

Table 13 – Resource property cross-model relationship roles 34

Table 14 – Commonly used CCTS types for exchange 37

Table 15 – Hierarchy scope attributes 41

Table 16 – Attributes of spatial definition 41

Table 17 – Operational location model relationships 44

Table 18 – Operational location class relationship roles 45

Table 19 – Operational location class attributes 45

Table 20 – Operational location class property relationship roles 45

Table 21 – Location class property attributes 46

Table 22 – Operational location relationship roles 46

Table 23 – Operational location attributes 46

Table 24 – Operational location property relationship roles 47

Table 25 – Operational location property attributes 47

Table 26 – Personnel model relationships 48

Table 27 – Personnel class relationship roles 49

Table 28 – Personnel class attributes 49

Table 29 – Personnel class property relationship roles 49

Table 30 – Personnel class property attributes 50

Table 31 – Person relationship roles 50

Table 32 – Person attributes 51

Table 33 – Person property relationship roles 52

Table 34 – Person property attributes 52

Table 35 – Role based equipment model relationships 53

Table 36 – Equipment class relationship roles 54

Table 37 – Equipment class attributes 54

Table 38 – Equipment class property relationship roles 55

Table 39 – Equipment class property attributes 55

Table 40 – Equipment relationship roles 56

Table 41 – Equipment attributes 56

Table 42 – Equipment property relationships 57

Table 43 – Equipment property attributes 58

Table 44 – Physical asset model relationships 59

Table 45 – Physical asset and equipment relationships 60

Table 46 – Physical asset class relationship roles 60

Table 47 – Physical asset class attributes 60

Table 48 – Physical asset class property relationship roles 61

Table 49 – Physical asset class property attributes 61

Table 50 – Physical asset relationship roles 62

Table 51 – Physical asset attributes 62

Table 52 – Physical asset property relationship roles 63

Table 53 – Physical asset property attributes 64

Table 54 – Equipment asset mapping relationship roles 64

Table 55 – Equipment asset mapping attributes 64

Table 56 – Material model relationships 65

Table 57 – Material class relationship roles 66

Table 58 – Material class attributes 67

Table 59 – Material class property relationship roles 68

Table 60 – Material class property attributes 68

Table 61– Material definition relationship roles 69

Table 62 – Material definition attributes 69

Table 63 – Material definition property relationship roles 70

Table 64 – Material definition property attributes 71

Table 65 – Material lot relationship roles 71

Table 66 – Material lot attributes 72

Table 67 – Material lot property relationship roles 74

Table 68 – Material lot property attributes 75

Table 69 – Material sublot relationship roles 76

Table 70 – Material sublot attributes 76

Table 71 – Process segment model relationships 80

Table 72 – Process segment relationship roles 83

Table 73 – Process segment attributes 83

Table 74 – Personnel segment specification relationship roles 84

Table 75 – Personnel segment specification attributes 84

Table 76 – Personnel segment specification property relationship roles 86

Table 77 – Personnel segment specification property attributes 86

Table 78 – Equipment segment specification relationship roles 86

Table 79 – Equipment segment specification attributes 87

Table 80 – Equipment segment specification property relationship roles 88

Table 81 – Equipment segment specification property attributes 88

Table 82 – Physical asset segment specification relationship roles 89

Table 83 – Physical asset segment specification attributes 89

Table 84 – Physical asset segment specification property relationship roles 90

Table 85 – Physical asset segment specification property attributes 91

Table 86 – Material segment specification relationship roles 91

Table 87 – Material segment specification attributes 91

Table 88 – Material segment specification property relationships 94

Table 89 – Material segment specification property attributes 95

Table 91 – Process segment parameter attributes 95

Table 92 - segment dependency relationship roles 96

Table 93 –Segment dependency attributes 96

Table 94 - Test model relationships 98

Table 95 – Realization of testable object / testable object property pair 98

Table 96 - Test specification relationship roles 99

Table 97 - Attributes of test specification 99

Table 98 - Test specification property relationship roles 100

Table 99 - Attributes of test specification property 101

Table 100 - Test specification criteria relationship roles 101

Table 101 - Attributes of test specification criteria 101

Table 102 - Evaluated property relationship roles 102

Table 103 - Attributes of evaluated property 102

Table 104 - Test result relationship roles 103

Table 105 - Attributes of test result 103

Table 106 – Property measurement relationship roles 104

Table 107 - Attributes of property measurement 104

Table 108 – Operations record model relationships 105

Table 109 - Operations record specification relationship roles 106

Table 110 - Operations record specification attributes 106

Table 111 - Operations record relationship roles 107

Table 112 - Operations record attributes 107

Table 113 – Operations record entry relationships 108

Table 114 – Operations record entry attributes 109

Table 115 – Operations record model relationships 110

Table 116 - Operations event class relationship roles 111

Table 117 - Attributes of operations event class 112

Table 118 – Example of operations event class locked hierarchy 112

Table 119 - Operations event class property relationship roles 113

Table 120 - Operations event class property attributes 113

Table 121 - Operations event class record specification relationship roles 113

Table 122 - Operations event class record specification attributes 114

Table 123 - Operations event definition relationship roles 116

Table 124 - Operations event definition attributes 117

Table 125 - Operations event definition property relationship roles 118

Table 126 - Operations event definition property attributes 119

Table 127 - Operations event definition record specification relationship roles 119

Table 128 - Operations event definition record specification attributes 120

Table 129 - Operations event relationship roles 122

Table 130 - Operations event attributes 122

Table 131 - Operations event property relationship roles 124

Table 132 - Operations event property attributes 125

Table 133 - Operations event record relationship roles 125

Table 134 - Operations event record attributes 125

Table 135 – Operations definition model relationships 128

Table 136 – Operations definition relationship roles 130

Table 137 – Operations definition attributes 130

Table 138 – Operations material bill relationship roles 132

Table 139 – Operations material bill attributes 132

Table 140 – Operations material bill item relationship roles 132

Table 141 – Operations material bill item attributes 133

Table 142 – Operations segment relationship roles 134

Table 143 – Operations segment attributes 135

Table 144 – Parameter specification relationship roles 136

Table 145 – Parameter specification attributes 136

Table 146 – Personnel specification relationship roles 137

Table 147 – Personnel specification attributes 137

Table 148 – Personnel specification property relationship roles 138

Table 149 – Personnel specification property attributes 139

Table 150 – Equipment specification relationship roles 139

Table 151 – Equipment specification attributes 140

Table 152 – Equipment specification property relationship roles 141

Table 153 – Equipment specification property attributes 142

Table 154 – Physical asset specification relationship roles 142

Table 155 – Physical asset specification attributes 143

Table 156 – Physical asset specification property relationship roles 144

Table 157 – Physical asset specification property attributes 144

Table 158 – Material specification relationship roles 145

Table 159 – Material specification attributes 145

Table 160 – Material specification property relationship roles 147

Table 161 – Material specification property attributes 148

Table 162 – Segment dependency relationship roles 148

Table 163 – Segment dependency attributes 148

Table 164 – Operations schedule model relationships 150

Table 165 – Operations schedule relationship roles 152

Table 166 – Operations schedule attributes 152

Table 167 – Operations request relationship roles 154

Table 168 – Operations request attributes 154

Table 169 – Segment requirement relationship roles 156

Table 170 – Segment requirement attributes 156

Table 171 – Segment parameter relationship roles 157

Table 172 – Segment parameter attributes 157

Table 173 – Personnel requirement relationship roles 158

Table 174 – Personnel requirement attributes 158

Table 175 – Personnel requirement property relationship roles 160

Table 176 – Personnel requirement property attributes 160

Table 177 – Equipment requirement relationship roles 161

Table 178 – Equipment requirement attributes 161

Table 179 – Equipment requirement property relationships 163

Table 180 – Equipment requirement property attributes 163

Table 181 – Physical asset requirement relationship roles 164

Table 182 – Physical asset requirement attributes 164

Table 183 – Physical asset requirement property relationship roles 166

Table 184 – Physical asset requirement property attributes 166

Table 185 – Material requirement relationship roles 167

Table 186 – Material requirement attributes 167

Table 187 – Material requirement property relationship roles 170

Table 188 – Material requirement property attributes 170

Table 189 – Operations performance model relationships 172

Table 190 – Operations performance relationship roles 174

Table 191 – Operations performance attributes 174

Table 192 – Operations response relationship roles 175

Table 193 – Operations response attributes 175

Table 194 – Segment response relationship roles 177

Table 195 – Segment response attributes 177

Table 196 – Segment data relationship roles 178

Table 197 – Segment data attributes 178

Table 198 – Personnel actual relationship roles 179

Table 199 – Personnel actual attributes 179

Table 200 – Personnel actual property relationship roles 181

Table 201 – Personnel actual property attributes 181

Table 202 – Equipment actual relationship roles 182

Table 203 – Equipment actual attributes 182

Table 204 – Equipment actual property relationship roles 183

Table 205 – Equipment actual property attributes 183

Table 206 – Physical asset actual relationship roles 184

Table 207 – Physical asset actual attributes 184

Table 208 – Physical asset actual property relationship roles 186

Table 209 – Physical asset actual property attributes 186

Table 210 – Material actual relationship roles 187

Table 211 – Material actual attributes 187

Table 212 – Material actual property relationship roles 189

Table 213 – Material actual property attributes 189

Table 214 – Operations capability model relationships 191

Table 215 – Operations capability relationship roles 192

Table 216 – Operations capability attributes 192

Table 217 – Personnel capability relationship roles 194

Table 218 – Personnel capability attributes 194

Table 219 – Personnel capability property relationship roles 197

Table 220 – Personnel capability property attributes 197

Table 221 – Equipment capability relationship roles 198

Table 222 – Equipment capability attributes 198

Table 223 – Equipment capability property relationships 201

Table 224 – Equipment capability property attributes 201

Table 225 – Physical asset capability relationship roles 202

Table 226 – Physical asset capability attributes 202

Table 227 – Physical asset capability property relationship roles 204

Table 228 – Physical asset capability property attributes 205

Table 229 – Material capability relationship roles 206

Table 230 – Material capability attributes 206

Table 231 – Material capability property relationship roles 209

Table 232 – Material capability property attributes 209

Table 233 – Operations capability model relationships 210

Table 234 – Process segment capability relationship roles 212

Table 235 – Process segment capability attributes 212

Table 236 – Operations segment capability model relationships 215

Table 237 – Operations segment capability relationship roles 216

Table 238 – operations segment capability attributes 217

Table 239 – Model cross-reference 219

Table 240 – Common resource objects 221

Table C.1 – Person attributes 228

Table C.2 – Database structure for person 231

Table C.3 – Database structure for person property 231

Table C.4 – Database for person with data 231

Table C.5 – Database for person property with data 232

Table E.1 – Definition of segment types 245

Table E.2 – Examples of materials and equipment 254

Table E.3 – Equipment and physical assets 255

Table 213 – Qualification test specification attributes 268

Figures

Figure 1 – Example, Production operations management information models 20

Figure 2 – Operations information models for operations management 21

Figure 3 – Example: UML Diagram for an information model, Personnel model 27

Figure 4 – Cross-model relationships to resource models 30

Figure 5 – Hierarchy scope model 39

Figure 6 – Example, WKT in 2D (3D is equally supported) 41

Figure 7 – Operational location model 41

Figure 8 – Personnel model 46

Figure 9 – Role based equipment model 51

Figure 10 – Physical asset model 57

Figure 11 – Physical asset and equipment relationships 58

Figure 12 – Material model 63

Figure 13 – Example of a material with an assembly 77

Figure 14 – Process segment model 78

Figure 15 – Segment dependency examples 95

Figure 16 - Test model 96

Figure 17 – Operations record model (abstract) 103

Figure 18 - Operations event model 108

Figure 19 - Relationship of operations event definition with operations events 114

Figure 20 – Operations definition model 126

Figure 21 – Operations schedule model 148

Figure 22 – Operations performance model 170

Figure 23 – Operations capability model 188

Figure 24 – Process segment capability object model 208

Figure 25 – Operations segment capability object model 213

Figure 26 – Object model inter-relationships 217

Figure C.1 – Personnel model 226

Figure C.2 – Instances of a person class 227

Figure C.3 – UML model for class and class properties 227

Figure C.4 – Class property 228

Figure C.5 – Instances of a person properties 228

Figure C.6 – Instances of person and person properties 228

Figure C.7 – XML schema for a person object 231

Figure C.8 – XML schema for person properties 231

Figure C.9 – Example of person and person property 232

Figure C.10 – Example of person class information 232

Figure C.11 – Adaptor to map different property IDs and values 232

Figure E.1 – Class and property IDs used to identify elements 245

Figure E.2 – A property defining overlapping subsets of the capability 247

Figure E.3 – Routing for a product 248

Figure E.4 – Routing with co-products and material dependencies 249

Figure E.5 – Product and process capability relationships 250

Figure E.6 – Time-based dependencies 251

Figure E.7 – Mixed operation example 254

Figure F.1 – Enterprise to manufacturing system abstract information flows 256

Figure F.2 – Abstract information flows among multiple systems 257

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ENTERPRISE-CONTROL SYSTEM INTEGRATION –

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

ed3 – CD01

# 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 and attributes of common information defined in Part 1.

Clause 6 is normative. It defines the object models 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.

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

Annex C is informative. It illustrates some example data sets.

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

Annex E is informative. It discusses how the standard relates to abstract information flows.

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

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

# INTRODUCTION

The primary updates in Part 2 CD01 are listed below. They have been incorporated through WD01-WD04 over 2 years of comments and discussion during quarterly committee meetings.

1. 4 new models:
   1. Operations Event Model for L3 Pub-Sub Reliable Messaging & Ex. Annex
   2. Operations Record Model aligns Operations Event Record & Work Record
   3. Test Model aligns with OAGIS BOD & Example Appendix
   4. Operational Location Model
2. Planning-Job Order State Model w/ Request/Response Definitions & Ex. Annex
3. Alignment of Updated Operations/Work Capability Definitions & Models
4. Explicit UML Relationship and Role Tables & Annex Examples
5. Hierarchy Scope attribute on Resource objects for context of Plans & Actuals
6. Alignment of Schedules, Actuals & Operations/Work Definitions & Models
   1. Operations Segment to Work Master
   2. Operations Segment to Segment Requirement
   3. Operations Segment to Segment Response
   4. Segment Requirement to Segment Response
   5. Segment Requirement to Job Order
   6. Work Master to Work Request
   7. Work Master to Job Response
   8. Job Order to Work Directive
   9. Workflow Specification to Job Response
7. Updated Cross-Model Relationship Method for Resource Models
8. Updated Confidence Factor attribute aligns w/ OAGIS & Best Practice

9. Updated Capability type attribute and defined values.

10. New Definition Type attribute for Operations & Work Definitions

11. New ID attribute for (Resource) Segment Specification & Specification objects aligns with B2MML

12. Material Use attribute: Updated Defined Value Definitions

13. New Material Lot Disposition attribute w/ Defined Value Definitions

14. New Posting Date attribute

15. New Spatial Definition attribute

This part of ISA-95.00.02 further defines formal object models for exchange information described in ISA-95.00.01 using UML object models, tables of attributes, and examples. The models and terminology defined in this part of ISA-95:

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 ISA-95 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

This part of ISA-95 specifies generic 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 ISA 95.00.01. 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 in 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 generic interface, together with a mechanism for extending those elements for implementations.

# The scope of ISA-95.00.02 is limited to the definition of object models and attributes of the exchanged information defined in ISA-95.00.01.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, the latest edition of the 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 and abbreviations

## Terms and definitions

For the purposes of this document, the terms and definitions given in ISA 95.00.01, 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

location

scope of exchanged information as identified by an element of the equipment hierarchy

EXAMPLE There can be an agreement to only supply an “Area” name for exchanged information, because the site and enterprise are implicitly defined through the messaging system

material class

grouping of materials with similar characteristics

material lot

uniquely identifiable amount of a material

NOTE 1 to entry It describes the actual or planned total quantity or amount of material available, its current state, and its specific property values.

material definition

definition of a material type and type properties

NOTE 1 to entry This includes material that can be identified as raw, intermediate, final material, or consumable.

material sublot

uniquely identifiable subset of a material lot

NOTE 1 to entry This can be a single item.

personnel class

grouping of persons with similar characteristics

product

desired output of an operations process

NOTE 1 to entry A product can be an intermediate product or end product from a business perspective.

NOTE 2 to entry 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.

**MOM** Manufacturing Operations Management

**UML** Unified Modeling Language

# Production operations models and generic operations models

## Information models

Information models in Figure 1 define a common way of representing information that can be exchanged between different activities. They define the objects that can be used to represent information, attributes of the objects, and relationships of objects in the exchange models.



Figure 1 – Example, Production operations management information models

A generic operations management information model is used to represent the information that can be exchanged between operations activities and business activities. This is illustrated in Figure 2 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 2 – Operations information models for operations management

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

The common information object models in Clause 5 describe the different types of resources and their uses in describing a (business) *process segment*. These object models are also used to describe the other (manufacturing) operations management information object models in Clauses 6, 7 and 8.

NOTE 1 The operations management information object models described in this part 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 object 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;
* user-defined operations.

## General information model characteristics

### Minimum attribute sets

Clause 5 describes the methods used to define object models and attributes for information exchanged between Level 3 activities. The attributes are part of the definition of object models for exchanged information and terms.

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

A minimum set of industry-independent information has been defined as attributes. However, values for all attributes may not be required depending on the actual usage of the models. If additional information, including industry- and application-specific information, is needed, it shall be 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.

NOTE This was written to make the standard as widely applicable as practical.

### Attribute extensibility

For particular applications, the objects defined in the object models will be extended through the addition of attributes to object class definitions. Accordingly, this standard provides for attributes that are application or industry specific, to be modeled in terms of properties and represented in property classes in the model.

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

This subclause describes the information object models and attributes for information exchanged in enterprise-control system integration. The attributes are part of the

## Information object model structure

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.

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. For example, 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 1    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 2    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 model provides a view into object lifecycles at the time of an information exchange.

### Object relationships in abstract information models and implementation models

ISA-95 information models represent exchanged data in an abstract UML model using

1. Objects
2. Attributes of objects
3. Relationships and roles between objects

NOTE 1 Abstract model, a conceptual abstract overview of the structure of data. An abstract 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 2 ISA-95 abstract information models can be represented as a logical model schema for the specific purpose to formally documents the contents of the abstract models.

NOTE 3 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

ISA-95 abstract information models differ from the logical models typically used by IT groups in application development. Logical models in application development focus on a specific target. ISA-95 abstract models are generic models so they can be applied across many industries and applications. As such the ISA-95 abstract 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 Implementation model, an interpretation / instance of the abstract model relevant as specific implementation scope. An implementation model applies rules and requirements to the abstract model to develop a model implemented with a specific exchange technology.

The data shown in the abstract ISA-95 UML models may be implemented as a subset, specialization or extension of those models. The relationship between the abstract ISA-95 UML and 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 (primary keys, secondary keys)
  5. Intermediate objects / link objects (e.g. Many to many tables)

NOTE 1 Implementation models may 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 ISA-95 abstract objects and UML models apply various technical methods to represent the object relationships presented in the ISA-95 abstract model.

EXAMPLE 1 ISA-95 object relationships 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 2 An ISA-95 implementation model is the Business-to-manufacturing-markup-language (B2MML) from MESA International.

The abstract to implementation model transformation process from ISA-95 abstract models 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 mode.

Implementation models may constrain ISA-95 logical model object relationships by applying additional constraints to the abstract ISA-95 logical models. The abstract ISA-95 models and associated relationship and role tables present information which may not be relevant to specific implementation models. The object lifetime and navigation information is typically required in a persistent store but is not required for a specific information exchange interpretation. Navigation constraints are applied to ISA-95 undefined navigations. Even though individual message payloads have no navigation and lifetime semantics applied, the ISA-95 information models 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 ISA-95 relationships vary depending on the implementation technology applied and implementation requirements. The related object naming conventions and relationship types in ISA-95 object relationship tables 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 ISA-95. 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 ISA-95 abstract model to an implementation model. Annex G shows typical implementation model examples. Annex H shows descriptions of typical implementation technologies.

NOTE 1 In the message payloads, the object relationship is either as contained objects or external references using reference ID values. The reference ID values may 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 2 If the transaction processing logic within the sender and receiver applications require navigation persistence, the message payload may require relationship attributes for the object relationships to aid in message processing.

ISA-95 abstract UML models are independent of the implementation models. Implementation models are classified by two categories representing application of ISA-95 models. 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 ISA-95 models, which can be part of messaging infrastructure or at application level in systems. This category of system receives and generate ISA-95 transactions with minimal additional translation between the message and the store’s meta data. ISA-95 objects are created, updated and deleted with ISA-95-based transactions. The persistence technology uses a storage model to implement the relationship rules.

EXAMPLE 1 Storage models relational, associative, object, semantic, graph, triple store.

In a message or information exchange, object lifetimes and navigation are defined by the object relationship and role tables represented in ISA-95. 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 ISA-95 models. 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 2

* Hierarchical (Nested XML)
* Flat (Flat buffers, flat XML, csv)
* Object (OMG - IDL), JSON

### Conventions used in tables of object relationships and roles

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

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

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. The generic specification may 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. The relationship table identifies the details of whether the relationship attribute is required or optional in the object. A dashed line indicates a weak association between objects.

EXAMPLE 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 an 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 may be required to be satisfied before the object can be created.
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 may 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 may be both a whole and part object (e.g. equipment hierarchy). This infers that implementations may 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.
6. 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 may be refined with the following keywords:
7. Whole The object is the whole object in the composition.
8. Part The object is the part object in the composition.
9. Hierarchy The objects may be both a whole and part object (e.g. material lot hierarchy). Implementations may utilize 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.

EXAMPLE The UML diagram of personnel model in Figure 3 below in combination with the associated relationship table in Table 2 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.

NOTE The “>” symbol on either end of the relationship name indicts the direction of the predominate relationship direction.

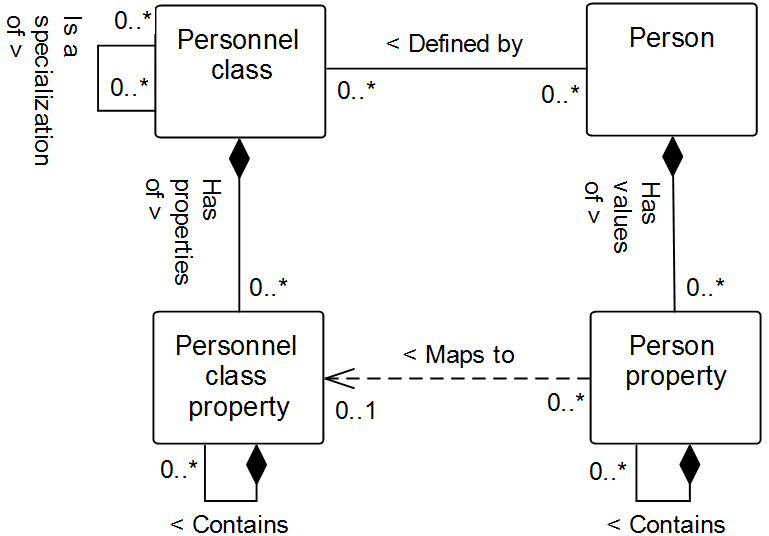


Figure 3 – Example: UML Diagram for an information model, Personnel model

Table 2 – 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 | Is a specialization of > |
| Person | Personnel class | Association | Defined by > |

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.

NOTE 1 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 may use to identify the related object).
3. Multiplicity The multiplicity in UML diagram that specifies cardinality - i.e. number of elements - of some collection 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.
4. Description The description of the object’s relationship.

EXAMPLE The example for role table for the personnel class object in the example of the UML diagram of personnel model is shown in Table 3.

Table 3 – Example: Relationship role table, Personnel class relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Personnel class | Personnel class | 0..\* | The *personnel class* is part of the related object as the whole. |
| Personnel class property | Personnel class property | 0..\* | The *personnel class properties* of this *personnel class*. |
| Person | NA | 0..\* | The *person* objects support this *personnel class.*  The *person* objects support the *personnel class property(s)* associated with this *personnel class*. |

### Conventions used in table of object attributes

#### Tables of object attributes

This subclause gives the meaning of the object attribute tables. This includes a listing of the object identification, data types, 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 shall be considered optional, except where specified as required in the attribute description.

#### Object identification

Many objects in the information model require unique identifications (IDs). These IDs shall be unique within the scope of the exchanged information.

NOTE This may require translations:

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

EXAMPLE 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 shall be agreed for an information exchange.

The object IDs are used only to identify objects within related exchanged information sets. The object ID attributes may be global object IDs or database index attributes.

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

#### Data types

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

NOTE Specific implementations of this part should 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.

#### Presentation of examples

Examples are included with each attribute given. Examples are presented for each of the main operations categories defined in ISA 95.00.01. Table 4 shows how the attribute example rows and columns are used.

Table 4 – 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. No attempt was made 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. For example, 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 attributes are meant to be illustrative, and do not imply requirements.

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

Data resolution used in the examples are typical examples.

NOTE 1 Specific implementations of this part should specify the data resolution required for each attribute.

NOTE 2 . 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>.

### Association relationships between object models and supporting resource models

The simplified ISA-95 UML model uses the ISA-95 cross-model relationship method to simplify the representation of the four possible associations between an object in any ISA-95 UML object model and an associated object in a resource object model. The simplified ISA-95 UML model does not fully document the possible cross-model relationships; thereby, the cross-model relationship method does not conform to the Unified Modeling Language (UML) notational methodology as defined in ISO/IEC 19501.

The simplified ISA-95 UML techniques are intended as a visualization method that must be used in combination with the object attribute tables, object model relationship table, and object role tables for an explicit definition of the abstract ISA-95 information exchanges supported by compliant integration implementations.

Figure 4 illustrates cross-model relationship method in the simplified ISA-95 UML model in the left column compared to the detailed relationships per the ISO/IEC 19501 compliant UML model in the right column.

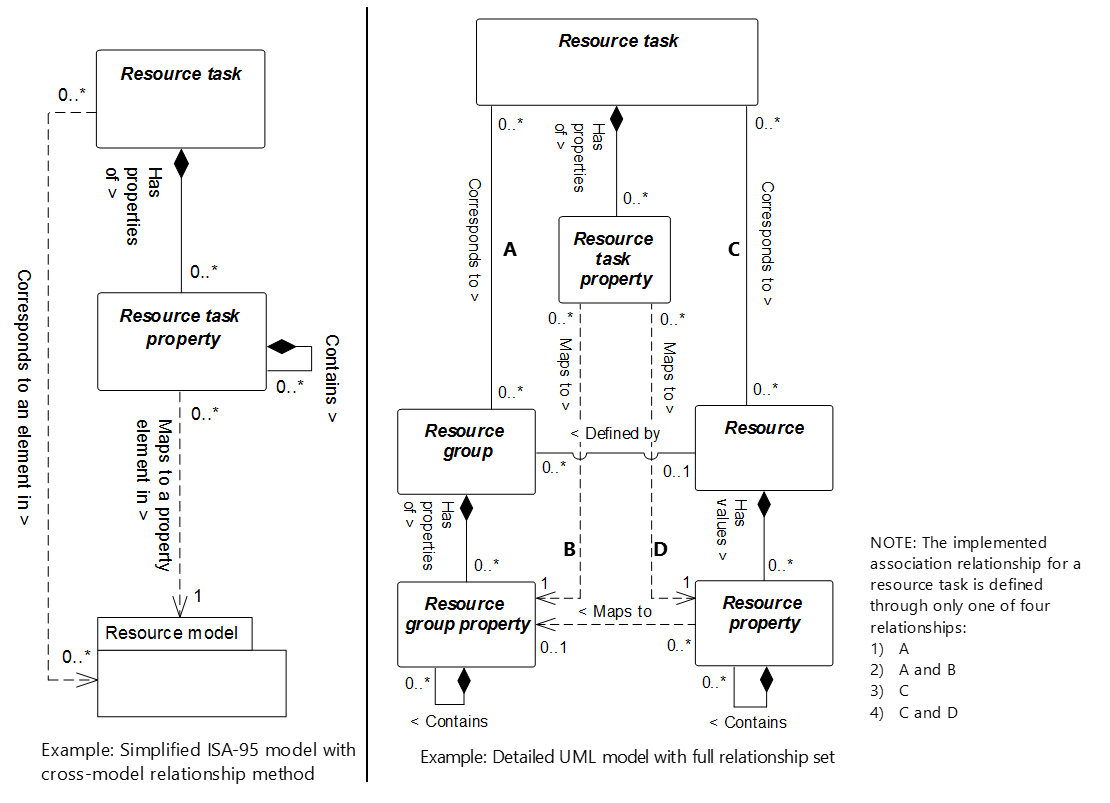


Figure 4 – Cross-model relationships to resource models

NOTE Reference terms for resource objects in Figure 4 are

1. *resource task* includes the resource task objects listed in Table 5,
2. *resource group* includes *personnel class, equipment class, physical asset class, material class, and material definition objects,*
3. *resource* includes *person, equipment, physical asset, material lot and material sublot objects.*

Table 5 lists the object relationships in the detailed UML model example in Figure 4.

Table 5 – Detailed UML model relationships in Figure 4

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Resource task | Resource group | Association (A) | Corresponds to > |
| Resource task | Resource | Association (C) | Corresponds to > |
| Resource task property | Resource group property | Dependency (B) | Maps to > |
| Resource task property | Resource property | Dependency (D) | Maps to > |
| Resource task | Resource task 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 | May contain nested > |
| Resource group property | Resource group property | Composition hierarchy | May contain nested > |

Table 6 provides the reference labels for each of the four possible cross-model relationships shown in Figure 4 for an implemented *resource task* instance such as Mixer 101 as an *equipment* object*.*

1. Only one of the four possible relationships are permitted for a given *resource task* instance.
2. The paired relationships, Label A with B and Label C with D, shows that a *resource task* 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 task* only references a resource model property if the property's parent object has an association relationship (A or D) with the *resource task*.

Table 6 – Four possible cross-model relationships for a *resource task* instance

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

Table 7 lists the ISA-95 models applying the simplified ISA-95 cross-model relationship method and defines the set of possible resource relationships for objects within each model.

Table 7 – List of ISA-95 models and their permitted resource object instances in cross-model relationships to resource models

| ISA-95 Model | *Resource task* | 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 8 to Table 13 provide the role table for the following reference objects contained in the detailed UML model in Figure 4: Resource task, resource task property, resource group, resource group property, resource, and resource property.

Table 8 – Resource task cross-model relationship roles

|  |  |  |  |
| --- | --- | --- | --- |
| Related Object | Role | Multiplicity | Description |
| Resource group (A) | Resource group | 0..\* | The *resource group(s)* support this *resource task*.  The *resource group(s)* support the *resource task* *property(s)* associated with this *resource task*. |
| Resource (C) | Resource | 0..\* | The *resource(s)* support this *resource task*.  The *resource(s)* support the *resource task* *property(s)* associated with this *resource task*. |
| Resource task property | Resource task property | 0..\* | The *resource task property(s)* defining in part this *resource task.* |
| EXAMPLE Personnel segment specification cross-model association relationships to personnel model | | | |
| Personnel class (A) | Personnel class | 0..\* | 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..\* | The *resource group(s)* support this *resource task*.  The *resource group(s)* support the *resource task* *property(s)* associated with this *resource task*. |

Table 9 – Resource task property cross-model relationship roles

|  |  |  |  |
| --- | --- | --- | --- |
| **Related Object** | **Role** | **Multiplicity** | **Description** |
| Resource group property (B) | Resource group property | 1 | This *resource task property* defined by the *resource group property*. |
| Resource property (D) | Resource property | 1 | This *resource task property* defined by the *resource property*. |
| Resource task | NA | 1 | This *resource task property(s)* of the *resource task.* |
| **EXAMPLE Personnel segment specification cross-model association relationships to personnel model properties** | | | |
| Personnel class property (B) | Personnel class property | 1 | 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 | 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** | **Role** | **Multiplicity** | **Description** |
| Resource task (A) | NA | 0..\* | The *resource task* related to this *resource group*. |
| Resource | NA | 0..\* | The *resource* defined by this *resource group.* |
| Resource group property | Resource group property | 0..\* | The *resource group property(s)* of this *resource group property.* |
| **EXAMPLE Personnel segment specification cross-model association relationships with personnel class** | | | |
| Personnel segment specification (A) | NA | 0..\* | 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 | NA | 0..\* | 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** | **Role** | **Multiplicity** | **Description** |
| Resource task property (B) | NA | 1 | The *resource task property* related to this *resource group property*. |
| Resource group | NA | 1 | The *resource group* defined in part by this *resource property*. |
| Resource property | NA | 0..1 | The *resource property* defined by this *resource group property.* |
| Resource group property | Resource group property | 0..\* | The *resource group property(s)* of this *resource group property.* |
| **EXAMPLE Personnel class property cross-model association relationships with a personnel segment specification property** | | | |
| Personnel segment specification property (B) | NA | 1 | 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..\* | 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** | **Role** | **Multiplicity** | **Description** |
| Resource task (C) | NA | 0..\* | This *resource* related to the *resource task*. |
| Resource group | Resource group | 0..1 | This *resource* defined by the resource group |
| Resource property | Resource property | 0..\* | The *resource property(s)* containing the values of this *resource.* |
| **EXAMPLE Personnel segment specification cross-model association relationships with a person** | | | |
| Personnel segment specification (C) | NA | 0..\* | 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..\* | 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** | **Role** | **Multiplicity** | **Description** |
| Resource task property (D) | NA | 1 | The *resource task property* related to this *resource group property*. |
| Resource | NA | 1 | The *resource* contains the values of this *resource property(s)*. |
| Resource group property | Resource group property | 0..1 | This *resource property* defined by the *resource group*. |
| Resource property | Resource property | 0..\* | The *resource property(s)* of this *resource property.* |
| **EXAMPLE Person property cross-model association relationships with a personnel segment specification property** | | | |
| Personnel segment specification property (D) | NA | 1 | 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 | 1 | 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*. |



## Value types

### Value use

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, and ranges of possible values, either as numerical or textual ranges or as sets of values. Simple value types

Simple value types in Table 14 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 (e.g. the meaning of a quantity, currency, amount, and identifier).

Table 14 – 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. For example, “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 (i.e. a finite set of characters) generally in the form of words of a language. |

### Unit of measure

This standard defines attributes for value, quantity, and other units of measure. The unit of measure was explicitly specified to ensure that it was not missed in information exchanges. Implementations of this standard may represent the unit of measure in the manner appropriate for the implementation.

### Array value types

Arrays of values may be represented following the syntax defined in the EBNF above.

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 the EBNF above.

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’s property model by representing the atomic elements of the structure in a flattened name space, or by using nested properties to represent the data structure.

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

A structure may be modeled by flattening the name space and having a single property for each structure element.

NOTE 2   This standard specifies how to exchange information without regard to the specific exchange element’s mapping. With structured elements, there is 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 1 A structured element of data would 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 2 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 3 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.

## Expression of measurement uncertainty

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.

Measurement uncertainty for a measurand Y, can be expressed for a specified level of confidence, p, 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 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 may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand. The fraction may 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]
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 1 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 may 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 2 Practical methods for the expression of measurement uncertainty where the probability distribution function is asymmetric are provided in ISO/IEC Guide 98-3.

The exchange of measured quantity values, y, are supported in this standard using value and/or quantity attributes with a type of MeasureType or QuantityType of objects within the ISA-95 information models. All value and quantity attributes defined in this standard may be subject to measurement uncertainty. All value and quantity attributes contain the following sub-attributes:

1. level of confidence, p;
2. expanded uncertainty, U; and
3. coverage factor, k.
4. precision
5. accuracy

Implementations are required to support the inclusion of one or more sets of values for the sub-attributes p, U, and k so that multiple levels of confidence can be exchanged for any given value or quantity 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 p value of 95%, U value of 10 widgets/hour and k value of 2. The second set has a p 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%.

# Common object models

## Hierarchy scope

The hierarchy scope attribute 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 attribute is optional and 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. A *Operations Capability* can have a Hierarchy Scope attribute that identifies the area.

EXAMPLE 3 Ahierarchy 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.

The hierarchy scope attribute may be modeled using the model illustrated in Figure 5 with attributes for the *hierarchy scope* object defined in Table 15. Each *hierarchy scope* object defines one element in the equipment hierarchy,



Figure 5 – Hierarchy scope model

Table 15 – 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)
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 optional and is not needed if there is no requirement for exchanging geospatial location information.

The spatial definition attribute may be modelled using attributes defined in Table 16.

Table 16 – Attributes of spatial definition

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Value | A string serialization  EXAMPLE 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 EPSG (see <http://www.epsg-registry.org/>).  An organization may choose to define its own *SRIDs* – i.e. be its own authority. | EPSG | EPSG | EPSG | EPSG |

NOTE Format attribute options 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 Version 2.2 is defined by the Open Geospatial Consortium (OGC) and used for the visualization of geographic information.
5. GPX GPX,1.1 schema (GPS Exchange Format) 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.
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 serialise 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 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).

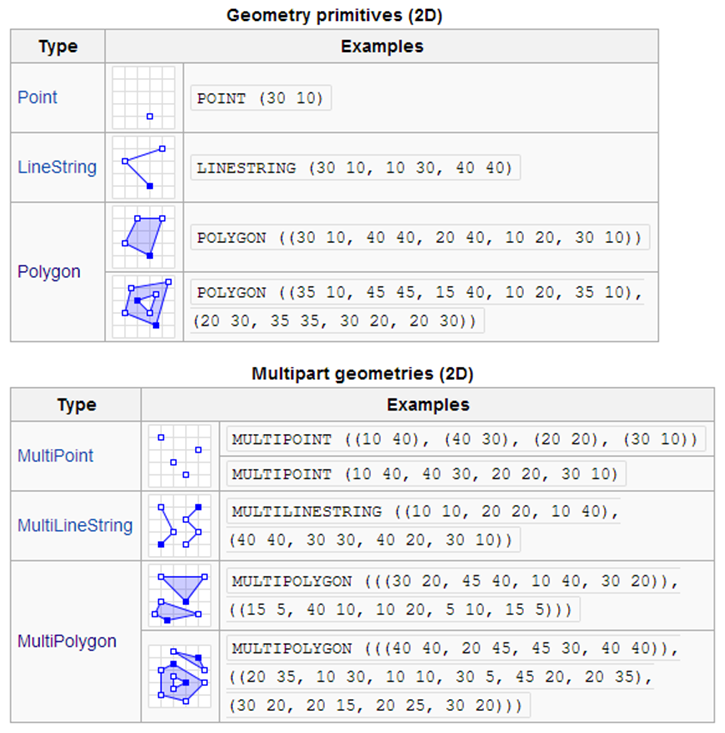


Figure 6 – Example, WKT in 2D (3D is equally supported)

## Operational location model

The operational location model shown in Figure 7 contains the information about specific *operational* *locations* and classes of *operational* *locations*. Table 17 lists the relationships of the objects in the operational location model.

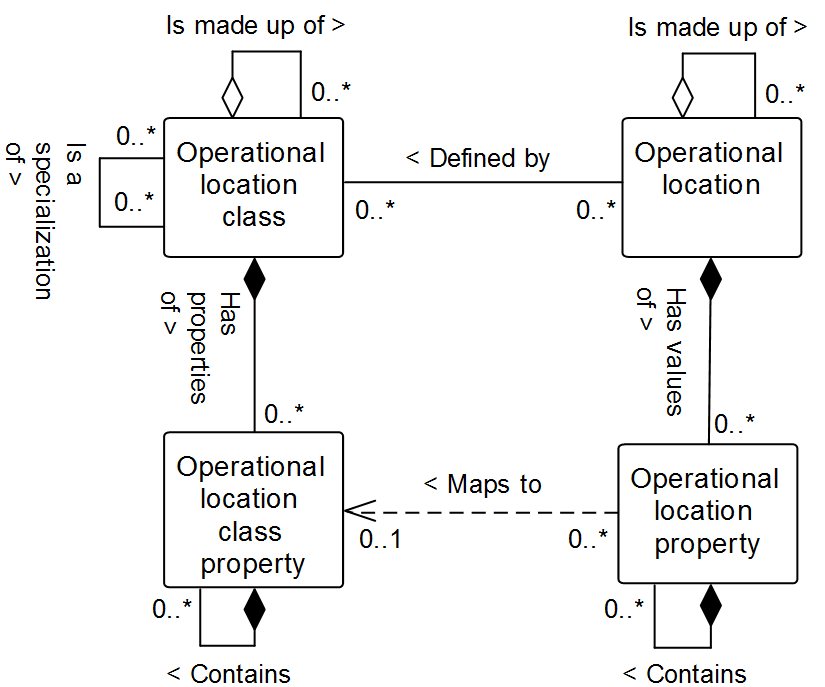


Figure 7 – Operational location model

Table 17 – 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 | Is a specialization 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 > |

*Operational locations* define the logical or physical places in which resources may 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*.

An *operational location* may specify a spatial definition, 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 and/or it may have a corresponding *operational location*, which in turn may specify a spatial definition.

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* may be stored in a wagon, represented as a *physical asset*.

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

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

EXAMPLE 4 A *material lot* or *sublot* may 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. 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 5.8.1 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*.

NOTE Examples of *operational location classes* are 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 18 lists the relationship roles of the *operational location class*. Table 19 lists the attributes of the *operational location class.*

Table 18 – Operational location class relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operational location class | Operational location superclass | 0..\* | The *operational* *location classes* of which this *operational location class* is a specialization*.* |
| Operational location class | Contained operational location class | 0..\* | The child *operational location classes* contained within this *operational location class*. |
| Operational location class property | Operational location class property | 0..\* | The *operational location class* *properties* of this *operational location class*. |

Table 19 – 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*. | 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 defines the scope of the *operational location class*, such as the site or area it is defined for. | 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 properties. An operational location class property may contain nested operational location class properties. An operational location class property may have zero or more operational location properties mapping to it.

Table 20 lists the relationship roles of the *operational location class property*. Table 21 lists the attributes of the *operational location class property.*

Table 20 – Operational location class property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operational location class property | Operational location class property child | 0..\* | The child *operational location class properties* of this *operational location class property*. |
| Operational location property | n/a | 0..\* | The *operational location properties* mapping to this *operational location class property*. |

Table 21 – 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*. | 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, if applicable. | n/a | n/a | n/a | n/a |
| Property type | Defines the type of the property. The 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.  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* may be located shall be presented as an *operational location*. *Operational locations* may be made up of other *operational locations*.

NOTE Examples of *operational locations* are bin 28, hatch 3 and stockpile footprint A1.

Table 22 lists the relationships roles of an *operational location*. Table 23 lists the attributes of an *operational location*.

Table 22 – Operational location relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operational location class | Operational location class | 0..\* | The *operational location classes* to which this *operational location* belongs*.* |
| Operational location | Operational location child | 0..\* | The child *operational locations* contained within this *operational location*. |
| Operational location property | Operational location property | 0..\* | The *operational location properties* of this *operational location*. |

Table 23 – 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*. | 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 defines the scope of the *operational location*, such as the site or area it is defined for. | 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 24 lists the relationship roles of an *operational location property*. Table 25 lists the attributes of an *operational location property*.

Table 24 – Operational location property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operational location property | Operational location property child | 0..\* | The child *operational location properties* of this *operational location property*. |
| Operational location class property | n/a | 0..1 | The *operational location class property* to which this *operational location class property* maps. |

Table 25 – 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*. | 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, if applicable. | kT | n/a | n/a | n/a |

## Personnel information

### Personnel model

The personnel model shown in Figure 8 contains the information about specific personnel, classes of personnel, and qualifications of personnel. Table 26 lists the relationships of the objects in the personnel model.

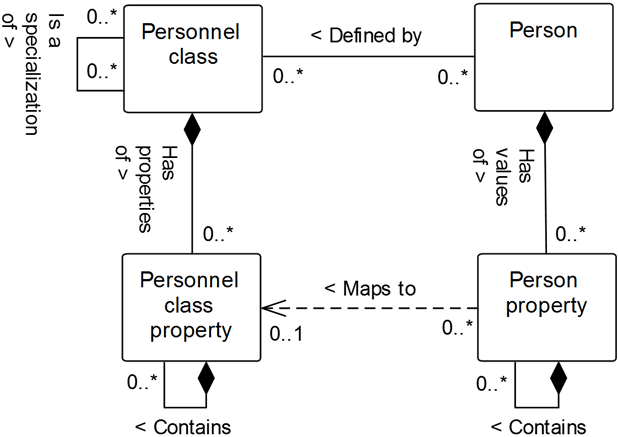


Figure 8 – Personnel model

Table 26 – Personnel model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Personnel class | Personnel class property | Composition | Has properties of > |
| Personnel class | Personnel class | Association | Is a specialization 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

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 a *test specification*.

Table 27 lists the relationship roles of the *personnel class*. Table 28 lists the attributes of the *personnel class.*

NOTE  Examples of *personnel classes* are cook machine mechanics, slicing machine operators, cat-cracker operator, and zipper line inspectors.

Table 27 – Personnel class relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Personnel class | Personnel class | 0..\* | The *personnel class* is part of the related object as the whole. |
| Personnel class property | Personnel class property | 0..\* | The *personnel class properties* of this *personnel class*. |
| Person | NA | 0..\* | The *person* objects support this *personnel class.*  The *person* objects support the *personnel class property(s)* associated with this *personnel class*. |

Table 28 – 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 defines the scope of the *personnel class* definition, such as the site or area it is defined for. | 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. Table 14 lists the attributes of the *personnel class property* object*.*

NOTE Examples of *personnel class properties* for the *personnel class* operators are 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 by the evaluation of a *test specification*. Personnel class properties may contain nested personnel class properties. *Personnel class properties* may contain nested *personnel class properties*.

Table 29 lists the relationship roles of the *person class property.* Table 30 lists the attributes of the *person class property.*

Table 29 – Personnel class property relationship roles

| Related Object | Role | Multiplicity | Descriptions |
| --- | --- | --- | --- |
| Personnel class | NA | 1 | The *personnel class* defined in part by this *personnel class property.* |
| Personnel class property | Personnel class property | 0..\* | The nested *personnel class property(s)* makes up part of this *personnel class property* as the whole. |
| Person property | NA | 0..\* | If the parent *person* supports 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.* |

Table 30 – 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.  For example, 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 |
| 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, if applicable. | 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 a *test specification*. *Person* shall include a unique identification of the individual.

Table 31 lists the relationship roles of *person.* Table 32 lists the attributes of *person.*

Table 31 – Person relationship roles

|  |  |  |  |
| --- | --- | --- | --- |
| Related Object | Role | Multiplicity | Description |
| Personnel class | Personnel class | 0..\* | *Personnel classes* supported by this *person.*  This *person* supports the *personnel class property(s)* associated with the *personnel class.* |
| Person property | Person property | 0..\* | The *person property* values of this *person*. |

Table 32 – 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 shall be 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 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* may specify both a spatial definition and an operational location 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*.

NOTE For 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 by the evaluation of a *test specification* with test results exchanged in a *test result*.

*Person properties* may contain nested *person properties*.

Table 33 lists the relationship roles of the *person property.*  Table 34 lists the attributes of the *person property.*

Table 33 – Person property relationship roles

|  |  |  |  |
| --- | --- | --- | --- |
| **Related Object** | **Role** | **Multiplicity** | **Description** |
| Person | NA | 1 | This *person property* values in part for the *person*. |
| Person property | Person property | 0..\* | This nested *person property(s)* is part of the *person property* as the whole. |
| Personnel class property | Personnel class property | 0..\* | 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*. |

Table 34 – Person property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property. | 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, if applicable. | 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 35 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 ISA 95.00.01. The model contains the information that may be used to construct the hierarchical models used in manufacturing scenarios. For purposes of corresponding to the ISA 95.00.01 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.

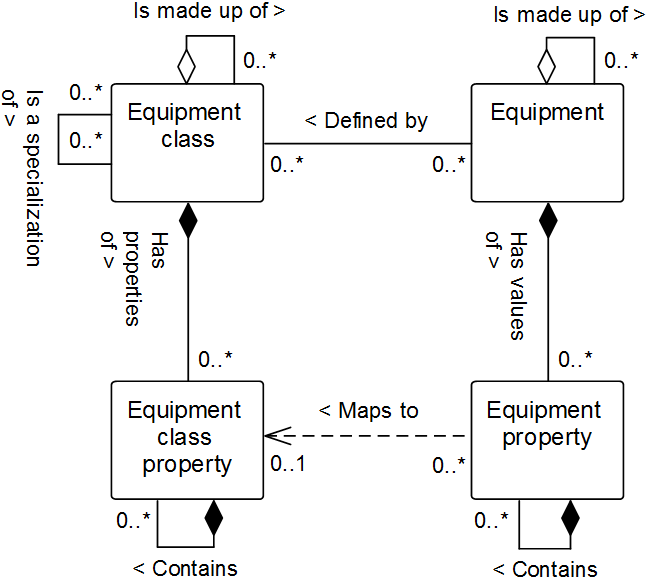


Figure 9 – Role based equipment model

Table 35 – Role based equipment model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Equipment class | Equipment class property | Composition | Has properties of > |
| Equipment class | Equipment class | Association | Is a specialization of > |
| Equipment | Equipment class | Association | Defined by > |
| Equipment | Equipment property | Composition | Has values 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

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 a *test specification*.

NOTE Examples of *equipment classes* are reactor unit, bottling line, and horizontal drill press.

Table 36 lists the relationship roles of the *equipment class.* Table 37 lists the attributes of the *equipment class.*

Table 36 – Equipment class relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Equipment class | Equipment superclass | 0..\* | The *equipment classes* of which this *equipment class* is a specialization*.* |
| Equipment class | Contained equipment class | 0..\* | The child *equipment classes* contained within this *equipment class*. |
| Equipment class | Equipment class | 0..\* | This *equipment class* is part of the related object as the whole. |
| Equipment class property | Equipment class property | 0..\* | The *equipment class properties* of this *equipment class*. |
| Equipment | NA | 0..\* | The *equipment* objects support this *equipment class.*  The *equipment* objects support the *equipment class property(s)* associated with this *equipment class*. |

Table 37 – 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*, …)  The ID shall be 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 defines the scope of the *equipment class*, such as the site or area it is defined for. | 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.

*Equipment* may be tested by the execution of a *test specification*.

*Equipment class properties* may contain nested *equipment class properties*.

NOTE Examples of *equipment class properties* for the *equipment class* reactor unit can be lining material, BTU extraction rate, and volume.

Table 38 lists the relationship roles of the *equipment class property.* Table 39 lists the attributes of the *equipment class property.*

Table 38 – Equipment class property relationship roles

| Related Object | Role | Multiplicity | Descriptions |
| --- | --- | --- | --- |
| Equipment class | NA | 1 | The *equipment class* defined in part by this *equipment class property.* |
| Equipment class property | Equipment class property | 0..\* | The nested *equipment class property(s)* makes up part of this *equipment class property* as the whole. |
| Equipment property | NA | 0..\* | 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.* |

Table 39 – Equipment class property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property. | 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 |
| 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, if applicable. | 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 sites, areas, production units, production lines, work cells, process cells, units, storage zones or storage units.

*Equipment* may be tested by the execution of a *test specification*.

*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 40 lists the relationship roles of the *equipment.* Table 41lists the attributes of the *equipment.*

Table 40 – Equipment relationship roles

|  |  |  |  |
| --- | --- | --- | --- |
| Related Object | Role | Multiplicity | Description |
| Equipment class | Equipment class | 0..\* | *Equipment classes* supported by this *equipment.*  This *equipment* supports the *equipment class property(s)* associated with the *equipment class.* |
| Equipment property | Equipment property | 0..\* | The *equipment property* values of this *equipment.* |
| Equipment | Equipment | 0..\* | The related object(s) makes up part of this *equipment* as the whole. |
| Equipment asset mapping | NA | 0..\* | The *equipment asset mapping* records the uses of the *equipment* performing the manufacturing function. |
| Physical asset | Physical asset | 0..1 | This *equipment* as role in a *process segment* is implemented by the *physical asset.* |

Table 41 – 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).  The equipment ID shall be 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 defines the scope of the *equipment definition*, such as the site or area it is defined for. | 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* may specify both a spatial definition and an *operational location* 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 by the evaluation of a *test specification* with results exchanged in a *test result*.

*Equipment properties* 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  Examples of *equipment properties* are

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

Table 42 lists the relationship roles of an *equipment property*. Table 43 lists the attributes of an *equipment property.*

Table 42 – Equipment property relationships

|  |  |  |  |
| --- | --- | --- | --- |
| **Related Object** | **Role** | **Multiplicity** | **Description** |
| Equipment | NA | 1 | These *equipment property* values in part for the *equipment*. |
| Equipment property | Equipment property | 0..\* | The nested *equipment property(s)* makes up part of this *equipment property* as the whole. |
| Equipment class property | Equipment class property | 0..\* | 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 e*quipment class property*. |

Table 43 – Equipment property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property. | 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, if applicable. | 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 TAGs, 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 The *physical asset* can be replaced (e.g. because it is broken) 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, this part of ISA-95 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 this part of ISA-95; 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 44 lists the relationships of the objects in the physical asset model.

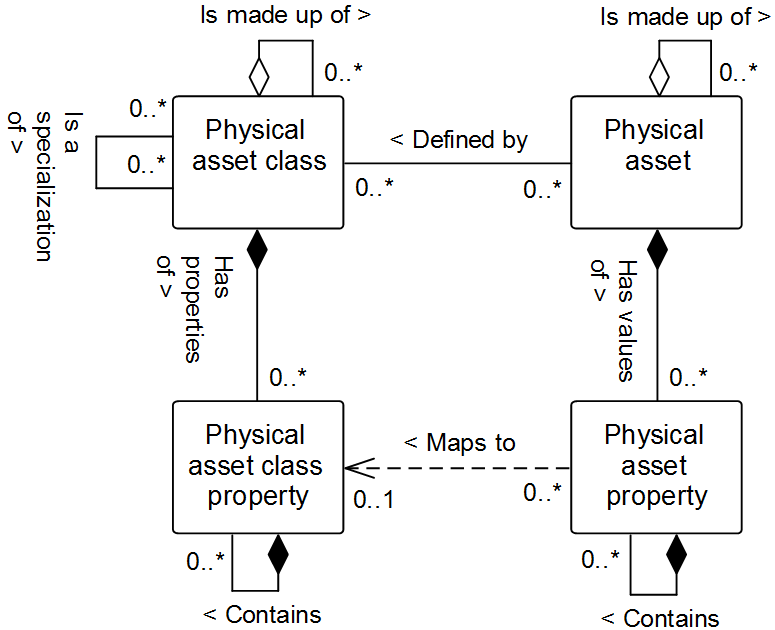


Figure 10 – Physical asset model

Table 44 – Physical asset model relationships

| From |  | To | Type | Relationship Name |
| --- | --- | --- | --- | --- |
| Physical asset class |  | Physical asset class property | Composition | Has properties of > |
| Physical asset class |  | Physical asset class | Association | Is a specialization 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 > |

The relationship between the *physical asset* information and the *equipment* information is shown in Figure 11. Table 44 lists the relationships of the objects in the physical asset 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.

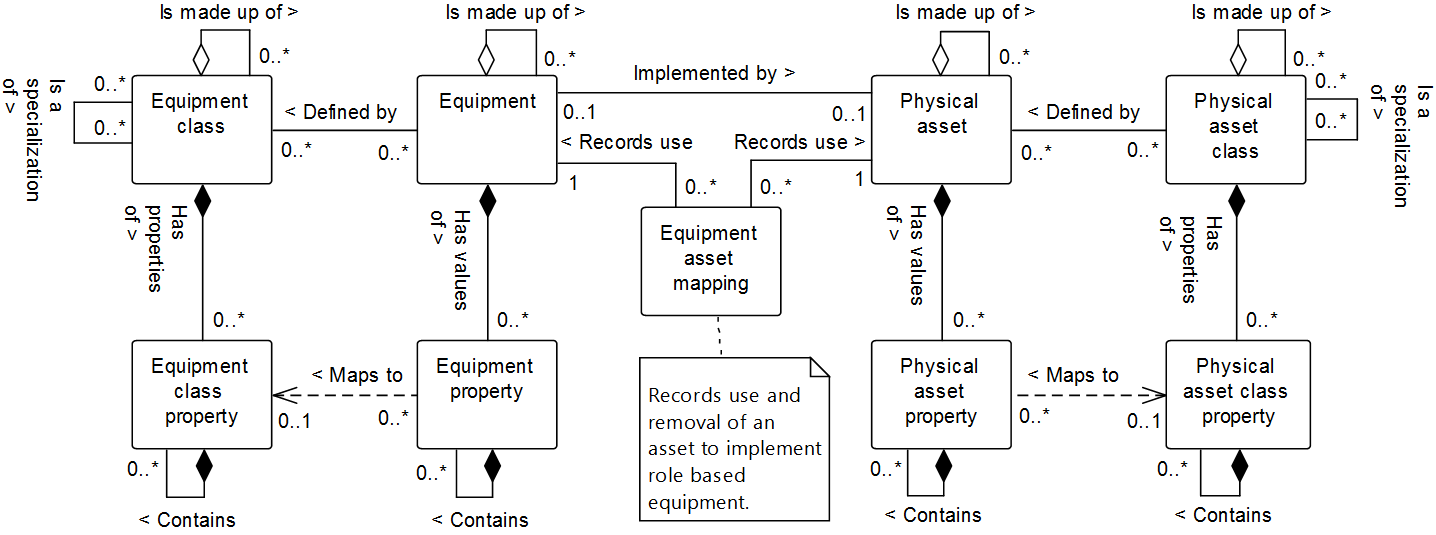


Figure 11 – Physical asset and equipment relationships

NOTE 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 45 – Physical asset and equipment relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Equipment asset mapping | Equipment | Association | Records use > |
| Equipment asset mapping | Physical asset | Association | Records use > |
| 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 the evaluated of a *test specification*.

Table 46 lists the relationship roles of a *physical asset class*. Table 47 lists the attributes of a *physical asset class*.

Table 46 – Physical asset class relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Physical asset class | Physical asset superclass | 0..\* | The *physical asset classes* of which this *physical asset class* is a specialization*.* |
| Physical asset class | Contained physical asset class | 0..\* | The child *physical asset classes* contained within this *physical asset class*. |
| Physical asset class | Physical asset class | 0..\* | This *physical asset class* is part of the related object as the whole. |
| Physical asset class property | Physical asset class property | 0..\* | The *physical asset class properties* of this *physical asset class*. |
| Physical asset | NA | 0..\* | 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*. |

Table 47 – 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*.  EXAMPLE Model number | 2HPWP | HPWLDR 103 | ATT 99 | Series K |
| Description | Additional information about the *physical asset class*. | Intrinsically Safe | (not applicable) | (not applicable) | (not applicable) |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally defines the scope of the *physical asset class*, such as the site or area it is defined for. | 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 by the evaluation of a *test specification*.

*Physical asset class properties* may contain nested *physical asset class properties*.

Table 48 lists the relationship roles of a *physical asset class property*. Table 49 lists the attributes of a *physical asset class property*.

Table 48 – Physical asset class property relationship roles

| Related Object | Role | Multiplicity | Descriptions |
| --- | --- | --- | --- |
| Physical asset class | NA | 1 | The *physical asset class* defined in part by this *physical asset class property.* |
| Physical asset class property | Physical asset class property | 0..\* | The nested *physical asset class property(s)* makes up part of this *physical asset class property* as the whole. |
| Physical asset property | NA | 0..\* | 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 this corresponding *physical asset class property.* |

Table 49 – Physical asset class property attributes

| Attribute Name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property. | 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 |
| 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, if applicable. | 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 a *test specification*.

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

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

Table 50 lists the relationship roles of a *physical asset*. Table 51lists the attributes of a *physical asset*.

Table 50 – Physical asset relationship roles

|  |  |  |  |
| --- | --- | --- | --- |
| Related Object | Role | Multiplicity | Description |
| Physical asset class | Physical asset class | 0..\* | *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..\* | The *physical asset property* values of this *physical asset.* |
| Physical asset | Physical asset | 0..\* | The related object(s) makes up part of this *physical asset* as the whole. |
| Equipment asset mapping | NA | 0..\* | 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 | This *equipment* as role in a *process segment* is implemented by the *physical asset.* |

Table 51 – Physical asset attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a *physical asset*. | 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 defines the scope of the *physical asset* definition, such as the site or area it is defined for. | 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 An *physical asset* may 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 Implementations could 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 may need to have other identifications of *physical assets* and additional correlated identifications represented as properties.

NOTE Materials used in maintenance operations can be represented in either 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* and *physical asset ID*) would normally 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 by the evaluation of a *test specification* with results exchanged using a *test result.*

*Physical asset properties* may contain nested *physical asset properties*.

Table 52 lists the relationship roles of a *physical asset property*. Table 53 lists the attributes of a *physical asset property*.

Table 52 – Physical asset property relationship roles

|  |  |  |  |
| --- | --- | --- | --- |
| **Related Object** | **Role** | **Multiplicity** | **Description** |
| Physical asset | NA | 1 | These *physical asset property* values in part for the *physical asset*. |
| Physical asset property | Physical asset property | 0..\* | 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..\* | If the parent *physical asset* supports an *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*. |

Table 53 – Physical asset property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific property. | 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, if applicable. | 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 54 lists the relationship roles of an *equipment asset mapping*. Table 55 lists the attributes of an *equipment asset mapping*.

Table 54 – Equipment asset mapping relationship roles

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

Table 55 – Equipment asset mapping attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *equipment asset mapping*. | 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) |
| 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 56 lists the relationships of the objects in the material model.

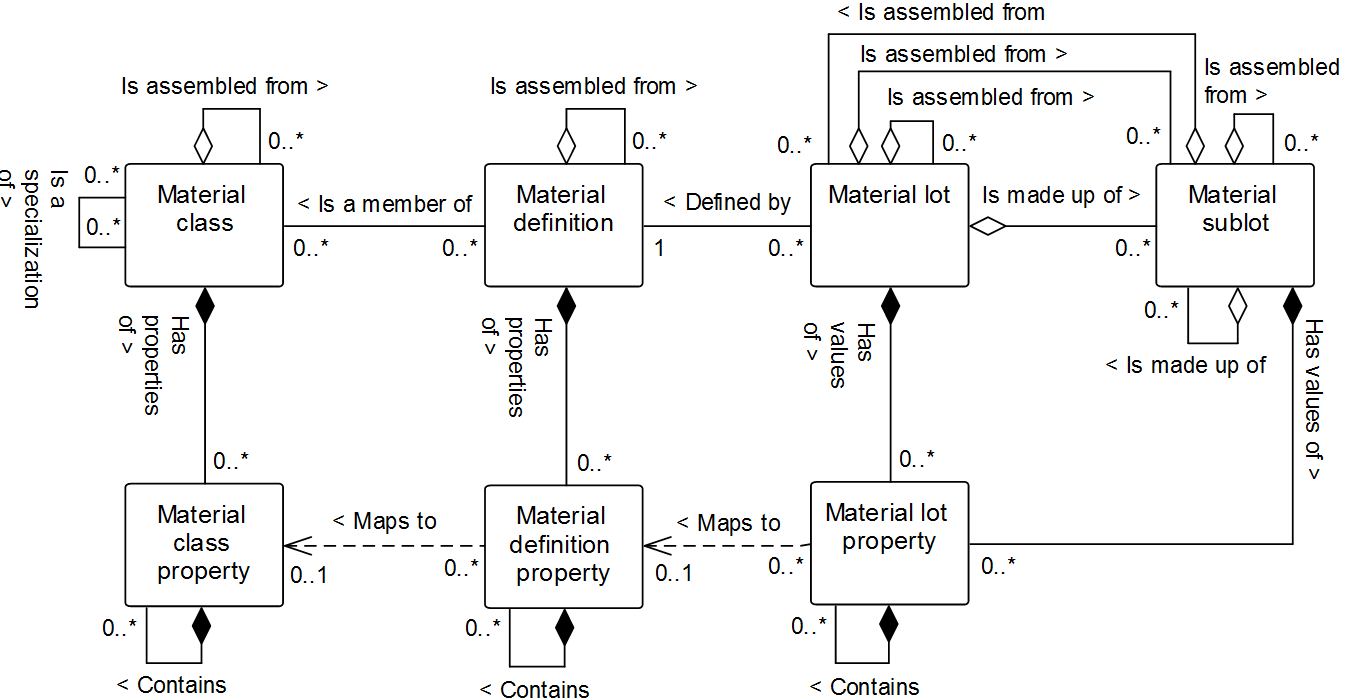


Figure 12 – Material model

NOTE This corresponds to a resource model for material, as defined in ISO 10303.

Table 56 – Material model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Material class | Material class | Aggregation hierarchy | Is assembled from > |
| Material class | Material class | Association | Is a specialization of > |
| Material class | Material class property | Composition | Has properties of > |
| Material definition | Material definition | Aggregation hierarchy | Is made up of > |
| Material definition | Material class | Association | Is a member of> |
| Material definition | Material definition property | Composition | Has properties of > |
| Material lot | Material definition | Aggregation hierarchy | Is made up of > |
| Material lot | Material class | 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 class 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 sublot property | Material sublot property | Composition hierarchy | Contains > |

### 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 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 a *test specification*.

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 57 lists the relationship roles of a *material class*. Table 58 lists the attributes of a *material class*.

Table 57 – Material class relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material class | Material superclass | 0..\* | The *material classes* of which this *material class* is a specialization*.* |
| Material class | Contained material class | 0..\* | The child *material classes* contained within this *material class*. |
| Material class | Material class | 0..\* | This *material class* is part of the related object as the whole. |
| Material class property | Material class property | 0..\* | The *material class properties* of this *material class*. |
| Material definition | NA | 0..\* | The *material definition* objects support this *material class.*  The *material definition* objects support the *material class property(s)* associated with this *material class*. |

Table 58 – 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*, …)  The ID shall be 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 defines the scope of the *material class*, such as the site or area it is defined for. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Assembly type | Optional: Defines the type of the assembly. The 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. The 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 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 by the evaluation of a *test specification*.

*Material class properties* may contain nested *material class properties*.

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* does not have to match a *material class property*.

Table 59 lists the relationship roles of a *material class property* object. Table 60 lists the attributes of a *material class property* object.

Table 59 – Material class property relationship roles

| Related Object | Role | Multiplicity | Descriptions |
| --- | --- | --- | --- |
| Material class | NA | 1 | The *material class* defined in part by this *material class property.* |
| Material class property | Material class property | 0..\* | The nested *material class property(s)* makes up part of this *material class property* as the whole. |
| Material definition property | NA | 0..\* | 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.* |

Table 60 – Material class property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of a specific *material class property*. | 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 |
| 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, if applicable. | mm | Pa-s | pH | g / m2 |

### Material definition

A representation of goods with similar name 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 a *test specification*.

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

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

Table 61 lists the relationship roles of a *material definition.* Table 62 lists the attributes of a *material definition.*

Table 61– Material definition relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material definition | Material definition | 0..\* | This *material definition* is part of the related object as the whole. |
| Material definition property | Material definition property | 0..\* | The *material definition properties* of this *material definition*. |
| Material class | Material class | 0..\* | 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..\* | The *material lot* occurrences that are constructed based on this *material definition*. The *material lot properties* map to a corresponding *material definition property*. |

Table 62 – 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*, …)  The ID shall be 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 defines the scope of the *material definition*, such as the site or area it is defined for. | 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 | Optional: Defines the type of the assembly. The 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. The 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 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 by the evaluation of a *test specification*.

*Material definition properties* may contain nested *material definition properties*.

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

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

Table 63 lists the relationship roles of a *material definition property* object*.* Table 64 lists the attributes of a *material definition property* object*.*

Table 63 – Material definition property relationship roles

| Related Object | Role | Multiplicity | Descriptions |
| --- | --- | --- | --- |
| Material definition | NA | 1 | The *material definition* defined in part by this *material definition property.* |
| Material definition property | Material definition property | 0..\* | 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 | 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..\* | 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.* |

Table 64 – Material definition property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *material definition property*. | 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 |
| 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, if applicable. | 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* (count, volume, weight);
3. the unit of measure of the *material* (for example, parts, liters, kg);
4. the storage location for the *material*;
5. 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 65 lists the relationship roles of a *material lot.* Table 66 lists the attributes of the *material lot.*

Table 65 – Material lot relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material lot | Material lot | 0..\* | This *material lot* is part of the related object as the whole. |
| Material lot property | Material lot property | 0..\* | The *material lot properties* of this *material lot*. |
| Material definition | Material definition | 1 | The *material definition* that defines this *material lot*.  This *material lot* objects support the *material definition property(s)* associated with the *material definition*.  NOTE The *material lot* may act as a container for other objects in which case it will not have *material definition* association. |
| Material sublot | Material sublot | 0..1 | The *material sublot* occurrences that are constructed based on this *material lot*. The *material sublot properties* map to a corresponding *material lot property*. |
| Material sublot | Material sublot | 0..\* | This *material lot* is part of the related object as the whole. |
| Material sublot | Material sublot | 0..\* | *The related object(s)* makes up part of this *material lot* as the whole. |

Table 66 – 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*, …)  The ID shall be 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 defines the scope of the *material lot*, such as the site or area it is defined for. | 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*.  Description – Storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Assembly type | Optional: Defines the type of the assembly. The 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. The 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.  NOTE *If material lots* (or *sublots*) are merged or absorbed (e.g. blended), then this is a new *material lot*. | Permanent | Transient | Permanent | Transient |
| Status | Status of the *material lot*.  EXAMPLE  released, approved, blocked, in process, in quality check. | In process | approved | blocked | approved |
| Disposition | Defines an enumerated list of *material lot statuses* of a *material lot* or assembly of *material lots*. The defined values for the *disposition* of a *material lot are:*  Planned, in process, restricted, unrestricted, closed  Planned – A *material lot* that does not yet physically exist, is assigned to an *operations request* (*segment requirement*) or *work request* *(job order*).  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. For example, a *material lot* may be awaiting a quality decision or a *material lot* may be physically inaccessible.  Unrestricted – A *material lot* is permitted for normal use without restriction.  Closed – A *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, if applicable. | sheets | Cans | Liter | Rolls |

NOTE 1 Representation of non-lot controlled items (for example, 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. For example, this could be the 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 may specify a spatial definition in addition to a storage location 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 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 1 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 2 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 3 A finished tractor is a physical assembly of materials.

EXAMPLE 4 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 by the evaluation of a *test specification* with results exchanged in a *test result*.

*Material lot properties* may contain nested *material lot properties*.

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 sublot.

Table 67 lists the relationship roles of a *material lot property.* Table 68 lists the attributes of *material lot property.*

Table 67 – Material lot property relationship roles

| Related Object | Role | Multiplicity | Descriptions |
| --- | --- | --- | --- |
| Material lot | NA | 1 | The *material lot* defined in part by this *material lot property.* |
| Material sublot | NA | 1 | 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 | 0..\* | The nested *material lot property(s)* makes up part of this *material* *lot property* as the whole. |
| Material class property | Material class property | 0..1 | If the parent *material* *lot* supports a *material class,* the *material class property(s)* is applied in the *material lot property(s)*.  This *material lot property* maps to the corresponding *material class property.* |

Table 68 – Material lot property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *material lot property*. | 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, if applicable. | 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* may be tested by the evaluation of a *test specification*.

*Material sublot properties* may contain nested *material sublot properties*.

EXAMPLE *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 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 sublot.

A *material sublot* shall include:

1. a unique identification of the sublot; the storage location of the sublot;
2. the unit of measure of the *material* (for example, parts, kg, tons);
3. any status of the sublot.

Table 69 lists the relationship roles of the *material sublot*. Table 70 lists the attributes of a *material sublot*.

Table 69 – Material sublot relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material sublot | Material sublot | 0..\* | This *material sublot* is part of the related object as the whole. |
| Material lot property | Material lot property | 0..\* | The *material lot properties* of this *material sublot*. |
| Material sublot | Material sublot | 0..\* | 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 | Material lot | 0..1 | This *material lot* is part of the related object as the whole. |
| Material lot | Material lot | 0..\* | *The related object(s)* makes up part of this *material sublot* as the whole. |

Table 70 – 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* …)  The ID shall be 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 a *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 defines the scope of the *material sublot*, such as the site or area it is defined for. | 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*.  Description – Storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Assembly type | Optional Defines the type of the assembly. The 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. The 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.  NOTE If material lots (or sublots) are merged or absorbed (e.g. blended), then this is a new material lot. | Permanent | Transient | Permanent | Transient |
| Status | Status of the current *material sublot*. For example,  Released, approved, blocked, in process, in quality check. | Released | approved | blocked | Approved |
| Disposition | Defines the *material sublot* d*isposition* types of a *material sublot* or assembly of *material sublots*. The defined values for the *disposition* of a *material sublot*:  Planned, in process, restricted, unrestricted, closed  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. For example, a *material sublot* may be awaiting a quality decision or a *material sublot* may be physically inaccessible.  Unrestricted – A *material sublot* is permitted for normal use without restriction.  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, if applicable. | sheets | Cans | Liter | Rolls |

NOTE A material sublot may specify a spatial definition in addition to a storage location 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 1  Many assembly type industries, such as automobile manufacturing, airplane assembly, and furniture manufacturing use the concept of assemblies. A produced *material*, with a unique identification and properties, is made up of other *materials* with their own unique identification and properties.

NOTE 2 In applying assemblies to resource objects, the associated child objects are 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*.

NOTE 3 In applying assemblies to resource objects, the assembly type and the assembly relationship attribute for the associated parent resource object 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, for example 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 of a 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 The term *business process segment* is a synonym for *process segment* and is 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 71 lists the relationships of the objects in the process segment model.

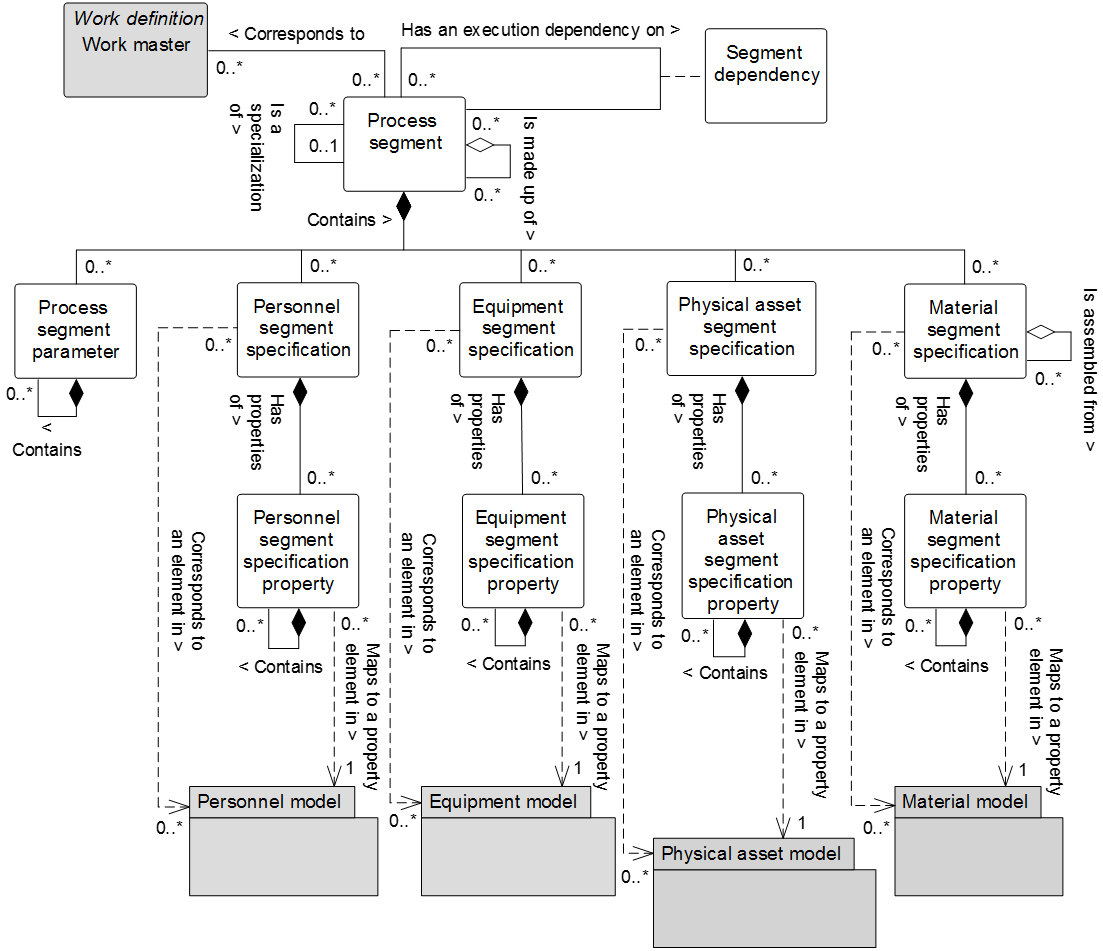
****Figure 14 – Process segment model

Table 71 – Process segment model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Process segment | Process segment | Aggregation hierarchy | Is made up of > |
| Process segment | Process segment | Association | Is a specialization of > |
| Process segment | Work master | Association | Corresponds to > |
| Process segment | Segment dependency | Aggregation class hierarchy | Has an execution dependency on > |
| Process segment | Process segment | Aggregation class hierarchy | Has an execution dependency on > |
| 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 | 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 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 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 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 > |
| Material segment specification property | Material sublot property | Dependency (D) | Maps to > |
| Material segment specification | Material segment specification | Aggregation hierarchy | Is assembled from > |
| Material requirement | Test specification | Association | Specifics > |

### 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 Five hours or 5 h/100 kg.

1. constraint rules associated with ordering or sequencing of segments.
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 abstract or concrete. An abstract *process segment* defines a ‘template’, upon which other abstract or concrete *process segments* may be based. Unlike concrete *process segments*, abstract *process segments* shall not be directly scheduled or tracked. Therefore, *segment requirements*, *segment responses* and *process segment capabilities* shall not reference abstract *process segments*.

Where a *process segment* references a *work master*, the definition type (abstract or concrete) 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 abstract *process segment* upon which the *process segment* is based.

EXAMPLE An abstract process segment may contain material segment specifications that reference material classes, while a concrete process segment based on this abstract process segment may contain material segment specifications that reference material definitions belonging to the material classes.

EXAMPLE A mining organization could define the following abstract and concrete *process segments*.

Extraction (abstract)

1. Open Cut Extraction (abstract), specialization of Extraction (abstract)
2. Underground Extraction (abstract), specialization of Extraction (abstract)
3. Site S1 Open Cut Extraction (concrete), specialization of Open Cut Extraction (abstract)
4. Site S2 Underground Extraction (concrete), specialization of Underground Extraction (abstract)

NOTE Abstract *process segments* provide a basis for standardization and reuse of abstract *process segments* across many concrete *process segments* across and between plants.

Table 72 defines the relationship roles for the *process segment*. Table 73 defines the attributes for the *process segment*.

Table 72 – Process segment relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment | Process segment | 0..\* | *The related object(s)* makes up part of this *process segment* as the whole. |
| Process segment | Abstract process segment | 0..1 | The abstract *process segment* upon which this *process segment* is based. The *process segment* of which this *process segment* is a specialization*.* |
| Process segment | Contained process segment | 0..\* | The child *process segments* contained within this *process segment*. |
| Work Master (Part 4) | Work master | 0..\* | This process segment(s) is applied in zero to many work masters. |
| Segment dependency | Segment dependency | 0..\* | The ordering / sequencing rules related to the process segment execution. |
| Process segment parameter | Process segment parameter | 0..\* | The *parameter specifications* related to this *process segment.* |
| Personnel segment specification | Personnel segment specification | 0..\* | The *personnel specifications* defining part of this *process segment.* |
| Equipment segment specification | Equipment segment specification | 0..\* | The *equipment specifications* defining part of this *process segment.* |
| Physical asset segment specification | Physical asset segment specification | 0..\* | The *physical asset specifications* defining part of this *process segment.* |
| Material segment specification | Material segment specification | 0..\* | The *material specifications* defining part of this *process segment.* |

Table 73 – 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* …)  The ID shall be 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” shall 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 defines the scope of the *process segment* definition, such as the site or area it is defined for. | 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*. The defined types are  Abstract – A *process segment* used as a template for other *process segments*.  Concrete – A *process segment* that may be directly scheduled and tracked. | Abstract | Concrete | Concrete | Abstract |
| Duration | Duration of *process segment*, if known. | 25 | (not applicable) | 20 | 5 |
| Duration unit of measure | The units of measure of the duration, if defined. | Minutes | (not applicable) | minutes | minutes |

### Personnel segment specification

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

Table 74 defines the relationship roles for a *personnel segment specification*. Table 75 defines the attributes for a *personnel segment specification*.

Table 74 – Personnel segment specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment | NA | 1 | The *process segment* defined in part by this *personnel* *segment* *specification*. |
| Personnel segment specification property | Personnel segment specification property | 0..\* | The *personnel segment specification property(s)* of this *personnel* *segment specification*. |
| Personnel class | Personnel class | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |
| Person | Person | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |

Table 75 – 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.* | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Personnel class | Identifies the associated *personnel class* or set of *personnel classes* specified | Milling Machine Operator | Type 2 Mechanic | Lab Tech A | Lift truck operator |
| Person \* | Identifies the associated *person* or set of *persons* specified | <n/a> | <n/a> | <n/a> | <n/a> |
| 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 defines the scope of the *personnel segment specification*, such as the site or area it is defined for. | 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*. | Allocated | Certified | Certified | Allocated |
| Quantity | Specifies the *personnel* resource required for the parent *process segment*, if applicable. | 1,3 | 2 | 0,5 | 5 |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | Hours / piece | Hours / motor | Hours / sample | minutes / transfer |
| \* Typically only *personnel class* is defined. | | | | | |

NOTE A personnel segment specification may 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 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 76 defines the relationship roles for the *personnel segment specification property*. Table 77 defines the attributes for the *personnel segment specification property*.

Table 76 – Personnel segment specification property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Personnel segment specification property | Personnel segment specification property child | 0..\* | The *personnel segment specification property(s)* of this *personnel* *segment specification property*. |
| Personnel segment specification | NA | 1 | The *personnel segment specification property(s)* of this *personnel* *segment specification property*. |
| Personnel class property | Personnel class property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |
| Person property | Person property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |

Table 77 – 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*. | 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, if applicable. | cm | <True, False> | <True, False> | <True, False> |
| Quantity | Specifies the personnel resource required, if applicable. | 1,3 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | 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 78 defines the relationship roles for the *equipment segment specification*. Table 79 defines the attributes for the *equipment segment specification*.

Table 78 – Equipment segment specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment | NA | 1 | The *process segment* defined in part by this *equipment segment* *specification*. |
| Equipment segment specification property | Equipment segment specification property | 0..\* | The *equipment segment specification property(s)* of this *equipment segment specification*. |
| Equipment class | Equipment class | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |
| Equipment | Equipment | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |

Table 79 – 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.* | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Equipment class | Identifies the associated *equipment class* or set of *equipment classes* of the capability. | (not applicable) | 10 Ton Crane | Reflecto-meter | 800 kg Fork Truck |
| Equipment\* | Identifies the associated *equipment* or set of *equipment* of the capability. | Milling Machine 001 | (not applicable) | (not applicable) | (not applicable) |
| 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 defines the scope of the *equipment segment specification*, such as the site or area it is defined for. | 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, if applicable. | 1,3 | 1 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | Machine Hours / piece | Day | Test | Move |
| \* Typically either *equipment class or equipment* is defined. | | | | | |

NOTE An equipment segment specification may specify both a spatial definition and an operational location 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 80 defines the relationship roles for the *equipment segment specification property*. Table 81 defines the attributes for the *equipment segment specification property*.

Table 80 – Equipment segment specification property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Equipment segment specification property | Equipment segment specification property child | 0..\* | The *equipment segment specification property(s)* of this *equipment* *segment specification property*. |
| Equipment segment specification | NA | 1 | The *equipment segment specification property(s)* of this *equipment* *segment specification property*. |
| Equipment class property | Equipment class property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |
| Equipment property | Equipment property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |

Table 81 – 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*. | 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. For example: vertical, horizontal | Vertical | TRUE | TRUE | Electric |
| Value unit of measure | The unit of measure of the associated property value, if applicable. | (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, if applicable. | 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 82 defines the relationship roles for the *physical asset segment specification*. Table 83 defines the attributes for the *physical asset segment specification*.

Table 82 – Physical asset segment specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment | NA | 1 | The *process segment* defined in part by this *physical asset segment* *specification*. |
| Physical asset segment specification property | Physical asset segment specification property | 0..\* | The *physical asset segment specification property(s)* of this *physical asset segment specification*. |
| Physical asset class | Physical asset class | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset | Physical asset | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |

Table 83 – 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.* | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Physical asset class | Identifies the associated *physical asset class* or set of *physical asset classes* of the capability. | Acme Super TT10 | Easy bake 1969 | Wafers R Us RF 100 | SuperTote 2000 |
| Physical asset | Identifies the associated *physical asset* or set of *physical assets* of the capability. | TI-101 | OV-1200 | RF-140 | Tote 12A |
| 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 defines the scope of the *physical asset segment specification*, such as the site or area it is defined for. | 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, if applicable. | 1 | 1 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | oC, K | hours | micron | Cubic feet |

NOTE A physical asset segment specification may specify both a spatial definition and a physical location 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 properties*.

*Physical asset segment specification* *properties* may contain nested *physical asset segment specification properties*.

Table 84 defines the relationship roles for the *physical asset segment specification property*. Table 85 defines the attributes for the *physical asset segment specification property*.

Table 84 – Physical asset segment specification property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Physical asset segment specification property | Physical asset segment specification property child | 0..\* | The *physical asset segment specification property(s)* of this *physical asset* *segment specification property*. |
| Physical asset segment specification | NA | 1 | The *physical asset segment specification property(s)* of this *physical asset* *segment specification property*. |
| Physical asset class property | Physical asset class property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset property | Physical asset property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |

Table 85 – 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*. | 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. For example: vertical, horizontal. | 1999-12-31 | 1200 | True | Plastic |
| Value unit of measure | The unit of measure of the associated property value, if applicable. | 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, if applicable. | (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 86 defines the relationship roles for *material segment specification*. Table 87 defines the attributes for the *material segment specification*.

Table 86 – Material segment specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment | NA | 1 | The *process segment* defined in part by this *material segment* *specification*. |
| Material segment specification property | Material segment specification property | 0..\* | The *material segment specification property(s)* of this *material segment specification*. |
| Material segment specification | Material segment specification child | 0..\* | The related object(s) makes up part of this *material* *segment specification* as the whole. |
| Material class | Material class | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |
| Material | Material | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |

Table 87 – 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.* | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Material class | Identifies the associated *material class* or set of *material classes* of the capability\* | Polymer sheet stock 1001A | Motor Brushes | Sample Holder | Pallet |
| Material definition | Identifies the associated *material definition* or set of *material definitions* of the capability. \* | Sheet stock 1443a | #9949 | Polyurethane sample holder | Plastic Pallet |
| 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 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*.  Description – Storage location attribute contains a description of the storage location, such as a street address. | Equipment | Physical Asset | Operational Location | Description |
| Assembly type | Optional: Defines the type of the assembly. The 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. The 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 material use.  Defined values for production operations are:  Consumable, material consumed, material produced, by-product produced, co-product produced, yield produced.  Defined values for maintenance operations are:  Consumable, replaced asset, replacement asset.  Defined values for quality operations are:  Consumable, sample, returned sample.  Defined values for Inventory operations are:  Consumable, carrier, returned carrier, 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, if applicable. | Sheets / piece | Units | Units | (not applicable) |
| \* Typically, either a *material class* or *material definition* is specified. | | | | | |

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

A *material segment specification* may be defined as 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, yield produced. The definitions of the defined values are:

1. 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)*
2. Material consumed – *(To be defined by Dec 2016)*
3. Material produced – *(To be defined by Dec 2016)*
4. 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.
5. 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.
6. 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, 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. For 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, replaced asset, replacement asset

1. Consumable – ibid
2. Replaced asset – *(To be defined by December 2017)*
3. Replacement asset – *(To be defined by December 2017)*

Defined values for the material use attribute for quality operations are:

Consumable, sample, returned sample

1. Consumable – ibid
2. Sample – *(To be defined by December 2017)*
3. Returned sample – *(To be defined by December 2017)*

Defined values for the material use attribute for inventory operations are:

Consumable, carrier, returned carrier, inventoried

1. Consumable – ibid.
2. Carrier – *(To be defined by December 2017)*
3. Returned carrier – *(To be defined by December 2017)*
4. 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 88 defines the relationships for the *material segment specification property*. Table 89 defines the attributes for the *material segment specification property*.

Table 88 – Material segment specification property relationships

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material segment specification property | Material segment specification property child | 0..\* | The *material segment specification property(s)* of this *material* *segment specification property*. |
| Material segment specification | NA | 1 | The *material segment specification property(s)* of this *material* *segment specification property*. |
| Material class property | Material class property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |
| Material property | Material property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |

Table 89 – 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*. | 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, if applicable. | Angstroms | <True, False> | <True, False> | <Active, Passive, None> |
| Quantity | Specifies the amount of resources required, if applicable. | 0,10 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated property value, if applicable. | Sheets / piece | (not applicable) | (not applicable) | (not applicable) |

### 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 90 defines the relationship roles for the *process segment parameter*. Table 91 defines the attributes for a *process segment parameter*.

Table 90 – Process segment parameter relationship roles

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

Table 91 – Process segment parameter attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the *process segment parameter.* | 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 |
| Value | The value, set of values, or range of acceptable values | {5..10} | {1..20} | {5-20} | (not applicable) |
| Unit of measure | Unit of measure of the values, if applicable. | Minutes | Days | mg | (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 92 defines the relationship roles for the *segment dependency*. Table 93 defines the attributes for the *segment dependency*.

Table 92 - segment dependency relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment | Process segment from | 0..\* | The source *process segments* that the *target process* *segments* are dependent. |
| Process segment | Process segment to | 0..\* | The target *process segments* that are dependent on *source process* *segments*. |

Table 93 –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*. | 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 by another segment | Start *Cleanout* no earlier than T (*Timing Factor*) after *Work* end | Start *Motor Replacement* after *Cleanout* end | *Pull Sample* can run in parallel with *MIX* | *Move Inventory* after *Quality Release* |
| Dependency factor | Factor used by dependency | 25 | (not applicable) | (not applicable) | (not applicable) |
| Unit of measure | The units of measure of the dependency factor, if defined. | Minutes | (not applicable) | (not applicable) | (not applicable) |

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, the dependencies include:

* B cannot follow A
* B can run in parallel to A
* B cannot run in parallel to A
* Start B at A start
* Start B after A start
* Start B after A end
* Start B no later than T (*dependency factor* with time T) after A start
* Start B no earlier than T (*dependency factor* with time T) after A start
* Start B no later than T (*dependency factor* with time T) after A end
* Start B no earlier than T (*dependency factor* with time T) after A end



Figure 15 – Segment dependency examples

NOTE The associations to the A and B segments are not represented as attributes, as per 4.6.5.

## Test information

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.

### Test model

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

* personnel, equipment, physical assets and/or materials that are to be, or have been, tested;
* each other; and
* the methods to be, or have been, used to perform the test(s).

Table 94 - Test model relationships lists the relationships of the objects in the test model.

NOTE The objects depicted in Figure 16 with italicised names do not represent actual object names. They are realized through use of other objects defined in this standard.

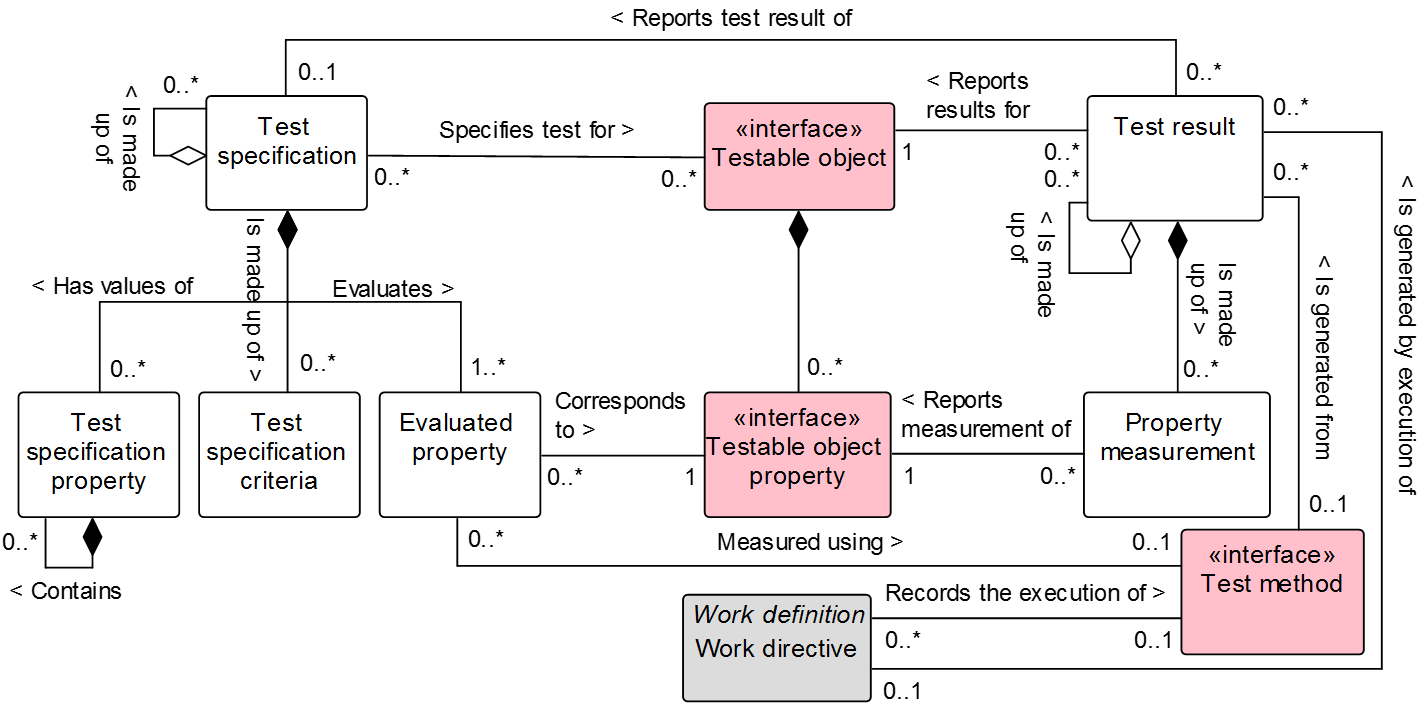


Figure 16 - Test model

Table 94 - Test model relationships

| **From** | **To** | **Type** | **Relationship Name** |
| --- | --- | --- | --- |
| Test specification | Test specification | Aggregation hierarchy | Is made up of > |
| 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 | Testable object | Association | Specifies test for > |
| Test specification property | Test specification property | Composition hierarchy | Contains > |
| Evaluated property | Testable object property | Association | Corresponds to > |
| Evaluated property | Test method | Association | Measured using > |
| Test result | Test result | Aggregation hierarchy | Is made up of > |
| Test result | Property measurement | Composition whole | (External object relationship) |
| Test result | Testable object | Association | < Reports result for |
| Test result | Test specification | Association | < Reports the test result of |
| Property measurement | Testable object property | Association | Reports the measurement of |
| Test result | Test directive | Association | Is generated by execution of |
| Test result | Test method | Association | Is generated from > |

### Testable object and testable object property

The *testable object* and *testable object property* are represented in the test model to simplify the model diagram. These interface objects represent the objects for which a *test specification(s)* test and the properties, or characteristics, that those *test specifications* shall evaluate. They shall be realized by any of the objects listed in Table 95.

Table 95 – Realization 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 |

### Test specification

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 96 defines the relationship roles for the *test specification.* Table 97 lists the attributes of the *test specification*.

Table 96 - Test specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Test specification | Test specification child ID | 0..\* | The child *test specifications* of this *test specification*. |
| Test specification property | Test specification property | 0..\* | The *test specification property* values of this *test specification*. |
| Test specification criteria | Test specification criteria | 0..\* | The criteria which is to be applied to determine the test outcome upon evaluation of the *test specification*. |
| Evaluated property | Evaluated property | 1..n | The property(s) measured and evaluated by this *test specification.* |
| Testable object | Testable object ID | 0..\* | The ID of the object to be tested by this *test specification.* |
| Test Result | NA | 0..\* | This test specification evaluated to generate the test result. |

Table 97 - Attributes of test specification

| 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 count | The quantum of operational activity required to be undertaken to obtain a valid sample. |  |  | 1 lot | 15 kt |
| Recurrence time interval | The duration of operational activity required to trigger evaluation of the test specification. | 20 min | 5,000 hours |  |  |

EXAMPLE 1 An online test may 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 2 An online test may be specified to be performed over every 15,000 metric tons of material produced. In which case the recurrence count attribute would have a value of 15 kt.

EXAMPLE 3 An offline test for engine oil contamination may 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 98 defines the relationship roles for the *test specification property.* Table 99 lists the attributes of the *test specification property*.

Table 98 - Test specification property relationship roles

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

Table 99 - Attributes of test specification property

| 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 criteria to evaluate and the test result to be reported when a testable object satisfies those criteria. Table 4 lists the attributes of the *test specification criteria*.

Table 100 defines the relationship roles for the *test specification criteria.* Table 101 lists the attributes of the *test specification criteria*.

Table 100 - Test specification criteria relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Test specification | NA | 1 | This *test specification criteria* determine the test outcome upon evaluation of the *test specification.* |

Table 101 - Attributes of test specification criteria

| 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  if (criterion 1) then ‘pass’  else if (criterion 2) then ‘warn’  else ‘fail’ | Oven Residence Time > 10 min and < 11 min | Cylinder Diamater > 71.960 mm | pH < 7.2 | Fe > 0.585 and Fe < 0.615 |
| 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 Consider the following sequence of *test specification criteria* where the sequence, result and expression are shown. A material definition propertyof Fe has been defined in the *material definition* with which 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%
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 102 defines the relationship roles for the *evaluated property.* Table 103 lists the attributes of the *evaluated property*.

Table 102 - Evaluated property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Testable object property | Testable object property ID | 1 | The testable object property ID which is to be measured by this *test specification*. |
| Test method | Test method ID | 0..1 | The ID of the test method which is to be applied to obtain the measurement for the testable object property ID. |
| Test specification | NA | 1 | This property(s) is measured and evaluated by the test specification. |

Table 103 - Attributes of evaluated property

| 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 evaluation of *test specifications* shall be presented as *test results.* A *test result* reports the results from a test for a specific *person, piece of equipment, physical asset, material lot* or *material sublot.*

Table 104 defines the relationship roles for the *test result.* Table 105 lists the attributes of the *test result*.

Table 104 - Test result relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Test result | Test result child ID | 0..\* | The child *test result(s)* of this *test result*. |
| Property measurement | Property measurement | 0..\* | The measurement obtained for each *testable object* property. |
| Testable object | Testable object ID | 1 | The tested object being reported |
| Test specification | Test specification ID | 0..1 | The *test specification* evaluated to generate this *test result*. |
| Work directive | Work directive ID | 0..1 | The *work directive* generated during execution of the test. |
| Test method | Test method ID | 0..1 | The *test method* applied to execute the test and generate the *test result*. |

Table 105 - Attributes of test result

| 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 | The 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 |
| Result | The result obtained from evaluation of the associated *test specification*. | Pass | Fail | Pass | Warn |
| Expiration | The date of the expiration of the *test result*. |  | 2017-10-25 13:30 | 2000-10-25 13:30 | 2002-10-25 13:30 |

### Property measurement

The measurements obtained during evaluation of *test specifications* shall be presented as *property measurements.* A *property measurement* reports the measurement obtained for a single property from a test of a *specific person, piece of equipment, physical asset, material lot* or *material sublot.*

Table 106 defines the relationship roles for the *property measurement.* Table 107 lists the attributes of the *property measurement*.

Table 106 – Property measurement relationship roles

| **Related Object** | **Role** | **Multiplicity** | **Description** |
| --- | --- | --- | --- |
| Testable object property | Testable object property ID | 1 | The testable object property ID for which this *property measurement* is reporting the measurement result. |
| Test result | NA | 1 | This measurement obtained for each testable object property in the *test result.* |

Table 107 - Attributes of property measurement

| 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 | 2000-10-25 13:30 | 2002-10-25 13:30 |

### Test method

The *test method* is represented in this model to simplify the model diagram. It represents the objects which can be used to define the method to perform a test. It shall be realized by any of the following objects:

* *Process segment*;
* *Operations definition*;
* *Operations segment*; or
* *Work master*.

## Operations record information

### Operations record model (abstract)

The operations record model is shown in Figure 17. The *operations record* and *operations record specification* are abstract types meaning they are not standalone exchange objects. These abstract objects are realized in implementations as occurrences of the *operations event record* 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* bundles operations record entry objects by the type of action specifying the attribute, action, with defined values of created, changed, deleted and observed. The *operations record entry* embeds objects defined in ISA-95 and manufacturing operations profiles or references to external objects. The *operations record specification* specifies the content and form of objects in an *operations record* within the associated *operations record entry(s).*

NOTE In an implementation, the *operations record entry* is validated against the *operations record specification*.

Table 108 lists the relationships of the objects in the operations record model.

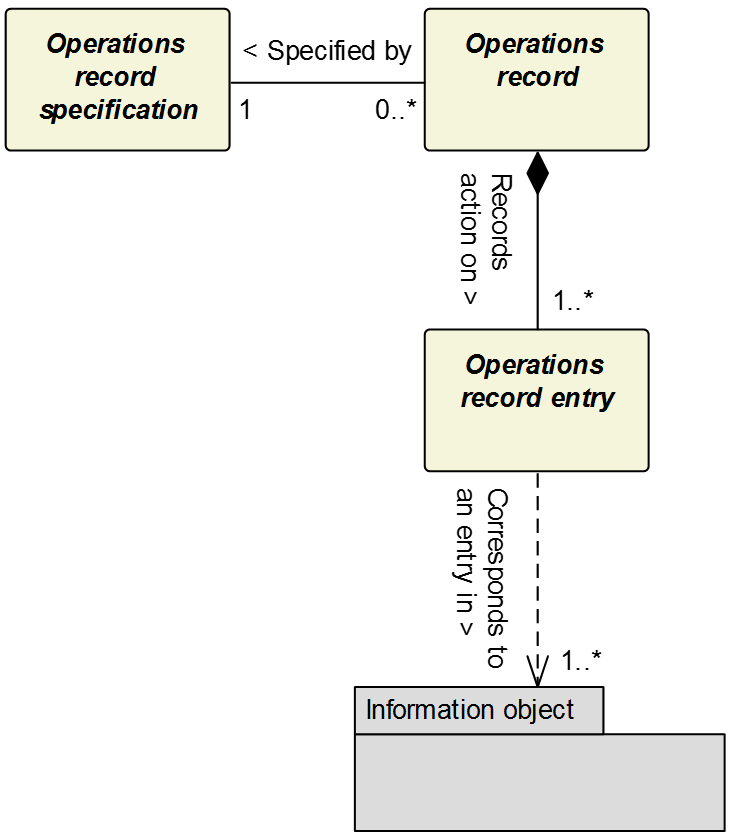


Figure 17 – Operations record model (abstract)

Table 108 – Operations record model relationships

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

### Operations record specification (abstract)

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

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

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

Table 109 defines the relationship roles for the *operations record specification*. Table 110 defines the attributes for the *operations record specification*.

Table 109 - Operations record specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations record | NA | 0..\* | The *operations record* maps to this corresponding *operations record specification*.  Allowed content in the *operations record* is defined by this *operations record specification*. |

Table 110 - Operations record specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the associated instance of *operations record* *specification*.  *Operations record* derived type instances include this value with their *operations record(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*. |  |  |  |  |
| Information object type | Permitted set of information objectsallowed in the *operations* *record* occurrence.  NOTE 1 An *operations record entry* contains the attributes to the information object for operations record.  NOTE 2 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* allowed in the *operations record* occurrence.  NOTE 1 If no limit is explicitly specified, the unbounded keyword is specified.  NOTE 2 If no *multiplicity* entry is specified, this is equivalent to no constraint, i.e.: {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* *object* in the *operations record* by the publisher.  Defined values for *action* are  *Added, changed, deleted, observed*  NOTE 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* occurrence.  NOTE 1 If no limit is explicitly specified, the unbounded keyword is specified.  NOTE 2 If no *multiplicity* entry is specified, this is equivalent to no constraint, i.e.: {Min: 0, Max: Unbounded}. | {Min: 1, Max: 1} | {Min:0, Max: 1} | {Min:0, Max: 10} | {Min:1, Max: Unbounded} |

Each *operations record* represents a single action. An *operations record specification* defines the content options permitted from one to many types of *operations records*.

NOTE 1 The number of *operations record entry* occurrences allowed in each *operations record* is specified using the attribute, information object type multiplicity.

NOTE 2 The number of operations record actions allowed to be applied to *operations record entry* is represented using the attribute, action multiplicity.

NOTE 3 The *ID*s may use the fully qualified name (FQN) syntax to avoid *ID* name collisions.

### Operations record

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

Table 111 defines the relationship roles for the *operations record*. Table 112 defines the attributes for the *operations record*.

Table 111 - Operations record relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations record entry | Operations record entry | 1..\* | This *operations record* acts as a container for *operations event entry*(s) applying a common *action* for each *operations record*. |
| Operations record specification | Operations record specification | 1 | The *operations record specification* defines theinformation object(s)allowed to be contained within an operations record entry in this *operation record.* The specified *action* must match the value in the attribute, action, in this *operations record.* |

Table 112 - Operations record attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the associated instance of *operations record*. | CR-87 | Uuid - 1FCF9DA1-DCC5-4012-BDEF-D76C754F4826 | 2016-03 | AB45 |
| Description | Contains additional information and description of the *operations record*. | Job order start | Schedule released | QA test scheduled | Lot 4A stored |
| Action | The action performed on the *operations record entry(s)* within the *operations record*.  Defined values are:  Added, changed, deleted and observed. | Deleted  Observed | Added | Changed | Changed |
| Effective timestamp | The date and time that the operations record entry was/is effective.  NOTE If no effective timestamp is provided with *operations record entry*, the effective timestamp is represented by the effective timestamp attribute in the *operations 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. | 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* may have a different data record of *operations record entry(s’)* information objects so the attribute, record timestamp, is used by the receiver to compare the same operations record entry(s) in each operations record occurrence.

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

NOTE 3 The attribute, record timestamp*,* explicitly states the time that the publisher took the action of the *operations record*.

NOTE 4 In the operations record entry, the attribute, effective timestamp, explicitly states the time of the real-world event’s recording. If no effective timestamp is provided, the effective timestamp is represented by the effective timestamp attribute in the *operations record* as the effective timestamp of the operations record entry.

### Operations record entry

The *operations record entry* objectshall be a single information object as defined in Part 2 and Part 4, and any third-party manufacturing operations message profile within an *operations record*. There shall be one or more *operations record entry* objectsin an *operations event* *record*.

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

Table 113 defines the relationship roles for *operations record entry*. Table 114 defines the attributes for *operations record entry*.

Table 113 – Operations record entry relationships

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations record | NA | 1 | The *operations record* applying a single common action (e.g. Changed) acts as a container for this *operations event entry(s)*. |
| Information object | Information object | 0..1 | An embedded information object.  NOTE 1 If data is referenced in this operations record entry, the attribute is not used.  NOTE 2 The format of the information object is specified in the *operations record specification*. |
| Information object | External reference | 0..1 | The reference to external data (information object) which is stored external to this *operations record entry*.  NOTE 1 If data is embedded in this operations record entry, the attribute is not used.  NOTE 2 The format of the reference is specified in the *operations record specification*. |

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

Table 114 – Operations record entry attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | ID which is unique within the scope of *operations record.* | 1 | 4A34B | 239432 | A11 |
| Description | Additional information about the *operations record entry*. | The control recipe is embedded in this *operations record* |  |  | Data set time series data is stored in the historian database |
| Information object | An embedded information object.  NOTE 1 If data is referenced in this operations record entry, the attribute is not used.  NOTE 2 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 record entry*.  NOTE 1 If data is embedded in this *operations record entry,* the attribute is not used.  NOTE 2 The format of the reference is specified in this *operations record specification*. | Material Lot 11A | Mixer 4 | Work Master QC5001 | Material Lot 59B |
| Confidence factor | Measure of the confidence of the ability to obtain the capacity value. | Good | 100% | bad | Uncertain |
| Effective timestamp | The date and time that the *operations record entry* was/is effective.  NOTE If no effective timestamp is provided with *operations record entry*, the effective timestamp is represented by the effective timestamp attribute in the *operations 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.  NOTE If no entry is provided, the record timestamp is the record timestamp attribute in the *operations 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 record entry is based upon.  NOTE The allowed *information object types* are defined in the *operations record specification*. | Work Master  Control Recipe | Physical Asset | Test Specification | Equipment |

NOTE When multiple *operations record entry* are exchanged, the effective timestamps of these *actions* of when each occurred may be relevant to the interpretation of the *operations record*.

EXAMPLE Aoperations 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.

## 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 115 lists the relationships of the objects in the operations event model.

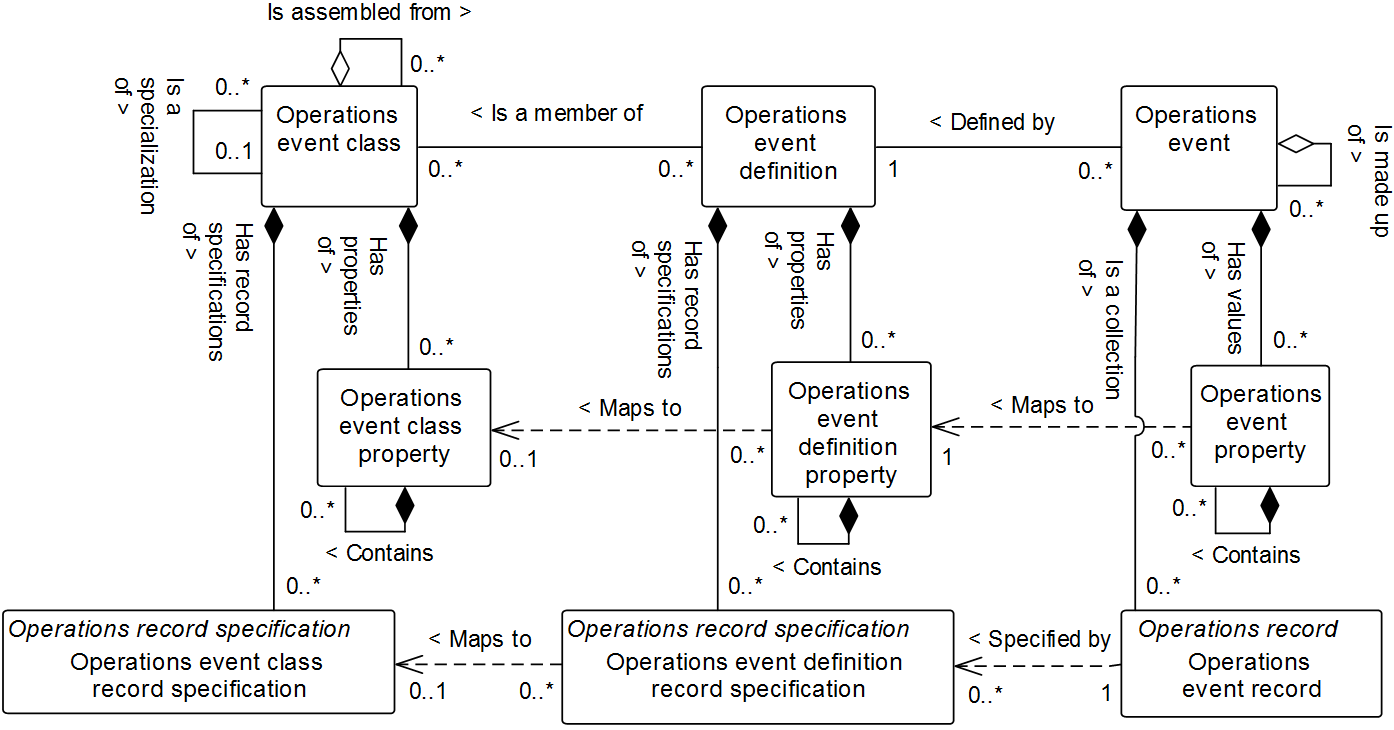


Figure 18 - Operations event model

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

NOTE 2 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* include the attributes of the abstract object, *operations record*.

NOTE 3 The operations record model is specialized in 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* include the attributes of the abstract *operations record specification*.

Table 115 – 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 | Is a specialization 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 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 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 record | Operations event class record specification | Dependency | Specified by > |

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. ISA-95, 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 116 defines the relationship roles for the *operations event class*. Table 117 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 116 - Operations event class relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations event class | Operations event class child | 0..\* | The nested *operations event class(s)* makes up part of this *operations event class as the whole*. |
| Operations event class | Abstract Operations event class | 0..1 | The abstract *operations event class* upon which this *operations event class* is based. The *operations event class* of which this *operations event class* is a specialization*.* |
| Operations event class | Contained Operations event class | 0..\* | The child *operations event classes* contained within this *operations event class*. |
| Operations event definition | NA | 0..\* | 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..\* | The *operations event class* *property(s)* of this *operations event class.* |
| Operations event class record specification | Operations event class record specification | 0..\* | The operations event class record specification(s) related to this operations event class. |

Table 117 - Attributes of operations event class

| Attribute names | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the associated *operations event class.* | Production, Deviation Alarm | Maintenance | MyOrg:Quality | MyOrg:Inventory |
| Description | Additional information and description about the *operations event class.* |  |  |  |  |
| Extension | Defines constraints on the inclusion of the respective *operations event class* in a hierarchy.  Defined value:  sealed - no entry can use this entry as its parent.  NOTE 1 *Extension* may contain a set of entries of other *operations event classes* who are allowed to represent this entry in their parent.  NOTE 2 No entry allows any entry to represent this entry as its parent /ancestor. | Sealed | NA | Sealed | NA |

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

EXAMPLE Table 118 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 118 – 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 A ‘*’plant manager’* *operations event class* has its parent class set to the ‘*approval level’* *operations event class*. An *operations event* declaring the event is a member of the ‘*plant manager*’ *operations event class* infers that it also is a member of the ‘*approval level’*. The *operations event class properties* and *operations event class record specifications* that defined the ‘*approval level’ 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 119 defines the relationship roles for the *operations event class property*. Table 120 defines the attributes for *operations event class property*.

Table 119 - Operations event class property relationship roles

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

Table 120 - 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*. | 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 |
| 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 may be empty if any value is valid. | 99387A | 105 | 88765 | 1856 |
| Value unit of measure | The unit of measure of the associated property values, if applicable. | 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 121 defines the relationship roles for the *operations event class record specification*. Table 122 defines the attributes for the *operations event class record specification*.

Table 121 - Operations event class record specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations event class | NA | 1 | The *operations event class* defined in part by this *operations event definition record specification.* |
| Operations event definition record specification | NA | 0..\* | 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*. |

Table 122 - Operations event class record specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the *operations event class record specification.* | CR-87 | Uuid - 1FCF9DA1-DCC5-4012-BDEF-D76C754F4826 | 2016-03 | AB45 |
| Description | Contains additional information and description of the *operations event class record specification*. |  |  |  |  |
| Information object type | Permitted set of information objectsallowed in the *operations* *record* occurrence.  NOTE 1 An *operations record entry* contains the attributes to the information object for operations record.  NOTE 2 An unconstrained set of values can be represented with the \* entry. | [Equipment, Personnel], | [JobList] | [TestSpecfication, Test Results] | [Material Lot, Material Sublot], |
| Information object type | Permitted set of information objects allowed in the *operations record* occurrence.  NOTE 1 An *operations record entry* contains the attributes to the information object for *operations record*.  NOTE 2 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* allowed in the *operations record* occurrence.  NOTE 1 If no limit is explicitly specified, the unbounded keyword is specified.  NOTE 2 If no *multiplicity* entry is specified, this is equivalent to no constraint, i.e.: {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* *object* in the *operations record* by the publisher.  Defined values for *action* are  *Added, changed, deleted, observed*  NOTE 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* occurrence.  NOTE 1 If no limit is explicitly specified, the unbounded keyword is specified.  NOTE 2 If no *multiplicity* entry is specified, this is equivalent to no constraint, i.e.: {Min: 0, Max: Unbounded}. | {Min: 1, Max: 1} | {Min:0, Max: 1} | {Min:0, Max: 10} | {Min:1, Max: Unbounded} |

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

1. *Operations event class record specification*
2. *Operations event definition record specification*
3. *Operations event record*

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

1. Created Create or add new entries
2. Changed Update or edit existing entries
3. Deleted Delete/deactivate/remove existing entries

### 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 123 defines the relationship roles for the *operations event definition*. Table 124 defines the attributes for the *operations event definition*.

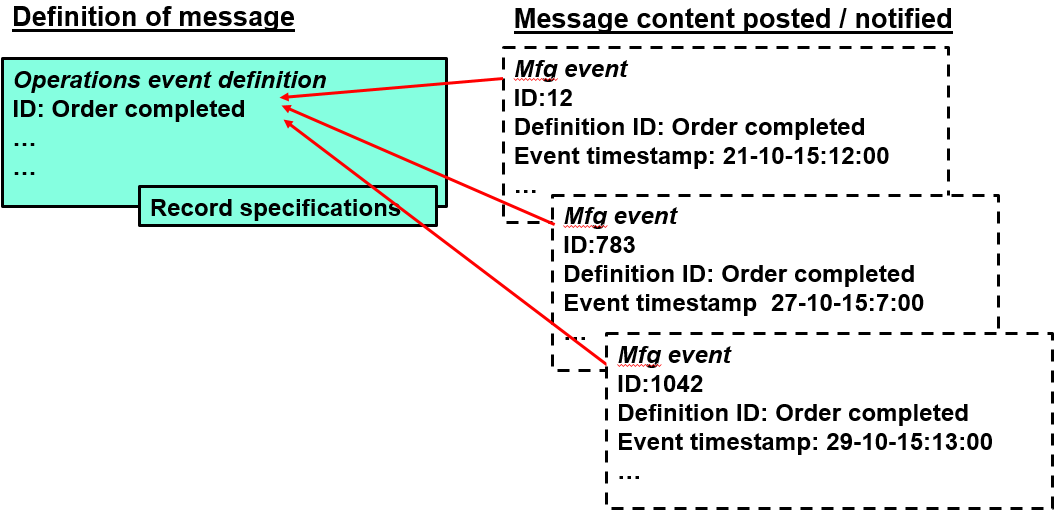


Figure 19 - Relationship of operations event definition with operations events

NOTE 1 *Operations event class and definition record specifications* provide explicit specification of the allowed content of *operations event record* attributes contained in an operations event occurrence.

NOTE 2 An *operations event record* is validated against the corresponding *operations event class and definition record specification*.

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

<OperationEvent>

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

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 3 Some attributes in the *operations event* occurrence are also represented in the corresponding *operations event definition*. The representation of attributes in the *operations event* explicitly provides 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 may not be accessible in some environments).

Table 123 - Operations event definition relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations event | NA | 0..\* | 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..\* | *Operations event classes* 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 this *operations event class*. |
| Operations event definition record specification | Operations event definition record specification | 0..\* | The *operations event definition record specification(s)* related to this *operations event definition.* |
| Operations event definition property | Operations event definition property | 0..\* | The *operations event definition property(s)* specifies this *operations event definition.* |

Table 124 - Operations event definition attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification of the *operations event definition*. | 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.*  The defined values are  Event, alert, 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  Level 3, Level 4 | 4 | 4 | 3 | 3 |
| Operations type | Describes the category of operation.  Required attribute.  Defined values  Production, inventory, quality, maintenance, mixed.  “Mixed” shall be used when the operations schedule contains several types of operations requests and/or segment requirements. | Production | Maintenance | Quality | Inventory |
| Function | Defines the *MOM function* of the *operations event* publisher.  Defined values  Part 3 MOM Activity Model defined values  Resource management, definition management, detailed scheduling, dispatching, execution management, data collection, performance analysis, tracking,  Part 1 Functional Model defined values for enterprise functions  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 | Detailed Scheduling | Dispatching | Analysis | Tracking |
| *Category* | General grouping associated with an *operations event definition.*  EXAMPLE *Scheduling, PM, Lab, Receiving* | Scheduling | Calibration | At Line Analysis | Receiving |
| Source | The activity that generated the *operations event*.  NOTE This is 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 The purpose of specifying an acknowledgement in an *operations event definition* is to satisfy application-level requirements for acknowledgement of an *operations event*. There will always 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 is considered an infrastructure consideration of the messaging implementation.

EXAMPLE A *operations event definition* for an *operations event type* “Alarm” may be defined for the purpose of 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 125 defines the relationship roles for the *operations event definition property*. Table 126 defines the attributes for the *operations event definition property*.

Table 125 - Operations event definition property relationship roles

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

Table 126 - 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*. | 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 |
| 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 may be empty if any value is valid. | 99387A | 105 | 88765 | 1856 |
| Value unit of measure | The unit of measure of the associated property values, if applicable. | 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 127 defines the relationship roles for the *operations event definition record specification*. Table 128 defines the attributes for the *operations event definition record specification*.

Table 127 - Operations event definition record specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations event definition | NA | 1 | The *operations event definition(s)* defined in part by this *operations event definition record specification*. |
| Operations event record | NA | 1 | 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 | 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*. |

Table 128 - Operations event definition record specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Identification within the associated *operations event definition* *specification*.  *Operations event* instances will include this value with their *operations event record* object to enable recognition / 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 event definition record specification*. |  |  |  |  |
| Information object type | Permitted set of information objectsallowed in the *operations* *record* occurrence.  NOTE 1 An *operations record entry* contains the attributes to the information object for operations record.  NOTE 2 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* allowed in the *operations record* occurrence.  NOTE 1 If no limit is explicitly specified, the unbounded keyword is specified.  NOTE 2 If no *multiplicity* entry is specified, this is equivalent to no constraint, i.e.: {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* *object* in the *operations record* by the publisher.  Defined values for *action* are  *Added, changed, deleted, observed*  NOTE 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* occurrence.  NOTE 1 If no limit is explicitly specified, the unbounded keyword is specified.  NOTE 2 If no *multiplicity* entry is specified, this is equivalent to no constraint, i.e.: {Min: 0, Max: Unbounded}. | {Min: 1, Max: 1} | {Min:0, Max: 1} | {Min:0, Max: 10} | {Min:1, Max: Unbounded} |

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 attribute, information object multiplicity, 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, changed) 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 ‘deleted’.

NOTE 1 If the attribute, information object multiplicity, is 0..1, the specified *operations event record* is optional.

NOTE 2 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 ISA-95 information exchanges 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 *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:

1. Self-contained All information relating to the context of the *operations event* is contained in the *operations event* message.
2. 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 129 defines the relationship roles for the *operations event*. Table 130 defines the attributes for the *operations event*.

Table 129 - Operations event relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations event record | Operations event record | 0..\* | The *operations event record*s related to this *operations event*. |
| Operations event property | Operations event property | 0..\* | The *operations event property* values of this *operations event.* |
| Operations event definition | Operations event definition | 1 | The *operations event definition* that defines the structure and generic context of the *operation event* message. |
| Operations event | Associated event child | 0..\* | 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 130 - Operations event attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Unique identification of the *operations event*. | P\_0004293 | M32D | 834 | Inven88 |
| Description | Additional information and description of the event occurrence. | The order P894 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, 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.* The defined values are:  Event, alert, 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:  Level 3, Level 4 | 4 | 4 | 3 | 3 |
| Operations type | Describes the category of operation.  Required attribute.  Defined values: Production, inventory, quality, maintenance, mixed.  “Mixed” shall be used when the operations schedule contains several types of operations requests and/or segment requirements. | Production | Maintenance | Quality | Inventory |
| Function | Defines the *MOM function* of the *operations event* publisher.  Defined values:  Part 3 MOM Activity Model defined values:  Resource management, definition management, detailed scheduling, dispatching, execution management, data collection, performance analysis, tracking,  Part 1 Functional Model defined values for enterprise functions:  Order processing, operations scheduling, operations control, material and energy control, procurement, quality assurance, product inventory control, product cost accounting, product shipping administration, maintenance management, marketing and sales, R&D, engineering | Detailed Scheduling | Dispatching | Analysis | Tracking |
| Category | General grouping associated with an *operations event definition*.  EXAMPLE Scheduling, PM, Lab, Receiving | Scheduling | Calibration | At Line Analysis | Receiving |
| Source | The activity, function, task or phase that generated the *operations event*.  EXAMPLES  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 1 Reporting of source operations event

When an *operations event* (*Definition ID: Job Order Started*) is generated during the execution of a job order, the ID of the associated ‘Work Dispatched’ *operations event* that contained the job order information can be represented as an associated *operation event ID* in the associated *operations event* list.

EXAMPLE 2 Detailed Scheduling

When a ‘Work Dispatched’ *operation event* is published after detailed scheduling of an ‘Operations Scheduled’ operations event, the ‘Work Dispatched’ *operations event* can reference the original ‘Operations Scheduled’ *operations event ID* as an associated *operations event ID* in the associated *operations event* list.

EXAMPLE 3 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 may 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.

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 …) e.g.: List boxes in HMI. *Operations alerts* may be generated by any Level 4 or 2 action or activity related to Level 4 or Level 3 manufacturing operations activities.
2. A *operations alarm* which is distinguished from other *operations events* and may specify an acknowledgement *operations event* from subscribers. The acknowledgement is generated as a separate notification.

NOTE 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 131 defines the relationship roles for the *operations event property*. Table 132 defines the attributes for the *operations event property*.

Table 131 - Operations event property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations event | NA | 1 | This *operations event property(s)* values in part for the *operations event as the whole.* |
| Operations event definition property | *Operations* event definition property | 1 | 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..\* | The nested *operations event property(s)* makes up part of this *operations event property* as the whole |

Table 132 - Operations event property attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification of the specific *operations event property.* | 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 |
| 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 manufacturing operations management event shall be defined as an *operations event record*.

Table 133 defines the relationship roles for the *operations event record*. Table 134 defines the attributes for the *operations event record*.

Table 133 - Operations event record relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations event | NA | 1 | 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..\* | 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 | 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* |

Table 134 - Operations event record attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Unique identification of the *operations event record.* | 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 |  |  |  |  |  |
| Effective timestamp | The date and time for which the *operations event record* and its *action* was/is effective.  NOTE 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*.  NOTE 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 Actions may be recorded or be available at times after the real-world event took place. Recipients of the *operations event* may have a different record of information objects at the time reported for the *operations event* occurrence due to external factors.

NOTE 2 The effective timestamp attribute explicitly states the time of the real-world event. The record timestamp attribute explicitly states the time that the publisher/sender took the reported *action*.

NOTE 3 If there are multiple *actions* recorded, the times these *actions* occurred may 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 fully qualified name (FQN) syntax to avoid *ID* collisions.

## Containers, tools and software

### Containers

A container for *material* shall be presented as role based *equipment, physical asset,* or both of type storage zone or storage unit.

EXAMPLE 1 In a refinery; bulk storage tanks would be represented as storage units and as containers for specific *materials*.

EXAMPLE 2 In an automotive plant; assembly parts bins would 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 would be represented as storage units for a specific *material lot* or *material sublot.*

EXAMPLE 4 In rail transportation; wagons may be represented as *physical assets*, assembled into rakes and trains.

EXAMPLE 5 Properties of containers would 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 may 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 defines in a *work definition*.

*Work definitions* are defined as the information used to instruct a manufacturing operation how to perform the operation. Production operations specific operations instructions may be called a general, site or master recipe (IEC 61512 series), standard operating procedure (SOP), standard operating conditions (SOC), master or product routing, or assembly steps based on the production strategy used.

An *operations definition* may be a specialization of another *operations definition*. An *operations definition* shall be defined as abstract or concrete. An abstract *operations definition* defines a ‘template’, upon which other abstract or concrete *operations definitions* may be based. Unlike concrete *operations definitions*, abstract *operations definitions* shall not be directly scheduled or tracked. Therefore, *operations requests* and *operations responses* shall not reference abstract *operations definitions*.

Where an *operations definition* references a *work master*, the definition type (abstract or concrete) 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 abstract *operations definition* upon which the *operations definition* is based.

EXAMPLE An abstract *operations definition* may reference an *operations material bill* that contains items referencing *material classes*, while a concrete *operations definition* based on this abstract *operations definition* may reference an *operations material bill* that contains items referencing *material definitions* belonging to those *material classes*.

EXAMPLE A mining organization could define the following abstract and concrete *operations definitions*.

Loading (abstract)

1. Train Loading (abstract), specialization of Loading (abstract)
2. Ship Loading (abstract), specialization of Loading (abstract)
3. Site S1 Train Loading (concrete), specialization of Train Loading (abstract)
4. Site S2 Ship Loading (concrete), specialization of Ship Loading (abstract)

NOTE Abstract *operations definitions* provide a basis for standardization and reuse of abstract *operations definitions* across many concrete *operations definitions* across and between plants.

Figure 20 illustrates the operations definition model. Table 135 lists the relationships of the objects in the operations definition model.

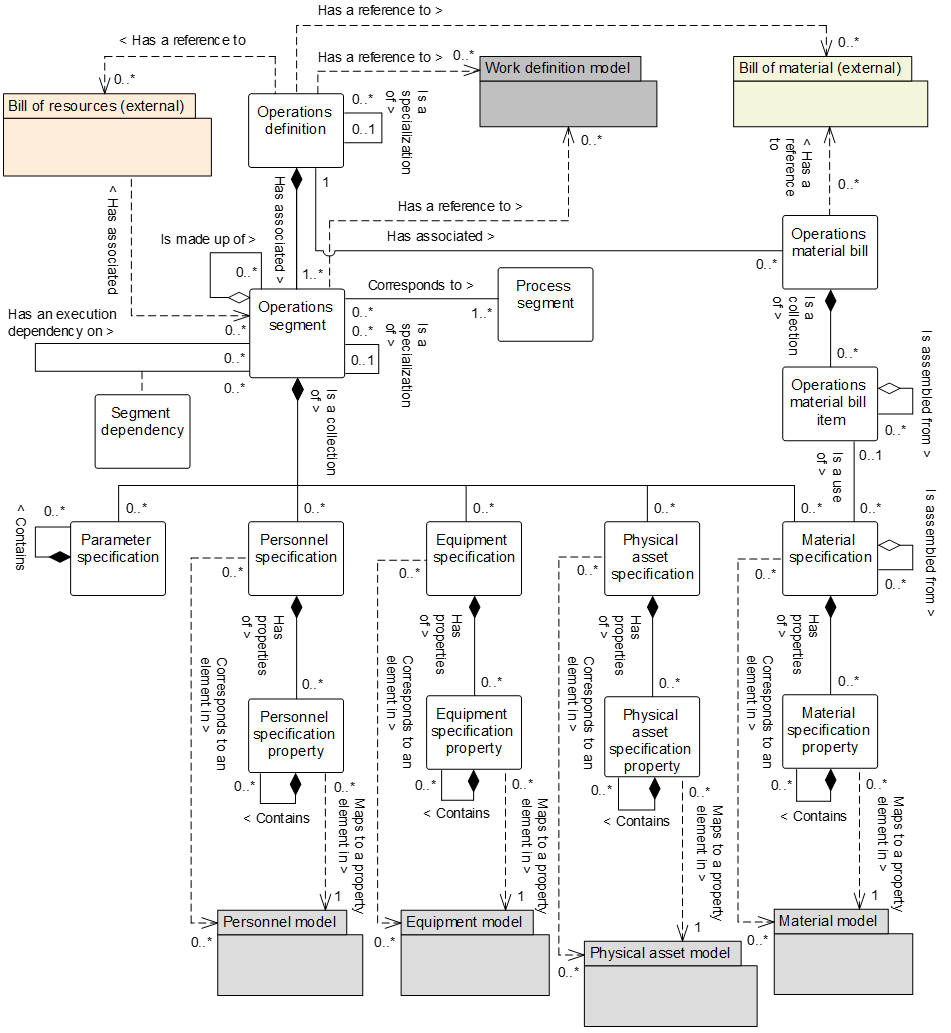


Figure 20 – Operations definition model

Table 135 – Operations definition model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations definition | Operations definition | Association | Is a specialization of > |
| Operations definition | Operations material bill | Association | Has associated > |
| Operations definition | Operations segment | Composition whole | Has associated > |
| Operations definition | Bill of resources (external) | Dependency | Has reference to > |
| Operations definition | Work definition model | Dependency | Has reference to > |
| Operations definition | Bill of material (external) | Dependency | Has reference to > |
| Operations segment | Segment dependency | Aggregation class hierarchy | Has an execution dependency on > |
| Operations segment | Operations segment | Aggregation class hierarchy | Has an execution dependency on > |
| Operations segment | Operations segment | Aggregation hierarchy | Is made up of > |
| Operations segment | Operations segment | Association | Is a specialization of > |
| Operations segment | Process segment | Association | Corresponds to > |
| Bill of resources (external) | Operations segment | Dependency | Has associated > |
| Operations segment | Work definition model | Dependency | Has reference to > |
| Operations segment | Parameter specification | Composition whole | Is a collection of > |
| Operations segment | Personnel specification | Composition whole | Is a collection of > |
| Operations segment | Equipment specification | Composition whole | Is a collection of > |
| Operations segment | Physical asset specification | Composition whole | Is a collection of > |
| Operations segment | Material specification | Composition whole | Is a collection of > |
| Operations material bill | Operations material bill item | Composition whole | Is a collection of > |
| Operations material bill | Bill of material (external) | Dependency | Has a reference to > |
| Operations material bill item | Operations material bill item | Aggregation hierarchy | Is assembled from > |
| Operations material bill item | Material specification | Association | Is a use of > |
| Parameter specification | Parameter specification | Composition hierarchy | Contains > |
| 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 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 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 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 > |
| Material specification property | Material sublot property | Dependency (D) | Maps to > |
| Material specification | Material specification | Aggregation hierarchy | Is assembled from > |

### Operations definition

The resources required to perform a specified operation shall be presented as an *operations definition*.

Table 136 defines the relationship roles for the *operations definition*. Table 137 defines the attributes for the *operations definition*.

Table 136 – Operations definition relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations segment | Operations segment | 1..\* | The detailed information needed to quantify a specific *operation definition.* |
| Operations definition | Abstract Operations definition | 0..1 | The abstract *operations definition* upon which this *operations definition* is based. The *operations definition* of which this *operations definition* is a specialization*.* |
| Operations definition | Contained operations definition | 0..\* | The child *operations definitions* contained within this *operations definition.* |
| Work Master (Part 4) | Work master | 0..\* | This *operations definition(s)* is applied in zero to many *work masters*. |
| Bill of resources (external) | Bill of resources (external) | 0..1 | Identification of the external *bill of resource* associated with this *operation definition*. |
| Bill of material (external) | Bill of material (external) | 0..1 | Identification of the *external bill of material* associated with this *operation definition.* |
| Operations Material bill | Operations Material bill | 0..\* | Identification of the *operations material bill* associated with this *operations definition*. |

Table 137 – Operations definition attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| ID | Uniquely identifies the *operations definition.*  The ID shall be 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” shall 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*. The defined types are  Abstract – An *operations definition* used as a template for other *operations definitions*.  Concrete – An *operations definition* that may be directly scheduled and tracked. | Abstract | Concrete | Concrete | Abstract |

NOTE 1 In the case of production, an operations definition ID can 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 138 defines the relationship roles for the *operations material bill*. Table 139 defines the attributes for the *operations material bill*.

Table 138 – Operations material bill relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations definition | NA | 1 | Identification of the *operations definition* associated with this *operations material bill*. |
| Bill of material | Bill of material | 0..1 | Identification of the *bill of material* associated with this *operations material bill*. |
| Operations material bill item | Operations material bill item | 0..\* | The *material bill items* that are part of this *operations material bill*. |

Table 139 – Operations material bill attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a *manufacturing* *bill*. | 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 |

### 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 140 defines the relationship roles for the *operations material bill item*. Table 1413 defines the attributes for the *operations material bill item*.

Table 140 – Operations material bill item relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations definition | NA | 1 | Identification of the *operations definition* associated with this *operations material bill*. |
| Operations material bill | NA | 1 | The *operations material bill* that this *material bill item* is a part. |
| Operations material bill item | Operations material bill item child | 0..\* | The *operations material bill item(s)* makes up part of this *operations material bill item* as the whole. |
| Material specification | Material specification | 0..\* | The *material specification(s)* defines this specified *operation material bill item(s).* |

Table 141 – Operations material bill item attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a *bill* item. | 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 | Optional Defines the type of the assembly. The 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. The 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, if applicable. | {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*.

An abstract *operations segment* defines a ‘template’, upon which other abstract or concrete *operations segments* may be based. Unlike concrete *operations segments*, abstract *operations segments* shall not be directly scheduled or tracked. Therefore, *segment requirements*, *segment responses* and *operations segment capabilities* shall not reference abstract *operations segments*.

*Operations segments* shall assume the definition type (abstract or concrete) of the *operations definition* to which they belong. Therefore, all *operations segments* contained within an abstract *operations definition* shall be assumed to be abstract, while all *operations segments* contained within a concrete *operations definition* shall be assumed to be concrete.

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 abstract *operations segment* upon which the *operations segment* is based.

EXAMPLE An abstract operations segment may contain material specifications that reference material classes, while a concrete operations segment based on this abstract operations segment may contain material specifications that reference material definitions belonging to those material classes.

Table 142 defines the relationship roles for the *operations segment*. Table 143 defines the attributes for the *operations segment*.

Table 142 – Operations segment relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations definition | NA | 1 | A collection information required to perform the specified operation.  EXAMPLE 1  *- Material Bill*  *- Bill of Resources*  *- Work Definition* |
| Operations segment | Abstract Operations segment | 0..1 | The abstract *operations segment* upon which this *operations segment* is based. The *operations segment* of which this *operations segment* is a specialization*.* |
| Operations segment | Contained operations segment | 0..\* | The child *operations segments* contained within this *operations segment.* |
| Process segment | Process segment | 1..\* | 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 definition (Work master) | Work master | 0..\* | *Work masters* related to this *operations segment.*  Information used to instruct **how** to perform the operation based on strategy used.  EXAMPLE 1  - Master recipe  - Routing  - Assembly steps  - Standard operating procedure (SOP)  - Standard operation condition (SOC)  - Work Master |
| Operations segment | Operations segment child | 0..\* | *Operations segment(s)* makes up part of this *operations segment* as the whole. |
| Segment dependency | Segment dependency | 0..\* | 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) | NA | 0..1 | Identification of the *external bill of material* associated with this *operation definition.* |
| Parameter specification | Parameter specification | 0..\* | The *parameter specifications* related to this *operations segment.* |
| Personnel specification | Personnel specification | 0..\* | The *personnel specifications* related to this *operations segment.* |
| Equipment specification | Equipment specification | 0..\* | The *equipment specifications* related to this *operations segment.* |
| Physical asset specification | Physical asset specification | 0..\* | The *physical asset specifications* related to this *operations segment.* |
| Material specification | Material specification | 0..\* | The *material specifications* related to this *operations segment.* |

Table 143 – 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.  The ID shall be 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.  Required attribute.  Defined values are: Production, maintenance, quality, inventory, or mixed.  “Mixed” shall be used when the *operations segment* contains several types of *operations requests* and/or *segment requirements*. | Production | Maintenance | Quality | Inventory |

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*.

NOTE Examples of *parameter specifications* are pH of 3.5, pressure limit of 35 psi, and flange color = orange.

*Parameter specifications* shall include

1. an identification of the parameter;
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 Ranges can be alarm or quality ranges; tolerances for acceptable parameter values.

Table 144 defines the relationship roles for the *parameter specification*. Table 145 defines the attributes for the *parameter specification*.

Table 144 – Parameter specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations Segment | NA | 1 | The *operations segment(s)* is a part of this *parameter* *specification*. |
| Parameter specification | Parameter specification child | 0..\* | The *parameter specification(s)* that are part of this *parameter specification*. |

Table 145 – Parameter specification attributes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| ID | Identification of the *parameter* for a specific segment*.* | 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 |
|  |  |  |  |  |  |
| 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, if applicable. | 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;
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 146 defines the relationship roles for the *personnel specification*. Table 147 defines the attributes for the *personnel specification*.

Table 146 – Personnel specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations segment | NA | 1 | The *operations segment* that is in part defined by this *personnel* *specification*. |
| Personnel specification property | Personnel specification property | 0..\* | The *personnel specification property(s)* of this *personnel* *specification*. |
| Personnel class | Personnel class | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |
| Person | Person | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |

Table 147 – Personnel specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *personnel segment specification.* | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Personnel class | Identifies the associated *personnel class* or set of *personnel classes* of the specification for a specific segment. | Widget Polisher | Diesel mechanic grade 2 | Lab Tech II | warehouse manager |
| Person | Identifies the associated *person* or set of *persons* of the specification for a specific segment. | 999-12-3456 | DMG2 422 | LT-101 | 999-99-9999 |
| 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*. | Allocated | Allocated | Allocated | Allocated |
| Quantity | Specifies the amount of personnel resources required for the parent segment, if applicable. | 0,25 | 2 | 1 | 0,000 1 |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | person hours | People | Tech | Man years |

NOTE A *personnel specification* may 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*.

NOTE Examples of *personnel specification properties* are training level required, specific skill required, and exposure availability.

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

Table 148 defines the relationship roles for the *personnel specification property*. Table 149 defines the attributes for the *personnel specification property*.

Table 148 – Personnel specification property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Personnel specification property | Personnel specification property | 0..\* | The *personnel specification property(s)* of this *personnel* *specification property*. |
| Personnel specification | NA | 1 | The *personnel specification property(s)* of this *personnel* *specification property*. |
| Personnel class property | Personnel class property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |
| Person property | Person property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |

Table 149 – 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. | 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 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, if applicable. | {Apprentice, Journeyman, Master} | Skill Level | Skill Level | Degree |
| Quantity | Specifies the amount of personnel resources required for the parent segment, if applicable. | 0,10 | 2 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | 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;
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 150 defines the relationship roles for the *equipment specification*. Table 151 defines the attributes for the *equipment specification*.

Table 150 – Equipment specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations segment | NA | 1 | This *equipment* *specification* is a part of the *operations segment*. |
| Equipment specification property | Equipment specification property | 0..\* | The *equipment specification property(s)* of this *equipment* *specification*. |
| Equipment class | Equipment class | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |
| Equipment | Equipment | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |

Table 151 – Equipment specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *equipment specification.* | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Equipment class | Identifies the associated *equipment class* or set of *equipment classes* of the specification for a specific segment. | Widget Polishing Machine | Drill | GCMS | 5000 LB CAP SS containment vessel |
| Equipment | Identifies the associated *equipment* or set of *equipment* of the specification for a specific segment. | WPM-10 | 18 VDC Hand Drill #5 | GCMS-#1001 | VC#5 |
| 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, if applicable. | 0,5 {shared between two segments} | 1 | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | Each | Each | Each | Each |

NOTE An *equipment specification* may specify both a spatial definition and an operational location 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*.

NOTE Examples of *equipment specification properties* are material of construction, maximum material capacity, and minimum heat extraction amount.

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

Table 152 defines the relationship roles for the *equipment specification property*. Table 153 defines the attributes for the *equipment specification property*.

Table 152 – Equipment specification property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Equipment specification property | Equipment specification property | 0..\* | The *equipment specification property(s)* of this *equipment* *specification property*. |
| Equipment specification | NA | 1 | The *equipment specification property(s)* of this *equipment* *specification property*. |
| Equipment class property | Equipment class property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |
| Equipment property | Equipment property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |

Table 153 – 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. | 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. For example: wet, dry | 190 ~ 240 | 20 to 40 | He | 316 |
| Value unit of measure | The unit of measure of the associated property value, if applicable. | Volts | mm | <n/a> | Composi-tion |
| Quantity | Specifies the amount of equipment resources required for the parent segment, if applicable. | n/a | 2 | 0,5 | n/a |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | 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;
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 154 defines relationship roles for the *physical asset* *specification*. Table 155 defines attributes of the *physical asset specification*.

Table 154 – Physical asset specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations segment | NA | 1 | The *operations segment* defined in part by this *physical asset specification*. |
| Physical asset specification property | Physical asset specification property | 0..\* | The *physical asset specification property(s)* of this *physical asset specification*. |
| Physical asset class | Physical asset class | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset | Physical asset | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |

Table 155 – 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.* | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Physical asset class | Identifies the associated *physical asset class* or set of *physical asset classes* of the specification for a specific segment. | Polishing Machine | Torque Wrench | GCMS | IBC |
| Physical asset | Identifies the associated *physical asset* or set of *physical assets* of the specification for a specific segment. | 20090121 | 100 N-m Torque Wrench | Model GCMS100 | Model IBC-SS-5K |
| 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, if applicable. | 1,25 | 2 | 1 | 5 000 |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | Minutes / piece | Each | Each | Each |

NOTE A *physical asset specification* may specify both a spatial definition and a physical location 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 156 defines the relationship roles for the *physical asset specification property*. Table 157 defines the attributes for the *physical asset specification property*.

Table 156 – Physical asset specification property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Physical asset specification property | Physical asset specification property | 0..\* | The *physical asset specification property(s)* of this *physical asset* *specification property*. |
| Physical asset specification | NA | 1 | The *physical asset specification property(s)* of this *physical asset* *specification property*. |
| Physical asset class property | Physical asset class property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset property | Physical asset property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |

Table 157 – 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. | 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. For example: wet, dry | Wet | 10-80 | < 1 | Top bung |
| Value unit of measure | The unit of measure of the associated property value, if applicable. | (not applicable) | ft. lbs. | ppm | (not applicable) |
| Quantity | Specifies the amount of physical asset resources required for the parent segment, if applicable. | 0,10 | 1 | 1 | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | 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;
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 158 defines the relationship roles for the *material specification*. Table 159 defines attributes for the *material specification*.

Table 158 – Material specification relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations segment | NA | 1 | The *operations segment* defined in part by this *material specification*. |
| Material segment specification property | Material specification property | 0..\* | The *material specification property(s)* of this *material specification*. |
| Material specification | Material specification child | 0..\* | The related object(s) makes up part of this *material specification* as the whole. |
| Operations material bill item | NA | 0,,1 | This *material specification*(s) defines the specified *operation material bill item*. |
| Material class | Material class | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |
| Material | Material | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |

Table 159 – Material specification attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *material specification.* | PS1-Employee 23 | PS1-22828 | PS1-999-123-4567 | PS1-007 |
| Material class | Identifies the associated *material class* or set of *material classes* of the specification for a specific segment\* | Abrasives | Impeller | Reference gas | Bung |
| Material definition | Identifies the associated *material definition* or set of *material definition* of the specification for a specific segment\* | Rouge | Motor-Impeller Subassembly | Nitrous Oxide 10 ppm | 2” bung |
| 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*.  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 material use.  Defined values for production operations are:  Consumable, material consumed, and material produced, by-product produced, and co-product produced, yield produced.  Defined values for maintenance operations are:  Consumable, replaced asset, replacement asset.  Defined values for quality operations are:  Consumable, sample, returned sample.  Defined values for inventory operations defined values are:  Consumable, carrier, returned carrier, inventoried. | Consumable | Consumable | Consumable | Consumable |
| Quantity | Specifies the amount of material resources required for the parent segment, if applicable. | 10 | 1 | 1,5 | 1 |
| Quantity unit of measure | The unit of measure of the associated property value, if applicable. | gm / piece | each | Liter | Each |
| Assembly type | Optional Defines the type of the assembly. The 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. The 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* or *material definition* is specified. | | | | | |

NOTE A *material specification* may specify a spatial definition in addition to a storage location 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*.

NOTE Examples of *material specification properties* are color range, density tolerance, and maximum scrap content.

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

Table 160 defines the relationship roles for the *material specification property*. Table 161 defines the attributes for the *material specification property*.

Table 160 – Material specification property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material specification property | Material specification property | 0..\* | The *material specification property(s)* of this *material specification property*. |
| Material specification | NA | 1 | The *material specification property(s)* of this *material specification property*. |
| Material class property | Material class property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |
| Material property | Material property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |

Table 161 – 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. | 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, if applicable. | Grit Number | Pitch | Ppb | Grade |
| Quantity | Specifies the amount of material resources required for the parent segment, if applicable. | 5 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated property value, if applicable. | 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 162 lists the relationship roles of the *segment dependency*. Table 163 lists the attributes of the *segment dependency*.

Table 162 – Segment dependency relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations segment | Operations segment from | 0..\* | The source *operations segments* that the *target operations segments* are dependent. |
| Operations segment | Operations segment to | 0..\* | The target *operations segments* that are dependent on *source operations segments*. |

Table 163 – 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*. | 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 operationssegment | Defines the sequence for replacing an impeller | Defines sampling sequence | Defines IBC sealing |
| Dependency type | Defines the execution dependency constraints of one segment by another segment. | Start *Acid Addition* no later than *T* (*Timing Factor*) after *Reaction Complete* end | Start disassembly after lock-out and tag-out segments are complete | Start calibration gas X minutes after purge gas ends | Insert and secure bung after IBC filling complete |
| Dependency factor | Factor used by dependency | 25 | <True, False> | 50 | <True, False> |
| Unit of measure | The units of measure of the *dependency factor*, if defined. | Minutes | Boolean | Minutes | Boolean |

EXAMPLE 2 Dependency type using A and B to identify the segments, or specific resources within the segments, and T to identify the timing factor, as shown in Figure 12, include the following:

* B cannot follow A
* B can run in parallel to A
* B cannot run in parallel to A
* start B at A start
* Start B after A start
* Start B after A end
* Start B no later than T (*dependency factor* with time T) after A start
* Start B no earlier than T (*dependency factor* with time T) after A start
* Start B no later than T (*dependency factor* with time T) after A end
* Start B no earlier than T *(dependency factor* with time T) after A end

NOTE The associations to the A and B segments are not represented as attributes, as per 4.5.6.

## Operations schedule information

### Operations schedule model

A request for operations to be performed is an *operations schedule*. The schedule may apply to scheduling of production, maintenance, quality test, and inventory operations.

Figure 21 is the operations schedule model. Table 164 lists the relationships of the objects in the operations schedule model.

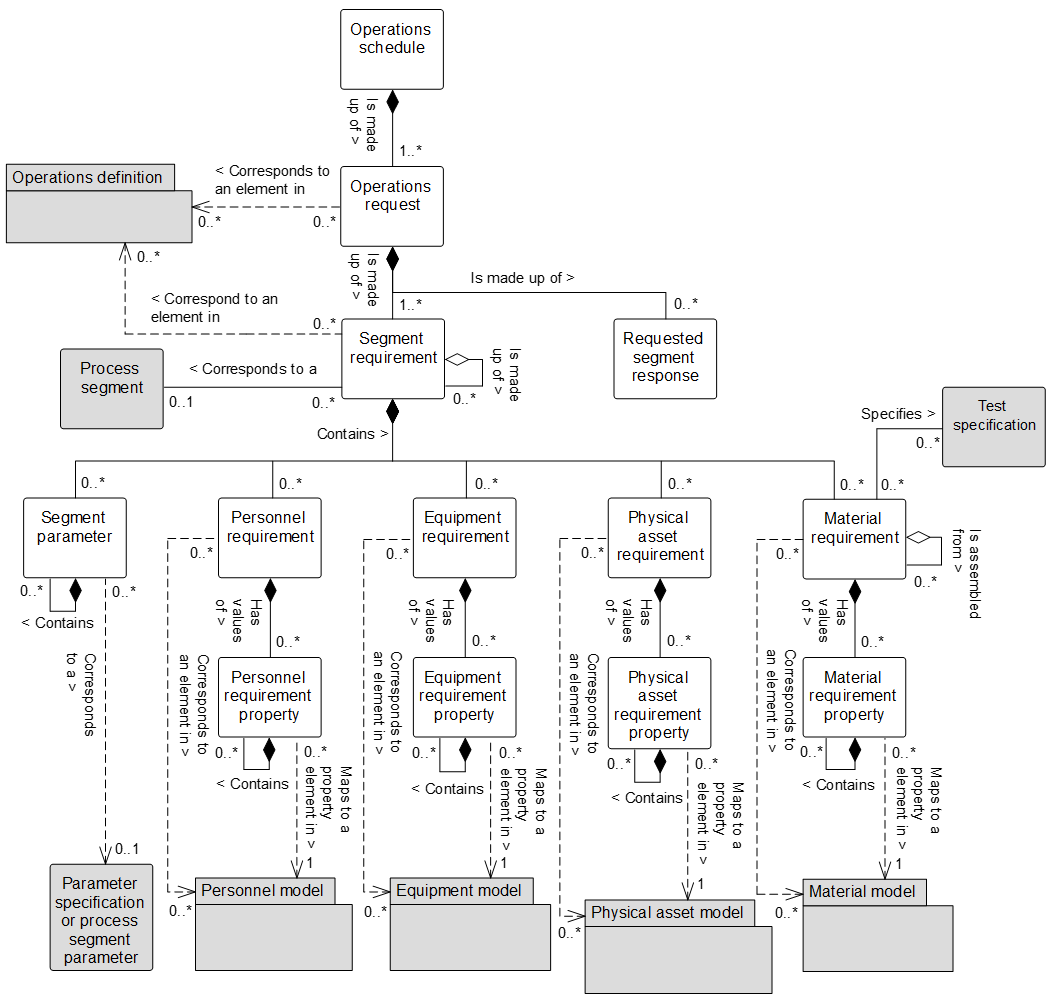


Figure 21 – Operations schedule model

Table 164 – Operations schedule model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations schedule | Operations request | Composition whole | Is made up of > |
| 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 | Dependency | Corresponds to an element in > |
| Segment requirement | Operations definition | Dependency | Corresponds to an element in > |
| Segment requirement | Process segment | Association | Corresponds to > |
| Segment requirement | Segment requirement | Aggregation hierarchy | Is made up of > |
| Segment requirement | Parameter specification | 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 > |
| Parameter specification | Parameter specification | Composition hierarchy | Contains > |
| 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 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 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 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 > |
| Material requirement property | Material sublot property | Dependency (D) | Maps to > |
| Material requirement | Material requirement | Aggregation hierarchy | Is assembled from > |
| Material requirement | Test specification | Association | Specifics > |

### 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 165 defines the relationship roles for the *operations schedule*. Table 166 defines the attributes for the *operations schedule*.

Table 165 – Operations schedule relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations request | Operations request | 1..\* | The *operations requests* that make up the *operations schedule*. |

Table 166 – 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.  The ID shall be 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. Required attribute. Defined values are:  Production, maintenance, quality, inventory, and mixed.  “Mixed” shall 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*, if applicable. | 10-28-2006 | 10-27-2006 | 10-28-2006 | 10-28-2006 |
| End time | The ending time for the associated *operations schedule*, if applicable. | 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, paused, closed. | Completed | Closed | Running | Paused |

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 attribute, scheduled state, from earlier versions of ANSI/ISA-95.00.02 has been deprecated and replaced with schedule state attribute.

NOTE 3 The defined values for state attributes for the following objects shall be clarified as the “principal name” per ISA-95.00.07, enterprise/control system integration – alias service model: *Operations schedule, operations request, segment requirement, operations performance, operations response,* and *segment response*.

NOTE 4 The ISA-95 standard does 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 must already have an agreement via an implementation mfg profile for the state model definitions. ISA-95-based exchanges transact the current state as a value/enumeration. The sending and receiving applications are “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:

Forecast – The requirements have not been released for use.

EXAMPLE This may 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.

Released – The requirements have been released for use.

Cancelled – A scheduling decision has been taken to cancel the requirements prior to commencement of execution.

Ready – Necessary pre-conditions have been met and the job orders or activities are ready to run.

Running – Job orders or activities are in execution.

Completed – Job orders or activities have been completed and are no longer in execution.

Aborted – An execution decision has been taken to terminate the job orders or activities that may, or may not, have been previously commenced.

Held – Job orders or activities have been temporarily stopped due to a constraint of some form.

Paused – Job orders or activities have been temporarily stopped due to a deliberate decision within execution.

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;
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 167 defines the relationship roles for the *operations request*. Table 168 defines the attributes for the *operations request*.

Table 167 – Operations request relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations schedule | NA | 1 | The *operations schedule object* defined in part by this *operations request*. |
| Requested segment response | Requested segment response | 0..\* | The *requested information to be* returned in *segment responses* during the processing / execution of this this *operations request.* |
| Operations definition | Operations definition | 0..\* | The *operations definition* reference that corresponds to this *operations request* if applicable. |
| Operations segment | Operations segment | 0..\* | The associated *operations segment*s reference that corresponds to this operations request if applicable. 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..\* | The segment *requirements* related to this *operations request.* |

Table 168 – Operations request attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of the *operations request*.  The ID shall be 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. Required attribute.  Defined values are:  Production, maintenance, quality, inventory, and mixed.  “Mixed” shall be used when the operations request contains several types of operations requests. | Production | Maintenance | Quality | Inventory |
| Start time | When operation is to be started, if applicable. | 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, if applicable. | 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, if applicable. | 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 |
| Operations definition ID | Identifies the associated *operations definition* and/or *operations segment* to be used, if applicable. | Export Quality Widget | CNC Daily Maintenance Procedure | T48323 | BOM for Export Quality Widget |
| Request state | Indicates the state of the *operations request.*  Defined values are:  Forecast, released, cancelled, ready, running, completed, aborted, held, paused, closed. | Completed | Closed | Running | Paused |

### 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 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 169 defines the relationship roles for the *segment requirement*. Table 170 defines the attributes for the *segment requirement*.

Table 169 – Segment requirement relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations request | NA | 1 | The *operations request* is defined in part by this *segment requirement*. |
| Operations definition | Operations definition | 0.\* | The *operations definition* reference that corresponds to this *segment requirement* if applicable. |
| Operations segment | Operations segment | 0..\* | The associated *operations segment*s that corresponds to this *segment requirement* if applicable. 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 | An identification of the *operations segment* or *process segment* associated with this *segment requirement*, if applicable. |
| Segment requirement | Segment requirement child | 0..\* | The related object(s) makes up part of this *segment requirement* as the whole. |
| Segment parameter | Segment parameter | 0..\* | The *segment parameters* related to this *segment requirement.* |
| Personnel requirement | Personnel requirement | 0..\* | The *personnel requirements* related to this *segment requirement.* |
| Equipment requirement | Equipment requirement | 0..\* | The *equipment requirements* related to this *segment requirement.* |
| Physical asset requirement | Physical asset requirement | 0..\* | The *physical asset requirements* related to this *segment requirement.* |
| Material requirement | Material requirement | 0..\* | The *material requirements* related to this *segment requirement.* |

Table 170 – 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*. | 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. Required attribute. 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*, if applicable. | 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*, if applicable. | 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*, if applicable.  NOTE This should match the associated segment *duration*. | 15 | 4 | 0,5 | 2,5 |
| Duration unit of measure | The unit of measure of the duration, if applicable. | 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, paused, closed. | Completed | Closed | Running | Paused |

### 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;
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 171 defines the relationship roles for the *segment parameter*. Table 172 defines the attributes for the *segment parameter*.

Table 171 – Segment parameter relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment requirement | NA | 1 | The *segment requirement* containing this *segment parameter*. |
| Segment parameter | Segment parameter child | 0..\* | The *segment parameter(s)* that are part of this *segment parameter*. |
| Parameter specification | Parameter specification | 0..1 | References to operations definition model elements*.* |
| Process segment parameter | Process segment parameter | 0..1 | References to process segment model elements. |

Table 172 – Segment parameter attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | The identification of the *segment parameter*. | 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 |
| 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, if applicable. | 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 1 There can be a requirement for one operator with a specified level of certification available 2 h 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;
2. the quantity of *personnel* needed.

Specific elements associated with each *personnel requirement* may be included in one or more *personnel requirement properties*.

Table 173 defines the relationship roles for the *personnel requirement*. Table 174 defines the attributes for the *personnel requirement*.

Table 173 – Personnel requirement relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment requirement | NA | 1 | This *personnel* *requirement* is a part of the *segment requirement* as the whole. |
| Personnel requirement property | Personnel requirement property | 0..\* | The values in the *personnel requirement property* are for this *personnel* *requirement*. |
| Personnel class | Personnel class | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |
| Person | Person | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |

Table 174 – Personnel requirement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *personnel requirement.* | Employee 23 | 22828 | 999-123-4567 | 007 |
| Personnel class | Identifies the associated *personnel class* or set of *personnel classes* of the requirement for a specific *segment requirement*. | Widget Polisher | CNC operator | Quality Assurance Tech | Ware-house worker |
| Person | Identifies the associated *person* or set of *persons* of the requirement for a specific *segment requirement*.  Typically, either *personnel class* or *person* is specified, but not both. | Gidget | Charlie Goode | (not applicable) | Joe Wurzelbacher |
| 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.* | Allocated | Certified | Certified | Uncertified |
| Quantity | Specifies the amount of personnel resources required for the parent segment, if applicable. 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, if applicable. | Full Time Equivalents | Full Time Equivalents | Full Time Equivalents | Full Time Equivalents |

NOTE A *personnel requirement* may 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 requirement property

Specific properties that are required for *personnel requirements* shall be presented as *personnel requirement properties*.

EXAMPLE  Examples of *personnel requirement properties* are 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 175 defines the relationship roles for the *personnel requirement property*. Table 176 defines the attributes for the *personnel requirement property*.

Table 175 – Personnel requirement property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Personnel requirement | NA | 1 | The values for this *personnel requirement property* in part are for the *personnel requirement.* |
| Personnel requirement property | Personnel requirement property child | 0..\* | The values in the child *personnel requirement property* for this *personnel* *requirement*. |
| Personnel class property | Personnel class property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |
| Person property | Person property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |

Table 176 – 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*. | 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, if applicable. | (not applicable) | Boolean | Boolean | Boolean |
| Quantity | Specifies the amount of the property required for the parent *personnel requirement*, if applicable. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity, if applicable. | (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 177 defines the relationship roles for the *equipment requirement*. Table 178 defines the attributes for the *equipment requirement*.

Table 177 – Equipment requirement relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment requirement | NA | 1 | The *segment requirement* defined in part by this *equipment* *requirement*. |
| Equipment requirement property | Equipment requirement property | 0..\* | The values in the *equipment requirement property* are for this *equipment* *requirement*. |
| Equipment class | Equipment class | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |
| Equipment | Equipment | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |

Table 178 – Equipment requirement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a specific *equipment requirement*. | Jig 347 | Wldr445 | SN3883AT | VIN28203 |
| Equipment class | Identifies the associated *equipment class* or set of *equipment classes* of the requirement for a specific *segment requirement*. | Widget Polishing Machine | CNC Drill Press | Micrometer | Bar code scanner |
| Equipment | Identifies the associated *equipment* set of *equipment* of the requirement for a specific *segment requirement*.  Typically, either *equipment class* or *equipment* is specified, but not both. | WPM-19 | DP-1 | (not applicable) | (not applicable) |
| 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, if applicable. 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, if applicable. | 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* may specify both a spatial definition and an operational location 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 Examples of *equipment requirement properties* are material of construction and minimum *equipment capacity*.

*Equipment requirement properties* may contain nested *equipment requirement properties*.

Table 179 defines the relationship roles for the *equipment requirement property*. Table 180 defines the attributes for the *equipment requirement property*.

Table 179 – Equipment requirement property relationships

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Equipment requirement | NA | 1 | The values for this *equipment requirement property* in part are for the *equipment requirement.* |
| Equipment requirement property | Equipment requirement property child | 0..\* | The values in the child *equipment requirement property* for this *equipment requirement*. |
| Equipment class property | Equipment class property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |
| Equipment property | Equipment property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |

Table 180 – 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*. | 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 Wet, dry | Dry | less than 0,000 08 | Metric | <True, False> |
| Value unit of measure | The unit of measure of the associated property value, if applicable. | (not applicable) | Inches | (not applicable) | Boolean |
| Quantity | Specifies the amount of equipment requirement property required for the parent *equipment requirement*, if applicable. | 1 | (not applicable) | 1 | 1 |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | 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 181 defines the relationship roles for the *physical asset requirement*. Table 182 defines the attributes for the *physical asset requirement*.

Table 181 – Physical asset requirement relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment requirement | NA | 1 | The *segment requirement* defined in part by this *physical asset requirement*. |
| Physical asset requirement property | Physical asset requirement property | 0..\* | The values in the *physical asset requirement property* are for this *physical asset* *requirement*. |
| Physical asset class | Physical asset class | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset | Physical asset | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |

Table 182 – 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.* | SN5246$9 | SN68928#1 | SN5247$3 | VIN 55262528 |
| Physical asset class | Identifies the associated *physical asset model* or set of *physical asset models* of the requirement for a specific *segment requirement*. | (not applicable) | Model 105, XYZ Corp, CNC Drill Press | (not applicable) | (not applicable) |
| Physical asset | Identifies the associated *physical asset* or set of *physical assets* of the requirement for a specific *segment requirement*.  Typically, either *physical asset* or *physical asset class* is specified, but not both. | (not applicable) | Serial #: 5563442  Asset ID: 44Q56W | (not applicable) | (not applicable) |
| 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, if applicable. 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, if applicable. | (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* may specify both a spatial definition and a physical location where it is necessary to specify the spatial definition of the specified physical asset(s) within a given physical location.

EXAMPLE 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: Pulley belt has broken on an induced draft fan, and the belt needs to be replaced.
2. 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. Example: 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.
3. 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: Remove and replace a 25 HP centrifugal transfer pump.
4. 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: the RTD on tank 225 was re-ranged and calibrated to 0 – 200 °F.
5. 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 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 Examples of *physical asset requirement properties* are material of construction and minimum physical asset capacity.

*Physical asset requirement properties* may contain nested *physical asset requirement properties*.

Table 183 defines the relationship roles for the *physical asset requirement property*. Table 184 defines the attributes for the *physical asset requirement property*.

Table 183 – Physical asset requirement property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Physical asset requirement | NA | 1 | 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..\* | The values in the child *physical asset requirement property* for this *physical asset* *requirement*. |
| Physical asset class property | Physical asset class property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset property | Physical asset property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |

Table 184 – 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*. | (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.  EXAMPE  Wet, dry | (not applicable) | 0,000 2 | (not applicable) | (not applicable) |
| Value unit of measure | The unit of measure of the associated property value, if applicable. | (not applicable) | Inches | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of *physical asset requirement property* required for the parent *physical asset*, if applicable. | (not applicable) | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | (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 185 defines the relationship roles for the *material requirement*. Table 186 defines the attributes for the *material requirement*.

Table 185 – Material requirement relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment requirement | NA | 1 | The *segment requirement* defined in part by this *material requirement*. |
| Material requirement property | Material requirement property | 0..\* | The values in the *material requirement property* are for this *material* *requirement*. |
| Material requirement | Material requirement child | 0..\* | *The related object(s)* makes up part of this *material* *requirement* as the whole. |
| Test specification | Test specification ID | 0..\* | Identification of the *test specification* to be applied. |
| Material class | Material class | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |
| Material | Material | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |

Table 186 – Material requirement attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a specific *material requirement*, | Sheet stock 1443a | DO200cpO | OA9929 | PW882929 |
| Material class | Identifies the associated *material class* or set of *material classes* of the requirement for a specific *segment requirement*.\* | Widgets | Aluminum | Widgets | Bolt |
| Material definition | Identifies the associated *material definition* or set of *material definitions* of the requirement for a specific *segment requirement*.\* | Export Quality Widgets | Aluminum sheet | Export Quality Widgets | 10 mm bolt |
| Material lot | Identifies the associated material lot, or set of *material lots* of the requirement for a specific *segment requirement*.\* | BWLOT-2282 | DW94 | BWLOT-2282 | 4823 |
| Material sublot | Identifies the associated *material sublot,* or set of *material sublots* of the requirement for a specific *segment requirement*.\* | BWLOT-2282-A | (not applicable) | (not applicable) | A |
| 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*.  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 material use.  Defined values for production operations are:  Consumable, material consumed, material produced, by-product produced, co-product produced, yield produced.  Defined values for maintenance operations are:  Consumable, replaced asset, replacement asset.  Defined values for quality operations are:  Consumable, sample, returned Sample.  Defined values for inventory operations are:  Consumable, carrier, returned carrier, Inventoried. | Consumed | Consumed | Inspection | Consumable |
| Storage location | Identifies the proposed location of the *material,* if applicable. | Finished Goods Inventory | Rack 11 | Finished Goods Inventory | Warehouse B, Bin 42 |
| Quantity | Specifies the amount of *material* to be used, if applicable. 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. The 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. The 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.  NOTE If *material lots* (or sublots) are merged or absorbed (e.g. blended), then this is a new *material lot.* | Permanent | Transient | Permanent | Transient |
| \* Typically, either a *material class, material definition, material lot*, *or material sublot* is specified. | | | | | |

NOTE A *material requirement* may specify a spatial definition in addition to a storage location 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 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 187 defines the relationship roles for the *material requirement property*. Table 188 defines the attributes for the *material requirement property*.

Table 187 – Material requirement property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material requirement | NA | 1 | The values for this *material requirement property* in part are for the *material requirement.* |
| Material requirement property | Material requirement property child | 0..\* | The values in the child *material requirement property* for this *material* *requirement*. |
| Material class property | Material class property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |
| Material property | Material property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |

Table 188 – 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*. | 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. For 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, if applicable. | (not applicable) | Feet | cm | (not applicable) |
| Quantity | Specifies the amount of material to be produced, if applicable. | 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 on 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 on from operations, such as operator-entered comments.

## Operations performance information

### Operations performance model

*Operations performance* is a report 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 189 lists the relationships of the objects in the operations performance model.

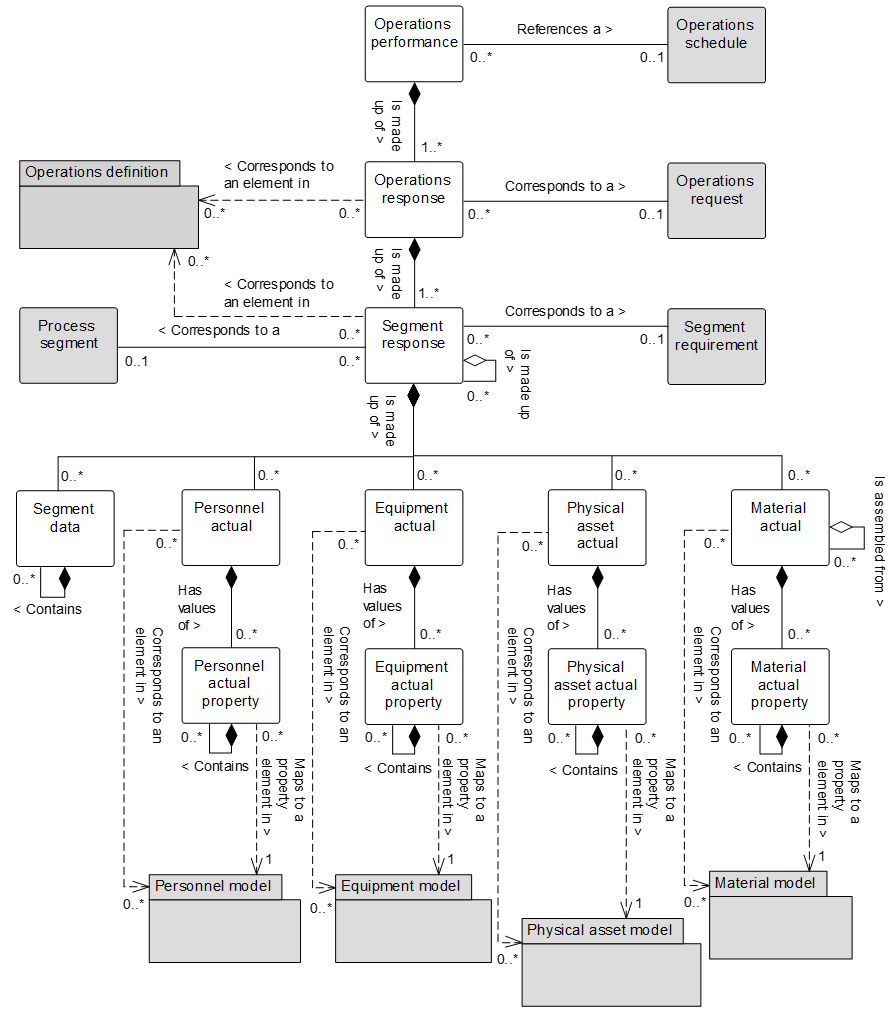


Figure 22 – Operations performance model

Table 189 – 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 a > |
| Operations response | Segment response | Composition whole | Is made up of > |
| Operations response | Operations request | Association | Corresponds to a > |
| Operations response | Operations definition | Dependency | Corresponds to an element in > |
| Segment response | Operations definition | Dependency | Corresponds to an element in > |
| Segment response | Process segment | Association | Corresponds to > |
| Segment response | Segment response | Aggregation hierarchy | Is made up of > |
| 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 property | Composition whole | Has values of > |
| Personnel actual property | Personnel actual property | Composition hierarchy | Contains > |
| 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 property | Composition whole | Has values of > |
| Equipment actual property | Equipment actual property | Composition hierarchy | Contains > |
| 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 property | Composition whole | Has values of > |
| Physical asset actual property | Physical asset actual property | Composition hierarchy | Contains > |
| 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 property | Composition whole | Has values of > |
| Material actual property | Material actual property | Composition hierarchy | Contains > |
| 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 > |
| Material actual property | Material sublot property | Dependency (D) | Maps to > |
| Material actual | Material actual | Aggregation hierarchy | Is assembled from > |

### 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 190 defines the relationship roles for the *operations performance*. Table 191 defines the attributes for the *operations performance*.

Table 190 – Operations performance relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations response | Operations response | 1..\* | The *operations responses* that make up part of this *operations performance* as the whole. |
| Operations schedule | Operations schedule | 0..1 | An identification of the associated *operations schedule,* if applicable.  *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 191 – 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.  The ID shall be 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. Required attribute. Defined values are:  Production, maintenance, quality, inventory, or mixed.  “Mixed” shall 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*, if applicable. | 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*, if applicable. | 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, paused, 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. Paused – *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 192 defines the relationship roles for the *operations response*. Table 193 defines the attributes for the *operations response*.

Table 192 – Operations response relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations performance | NA | 1 | The *operations performance is defined in part by* this *operations response.* |
| Operations request | Operations request | 0..1 | The *operations request* that corresponds to this *operations respons*e if it exists or is relevant. |
| Operations definition | Operations definition | 1 | The *operations definition* that corresponds to this *operations respons*e if it exists or is relevant. |
| Segment response | Segment response | 1..\* | The *segment responses* related to this *operations response.* |

Table 193 – Operations response attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | An identification within the associated *operations response*.  The ID shall be 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. Required attribute. Defined values are:  Production, maintenance, quality, inventory, or mixed.  “Mixed” shall 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, paused, 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,* 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 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 194 defines the relationship roles for the *segment response*. Table 195 defines the attributes for the *segment response*.

Table 194 – Segment response relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment | Process segment | 0..1 | The *process segment that* corresponds to this *segment response.* |
| Operations definition | Operations definition | 0..\* | The *operations definition(s) that* corresponds to this *segment response.* |
| Segment requirement | Segment requirement | 0..\* | The *segment requirement*(s) that corresponds to this segment response. |
| Segment response | Segment response child | 0..\* | The related object(s) makes up part of this *segment response* as the whole. |
| Operations response | NA | 1 | This *segment response* is a part of the *operations response* as the whole. |
| Segment data | Segment data | 0..\* | The *segment data* related to this *segment response.* |
| Personnel actual | Personnel actual | 0..\* | The *personnel actuals* related to this *segment response.* |
| Equipment actual | Equipment actual | 0..\* | The *equipment actuals* related to this *segment response.* |
| Physical segment actual | Physical segment actual | 0..\* | The *physical asset actuals* related to this *segment response* |
| Material actual | Material actual | 0..\* | The *material actuals* related to this *segment response.* |

Table 195 – Segment response attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Uniquely identifies an instance of a *process segment* executed.  NOTE The same *process 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. Required attribute. 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 that should be used for posting resource actuals to supporting applications.  EXAMPLE *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 *operations response.* Defined values are:  Waiting, ready, running, completed, aborted, held, paused, 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 196 defines the relationship roles for the *segment data*. Table 197 defines the attributes for the *segment data*.

Table 196 – Segment data relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment response | Segment response | 1 | The *segment response* defined in part by this *segment data.* |
| Segment data | Segment data child | 0..\* | The *segment data(s)* that is part of this *segment data* as the whole. |

Table 197 – Segment data attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | The identification of the *segment data*. | 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, if applicable. | 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 In operational functions, people are often 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*.

NOTE Examples of *personnel actual properties* are

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;*
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 198 defines the relationship roles for the *personnel actual*. Table 199 defines the attributes for the *personnel actual*.

Table 198 – Personnel actual relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment response | NA | 1 | This *personnel* *actual* is a part of the *segment response* as the whole. |
| Personnel actual property | Personnel actual property | 0..\* | The values in the *personnel actual property* are for this *personnel* *actual*. |
| Personnel class | Personnel class | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |
| Person | Person | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |

Table 199 – Personnel actual attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | A unique identification of a specific *personnel actual*. | Employee 23 | 22828 | 999-123-4567 | 007 |
| Personnel class | Identifies the associated *personnel class* or set of *personnel classes* actually used for a specific *segment response*. | Widget Polisher | CNC operator | [not applicable | Warehouse worker |
| Person | 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. | Gadget | (not applicable) | 261343 | Sara Feye |
| 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 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 actual use of the *personnel class* or *person*. | Allocated | Certified | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of personnel resources used in the parent segment, if applicable. 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, if applicable. | Full Time Equivalents | Full Time Equivalents | Full Time Equivalents | Full Time Equivalents |

NOTE A *personnel actual* may 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 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 200 defines the relationship roles for the *personnel actual property*. Table 201 defines the attributes for the *personnel actual property*.

Table 200 – Personnel actual property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Personnel actual | NA | 1 | The values for this *personnel actual property* in part are for the *personnel actual.* |
| Personnel actual property | Personnel actual property child | 0..\* | The values in the child *personnel actual property* for this *personnel* *actual*. |
| Personnel class property | Personnel class property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |
| Person property | Person property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |

Table 201 – 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*. | 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, if applicable. | (not applicable) | Boolean | Boolean | (not applicable) |
| Quantity | Specifies the amount of personnel resources used in the parent segment, if applicable. | 0,25 | (not applicable) | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity, if applicable. | 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 In operations functions, *equipment* are often 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*.

NOTE Examples of *equipment actual properties* are

– the actual duration of use of the *equipment* during the *operations segment*; this information is often needed for actual costing analysis;

– 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;

– the equipment set-up procedures used for the **operations segment**; this information is often needed for actual costing analysis and scheduling feedback;

– other equipment attributes, such as percentage of available capability used.

Table 202 defines the relationship roles for the *equipment actual*. Table 203 defines the attributes for the *equipment actual*.

Table 202 – Equipment actual relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment response | NA | 1 | The *segment response* containing in part this *equipment* *actual*. |
| Equipment actual property | Equipment actual property | 0..\* | The values in the *equipment actual property* are for this *equipment* *actual*. |
| Equipment class | Equipment class | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |
| Equipment | Equipment | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |

Table 203 – Equipment actual attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Defines a unique identification of a specific *equipment actual*. | Jig 347 | Wldr445 | SN3883AT | VIN28203 |
| Equipment class | Identifies the associated *equipment class* or set of *equipment classes* actually used for a specific *segment response*. | Widget Polishing Machine | CNC Drill Press | (not applicable) | (not applicable) |
| Equipment | 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. | WPM-20 | DP-1 | (not applicable) | (not applicable) |
| 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, if applicable. 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, if applicable. | Machine Hours | Machine | (not applicable) | (not applicable) |

NOTE An *equipment actual* may specify both a spatial definition and an operational location 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 204 defines the relationship roles for the *equipment actual property*. Table 205 defines the attributes for the *equipment actual property*.

Table 204 – Equipment actual property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Equipment actual | NA | 1 | The values for this *equipment actual property* in part are for the *equipment actual.* |
| Equipment actual property | Equipment actual property child | 0..\* | The values in the child *equipment actual property* for this *equipment actual*. |
| Equipment class property | Equipment class property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |
| Equipment property | Equipment property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |

Table 205 – 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*. | 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, if applicable. | (not applicable) | Number of Holes | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of equipment resources used in parent segment, if applicable | 0,05 | 2 | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity, if applicable. | 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 In operations functions physical asset are often 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 206 defines the relationship roles for the *physical asset actual*. Table 207 defines the attributes for the *physical asset actual*.

Table 206 – Physical asset actual relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment response | NA | 1 | The *segment response* as whole defined in part by this *physical asset* *actual*. |
| Physical asset actual property | Physical asset actual property | 0..\* | The values in the *physical asset actual property* are for this *physical asset* *actual*. |
| Physical asset class | Physical asset class | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset | Physical asset | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |

Table 207 – 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.* | SN5246$9 | SN68928#1 | SN5247$3 | VIN 55262528 |
| Physical asset class | Identifies the associated *physical asset class* or set of *physical asset classes* actually used for a specific *segment response*. | (not applicable) | CNC Drill Press | (not applicable) | (not applicable) |
| Physical asset | 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. | (not applicable) | Serial #: 5563442  Asset ID: 44Q56W | (not applicable) | (not applicable) |
| 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. Examples for maintenance operations:  Repaired, removed, replacement, calibrated, modified, improved | (not applicable) | Calibrated | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of equipment resources used in parent segment, if applicable. 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, if applicable. | (not applicable) | Machine | (not applicable) | (not applicable) |

NOTE A *physical asset actual* may specify both a spatial definition and a physical location 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 208 defines the relationship roles for the *physical asset actual property*. Table 209 defines the attributes for the *physical asset actual property*.

Table 208 – Physical asset actual property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Physical asset actual | NA | 1 | 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..\* | The values in the child *physical asset actual property* for this *physical asset* *actual*. |
| Physical asset class property | Physical asset class property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset property | Physical asset property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |

Table 209 – 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*. | 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 segment. | 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, if applicable. | (not applicable) | Inches | (not applicable) | (not applicable) |
| Quantity | Specifies the amount of physical asset resources used in parent segment, if applicable | 0,05 | 2 | (not applicable) | (not applicable) |
| Quantity unit of measure | Identifies the unit of measure of the quantity, if applicable. | 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 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 210 defines the relationship roles for the *material actual*. Table 211 defines the attributes for the *material actual*.

Table 210 – Material actual relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Segment response | NA | 1 | The *segment response* defined as the whole in part by this *material* *actual*. |
| Material actual property | Material actual property | 0..\* | The values in the *material actual property* are for this *material* *actual*. |
| Material actual | Material actual child | 0..\* | *The related object(s)* makes up part of this *material* *actual* as the whole. |
| Material class | Material class | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |
| Material | Material | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |

Table 211 – Material actual attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| ID | Define a unique identification of a specific *material actual*. | Sheet stock 1443a | DO200cpO | OA9929 | PW882929 |
| Material class | Identifies the associated *material class* or set of *material classes* actually made for a specific *segment response*.\* | Widgets | Aluminum | (not applicable) | Bolt |
| Material definition | Identifies the associated *material definition* or set of *material definitions* actually made for a specific *segment response*.\* | Export Quality Widgets | Aluminum sheet | (not applicable) | 10 mm bolt |
| Material lot | Identifies the associated *material lot* or set of *material lots* actually made for a specific *segment response*.\* | BWLOT-2282 | DW94 | (not applicable) | 4857 |
| Material sublot | Identifies the associated *material sublot* or set of *material sublots* actually made for a specific *segment response*.\* | BWLOT-2282-A | DW94-3 | (not applicable) | 4857F |
| 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*. 1 | 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 material use.  Defined values for production operations are:  Consumable, consumed, produced, by-product produced, co-product produced, yield produced.  Defined values for maintenance operations are:  Consumable, replaced asset, replacement asset  Defined values for quality operations are:  Consumable, sample, returned sample  Defined values for inventory operations are:  Consumable, carrier, returned carrier, 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, if applicable. | Units | Sheet | (not applicable) | Each |
| Assembly type | Optional: Defines the type of the assembly. The 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. The 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* may specify a spatial definition in addition to a storage location 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 212 defines the relationship roles for the *material actual property*. Table 213 defines the attributes for the *material actual property*.

Table 212 – Material actual property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material actual | NA | 1 | The values for this *material actual property* in part are for the *material actual.* |
| Material actual property | Material actual property child | 0..\* | The values in the child *material actual property* for this *material* *actual property*. |
| Material class property | Material class property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |
| Material property | Material property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |

Table 213 – Material actual property attributes

| 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*. | 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.  EXAMPE  Red, orange, yellow, green, blue, indigo, violet. | Red | 3 x 5 | (not applicable) | 316 Stainless |
| Value unit of measure | The unit of measure of the associated property value, if applicable. | 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, if applicable. | 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 test and inventory. Table 214 lists the relationships of the objects in the operations capability model.

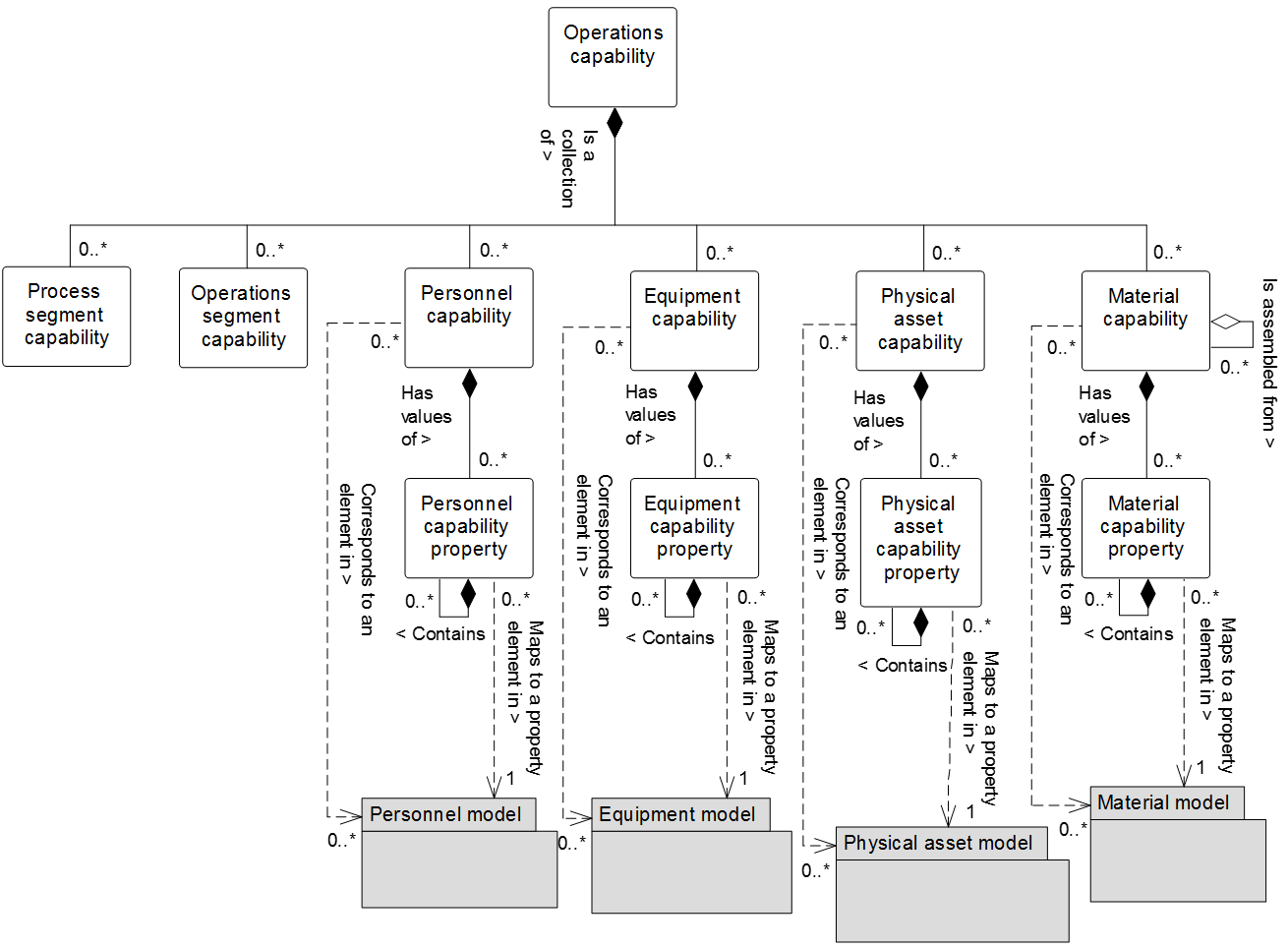


Figure 23 – Operations capability model

Table 214 – Operations capability model relationships

| From | To | Type | Relationship Name |
| --- | --- | --- | --- |
| Operations capability | Process segment capability | Composition whole | Contains > |
| Operations capability | Operations segment capability | Composition whole | Contains > |
| Operations capability | Personnel capability | Composition whole | Contains > |
| Operations capability | Equipment capability | Composition whole | Contains > |
| Operations capability | Physical asset capability | Composition whole | Contains > |
| Operations capability | Material capability | Composition whole | Contains > |
| Material capability | Material capability | Aggregation hierarchy | Is assembled from > |
| 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 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 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 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 > |
| Material capability property | Material sublot property | Dependency (D) | Maps to > |

### Operations capability

A collection of *personnel capabilities, equipment capabilities, physical asset capabilities, material capabilities*, and *process segment capabilities*, for a given slice of time (past, current, or future), shall be presented as an *operations capability*.

Table 215 defines the relationship roles for the *operations capability*. Table 216 defines the attributes for the *operations capability*.

Table 215 – Operations capability relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment capability | Process segment capability | 0..\* | The *process segment capability(s)* related to this *operations capability.* |
| Operations segment capability | Operations segment capability | 0..\* | The *operations segment capability(s)* related to this *operations capability.* |
| Personnel capability | Personnel capability | 0..\* | The *personnel capability* related to this *operations capability.* |
| Equipment capability | Equipment capability | 0..\* | The *equipment capability* related to this *operations capability.* |
| Physical segment capability | Physical segment capability | 0..\* | The *physical asset capability* related to this *operations capability.* |
| Material capability | Material capability | 0..\* | The *material capability* related to this *operations capability.* |

Table 216 – 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*). | 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. Required attribute. Defined values are:  Production, maintenance, quality, inventory, or mixed.  “Mixed” shall 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, unattainable, available, used, unused, total.  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.  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 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 inspections | Down for inventory cycle count |
| Confidence factor | Measure of the confidence of the ability to obtain the capacity value.  EXAMPLE 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 1 Productive use for a piece of production equipment takes place when it is used to execute production operations.

EXAMPLE 2 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 3 Productive use for maintenance personnel takes place when they are performing maintenance activities. In some enterprises, this may be known as “tool time”.

EXAMPLE 4 Maintenance tools are productively used when they are used to execute maintenance activities.

EXAMPLE 5 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);
2. the time associated with the availability (for example, 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 3 horizontal drill press operators available for the third shift on 2000-02-29.

Table 217 defines the relationship roles for the *personnel capability*. Table 218 defines the attributes for the *personnel capability*.

Table 217 – Personnel capability relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations capability | NA | 1 | The *operations capability* defined in part by this *personnel capability*. |
| Personnel capability property | Personnel capability property | 0..\* | The values in the *personnel capability property* are for this *personnel* *capability* |
| Personnel class | Personnel class | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |
| Person | Person | 0..\* | A cross-model association to element in the personnel model as explained in clause 4.6.4. |

Table 218 – Personnel capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Personnel class | Identifies the associated *personnel class* of the capability. | Widget Assembly Machine Operator | CNC operator | Quality Assurance Tech | (not applicable) |
| Person | Identifies the associated *person* of the capability. | SSN 999-55-1212 | Charlie Goode | (not applicable) | (not applicable) |
| 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, unattainable, available, used, unused, total.  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.  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 1 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 capability use of the *personnel class* or person. | (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, if applicable. | 48 | 1 | 1 | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | Hours | Full Time Equivalent | Full Time Equivalent | (not applicable) |

NOTE A *personnel capability* may 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.

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 219 defines the relationship roles for the *personnel capability property*. Table 219 defines the attributes for the *personnel capability property*.

Table 219 – Personnel capability property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Personnel capability | NA | 1 | The *personnel capability* defined in part by this *personnel capability property*. |
| Personnel capability property | Personnel capability property child | o..\* | The values in the child *personnel capability property* for this *personnel capability property*. |
| Personnel class property | Personnel class property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |
| Person property | Person property | 0..\* | A cross-model dependency to element in the personnel model as explained in clause 4.6.4. |

Table 220 – 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, if applicable. | (not applicable) | Boolean | Boolean | (not applicable) |
| Quantity | Specifies the quantity of the *personnel capability* defined, if applicable. | 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 classesthat 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);
2. the time associated with the availability (for example, 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 3 horizontal drill presses currently available.

Table 221 defines the relationship roles for the *equipment capability*. Table 222 defines the attributes for the *equipment capability*.

Table 221 – Equipment capability relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations capability | NA | 1 | The *operations capability* defined in part by this *equipment* *capability*. |
| Equipment capability property | Equipment capability property | 0..\* | The values in the *equipment capability* *property* are for this *equipment* *capability*. |
| Equipment class | Equipment class | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |
| Equipment | Equipment | 0..\* | A cross-model association to element in the equipment model as explained in clause 4.6.4. |

Table 222 – Equipment capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Equipment class | Identifies the associated *equipment class* of the capability. | Widget Lathe | CNC Drill Press | Micrometer | (not applicable) |
| Equipment | Identifies the associated *equipment* of the capability. | Lathe machine 15 | DP-1 | (not applicable) | (not applicable) |
| 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, unattainable, available, used, unused, total.  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.  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 1 If 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 | 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, if applicable. | 48 | 1 | 1 | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | Hours | Machine | Tool | (not applicable) |

NOTE An *equipment capability* may specify both a spatial definition and an operational location 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 223 defines the relationships for the *equipment capability property*. Table 224 defines the attributes for the *equipment capability property*.

Table 223 – Equipment capability property relationships

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Equipment capability | NA | 1 | The *equipment capability* defined in part by this *equipment capability property*. |
| Equipment capability property | Equipment capability property child | 0..\* | The values in the child *equipment capability property* for this *equipment capability property*. |
| Equipment class property | Equipment class property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |
| Equipment property | Equipment property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |

Table 224 – 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*. | 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, if applicable. | Liters | Inches | (not applicable) | (not applicable) |
| Quantity | Specifies the quantity of the *equipment capability* defined, if applicable. | 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);
2. the time associated with the availability (for 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 225 defines the relationship roles for the *physical asset* *capability*. Table 226 defines the attributes for the *physical asset* *capability*.

Table 225 – Physical asset capability relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations capability | NA | 1 | The *operations capability* defined in part by this *physical asset capability*. |
| Physical asset capability property | Physical asset capability property | 0..\* | The values in the *physical asset capability* *property* are for this *physical asset capability*. |
| Physical asset class | Physical asset class | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset | Physical asset | 0..\* | A cross-model association to element in the physical asset model as explained in clause 4.6.4. |

Table 226 – Physical asset capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Physical asset class | Identifies the associated *physical asset class* of the capability. | Jones Model 23 Lathe | Model 105, XYZ Corp, CNC Drill Press | (not applicable) | (not applicable) |
| Physical asset | Identifies the associated *physical asset* of the capability. | Machine #99298 | Serial #: 5563442  Asset ID: 44Q56W | (not applicable) | (not applicable) |
| 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, unattainable, available, used, unused, total.  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.  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 1 If 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, if applicable. | 48 | 1 | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the associated quantity, if applicable. | Hours | Machine | (not applicable) | (not applicable) |

NOTE A *physical asset capability* may specify both a spatial definition and an operational location 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 227 defines the relationship roles for the *physical asset capability property*. Table 228 defines the attributes for the *physical asset capability property*.

Table 227 – Physical asset capability property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Physical asset capability | NA | 1 | The *physical asset capability* defined in part by this *physical asset capability property*. |
| Physical asset capability property | Physical asset capability property child | 0..\* | The values in the child *physical asset capability property* for this *physical asset capability property*. |
| Physical asset class property | Physical asset class property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |
| Physical asset property | Physical asset property | 0..\* | A cross-model dependency to element in the physical asset model as explained in clause 4.6.4. |

Table 228 – 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*. | 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, if applicable. | Liters | Inches | (not applicable) | (not applicable) |
| Quantity | Specifies the quantity of the physical asset capability defined, if applicable. | 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);
2. the time associated with the availability (for example, 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 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 229 defines the relationship roles for the *material capability*. Table 230 defines the attributes for the *material capability*.

Table 229 – Material capability relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations capability | NA | 1 | The *operations capability* defined in part by this *material capability*. |
| Material capability property | Material capability property | 0..\* | The values in the *material capability* *property* are for this *material capability*. |
| Material capability | Material capability child | 0..\* | *The related object(s)* makes up part of this *material capability* (lot or sublot) as the whole. |
| Material class | Material class | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |
| Material | Material | 0..\* | A cross-model association to element in the material model as explained in clause 4.6.4. |

Table 230 – Material capability attributes

| Attribute name | Description | Production examples | Maintenance examples | Quality examples | Inventory examples |
| --- | --- | --- | --- | --- | --- |
| Material class | Identifies the associated *material class* of the capability.\* | Lubricant Oil | Aluminum | (not applicable) | (not applicable) |
| Material definition | Identifies the associated *material definition* of the capability.\* | Lube Oil 8999 | Aluminum sheet | (not applicable) | (not applicable) |
| Material lot | Identifies the associated *material lot* of the capability.\* | 8999LU-5G | DW94 | (not applicable) | (not applicable) |
| Material sublot | Identifies the associated *material sublot* of the capability.\* | 8999LU-5G-SL15 | (not applicable) | (not applicable) | (not applicable) |
| 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, unattainable, available, used, unused, total.  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.  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 1 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 | (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*.  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 capability use of the material.  Defined values for production operations are:  Consumable, consumed, produced, by-product produced, co-product produced, yield produced.  Defined values for maintenance operations are:  Consumable, replaced asset, replacement asset  Defined values for quality operations are:  Consumable, sample, returned sample  Defined values for inventory operations are:  Consumable, carrier, returned carrier, 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, if applicable. | 155 | 1 | (not applicable) | (not applicable) |
| Quantity unit of measure | The unit of measure of the material quantity, if applicable. | Liters | Sheet | (not applicable) | (not applicable) |
| Assembly type | Optional: Defines the type of the assembly. The 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. The 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* may specify a spatial definition in addition to an operational location 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 231 defines the relationship roles for the *material capability property*. Table 232 defines the attributes for the *material capability property*.

Table 231 – Material capability property relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Material capability | NA | 1 | The *material capability* defined in part by this *material capability property*. |
| Material capability property | Material capability property child | 0..\* | The values in the child *material capability property* for this *material capability property*. |
| Material class property | Material class property | 0..\* | A cross-model dependency to element in the material model as explained in clause 4.6.4. |
| Equipment property | Equipment property | 0..\* | A cross-model dependency to element in the equipment model as explained in clause 4.6.4. |

Table 232 – 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*. | 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, if applicable. | pH | Feet | (not applicable) | (not applicable) |
| Quantity | Specifies the quantity of the *material capability* defined, if applicable. | 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);
2. the time associated with the capability (for 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 233 lists the relationships of the objects in the process segment capability model.

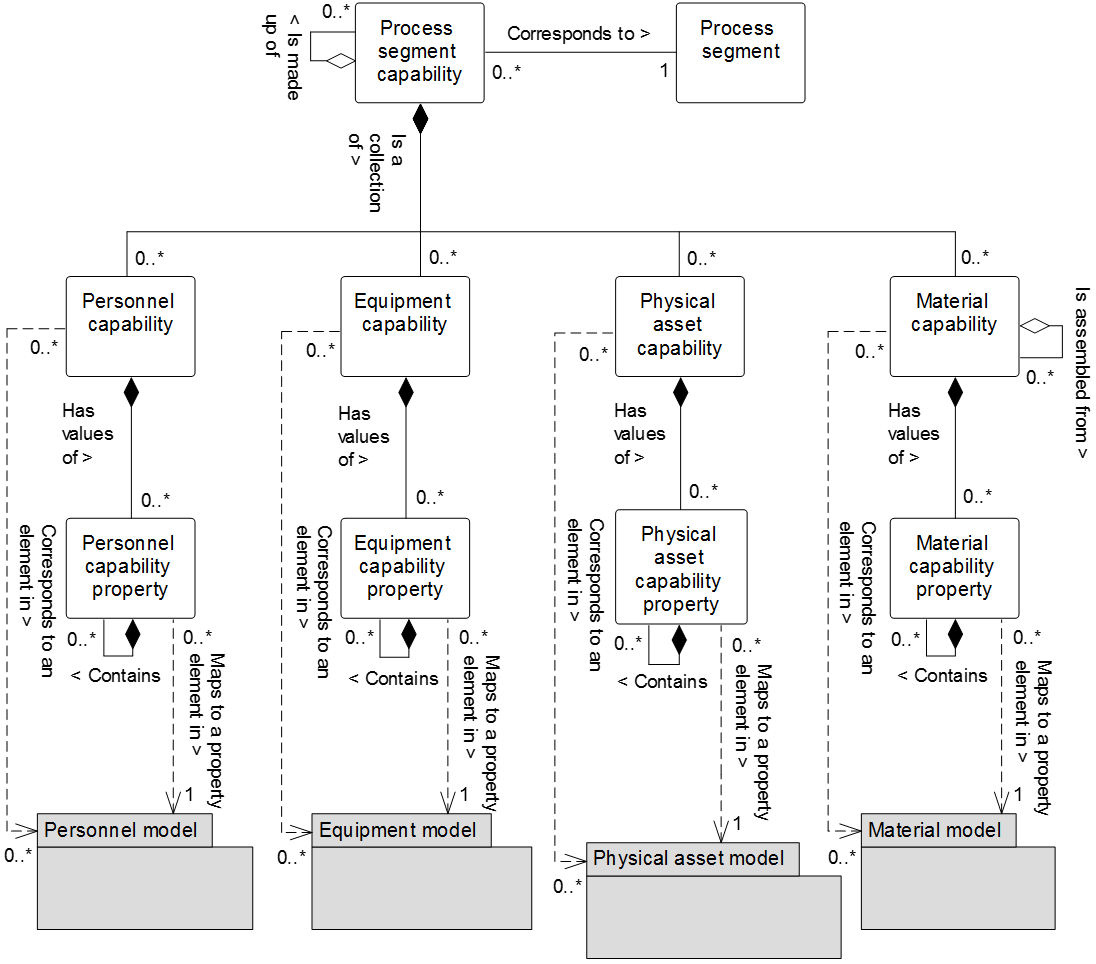


Figure 24 – Process segment capability object model

Table 233 – Operations 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 > |
| Material capability | Material capability | Aggregation hierarchy | Is assembled from > |
| 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 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 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 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 > |
| Material capability property | Material sublot 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 234 lists the relationship roles of the *process segment capability.*  Table 235 lists the attributes of the *process segment capability.*

Table 234 – Process segment capability relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Process segment | Process segment | 0..\* | The *process segment* related to this *operations capability.* |
| Process segment capability | Process segment capability child | 0..\* | The nested *process segment capability(s)* makes up part of this *process segment capability as the whole*. |
| Personnel capability | Personnel capability | 0..\* | The *personnel capability* related to this *process segment capability.* |
| Equipment capability | Equipment capability | 0..\* | The *equipment capability* related to this *process segment capability.* |
| Physical segment capability | Physical segment capability | 0..\* | The *physical asset capability* related to this *process segment capability.* |
| Material capability | Material capability | 0..\* | The *material capability* related to this *process segment capability.* |

Table 235 – 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*). | 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. Required attribute. Defined values are:  Production, maintenance, quality, inventory, or mixed.  “Mixed” shall 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, unattainable, available, used, unused, total.  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.  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 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 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);
2. the time associated with the capability (for 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*;
4. *material capabilities*, and any specific properties required in *material capability properties.*

Figure 25 is the operations segment capability model. Table 236 lists the relationships of the objects in the operations segment capability model.

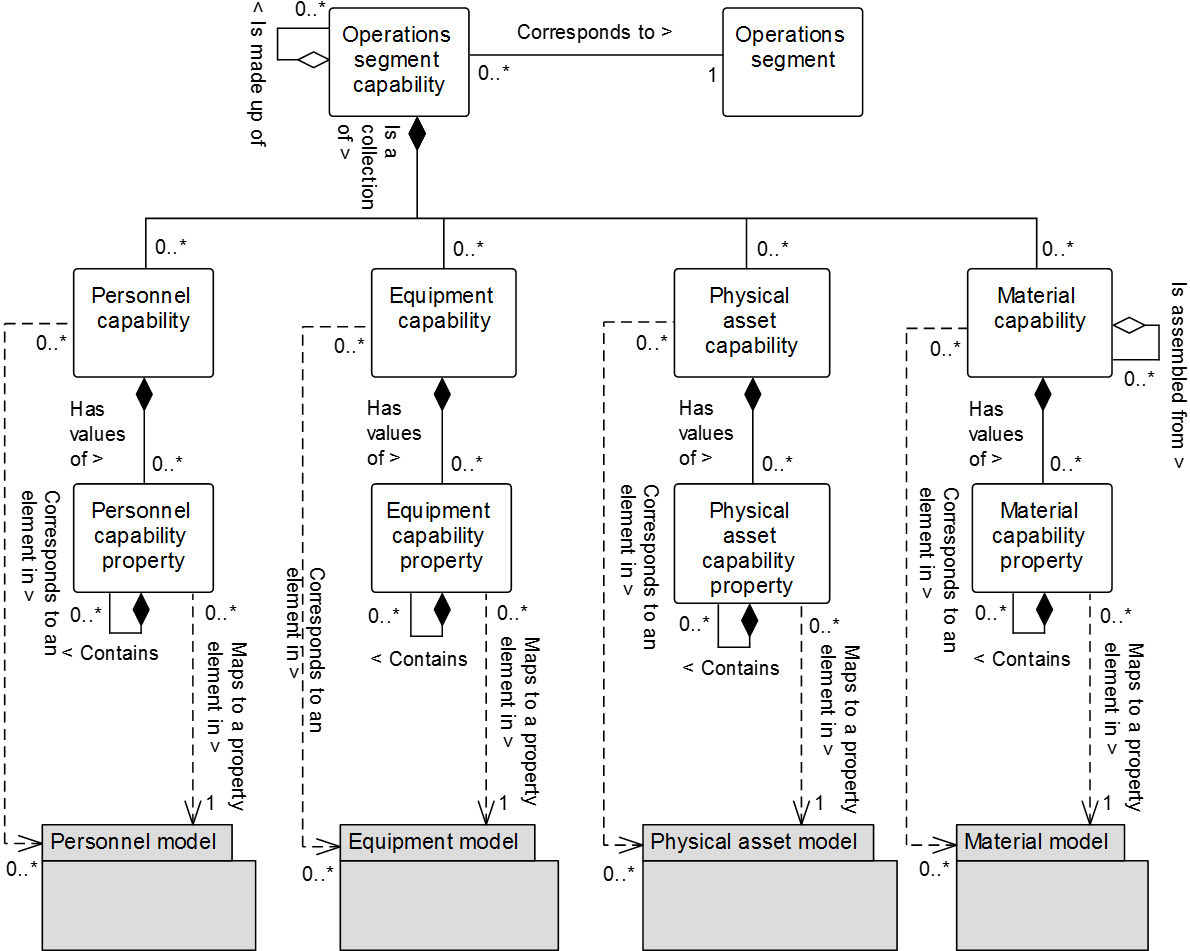


Figure 25 – Operations segment capability object model

Table 236 – 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 > |
| Material capability | Material capability | Aggregation hierarchy | Is assembled from > |
| 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 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 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 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 > |
| Material capability property | Material sublot 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 237 lists the relationship roles of the *operations segment capability.* Table 238 lists the attributes of the *operations segment capability.*

Table 237 – Operations segment capability relationship roles

| Related Object | Role | Multiplicity | Description |
| --- | --- | --- | --- |
| Operations segment | Operations segment | 0..\* | The *Operations segment* related to this *operations capability.* |
| Operations segment capability | Operations segment capability child | 0..\* | The nested *operations segment capability(s)* makes up part of this *operations segment capability as the whole*. |
| Personnel capability | Personnel capability | 0..\* | The *personnel capability* related to this *process segment capability.* |
| Equipment capability | Equipment capability | 0..\* | The *equipment capability* related to this *process segment capability.* |
| Physical segment capability | Physical segment capability | 0..\* | The *physical asset capability* related to this *process segment capability.* |
| Material capability | Material capability | 0..\* | The *material capability* related to this *process segment capability.* |

Table 238 – 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*. | 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. Required attribute. Defined values are:  Production, maintenance, quality, inventory, or mixed.  “Mixed” shall 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, unattainable, available, used, unused, total.  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.  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 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 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.*

# Object model inter-relationships

Figure 22 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.

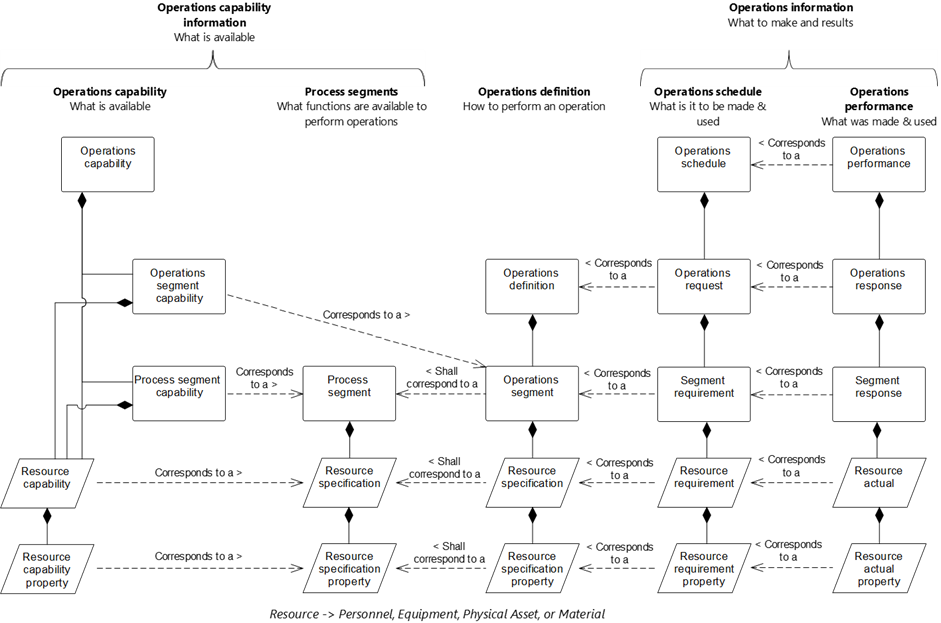


Figure 26 – Object model inter-relationships

NOTE Both resource capability properties and *operation segment*’s *operations specifications /properties* 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 239 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 239 – Model cross-reference

| ISA-95.00.01 Data flow model information | ISA-95.00.01 - From function | ISA-95.00.01 - To function | Part 2 - Object model clause |
| --- | --- | --- | --- |
| 6.5.2 Schedule | Production scheduling | Production control | 6.2 and A.2 |
| 6.5.3 Production from plan | Production control | Production scheduling | 6.3 and A.3 |
| 6.5.4 Production capability | Production control | Production scheduling | 6.4 and A.4 |
| 6.5.5 Material and energy order requirements | Material and energy control | Procurement | Described in terms of the material model, 5.4. |
| 6.5.6 Incoming order confirmation | Material and energy control | Procurement | Described in terms of the material model, 5.4. |
| 6.5.7 Long-term material and energy requirements | Production scheduling | Material and energy control | Described in terms of the material model, 5.4. |
| 6.5.8 Short-term material and energy requirements | Production control | Material and energy control | Described in terms of the material model, 5.4. |
| 6.5.9 Material and energy inventory | Material and energy control | Production control | Described in terms of the material model, 5.4. |
| 6.5.10 Production cost objectives | Product cost accounting | Production control | 6.2 and A.2 |
| 6.5.11 Production performance and costs | Production control | Product cost accounting | 6.3 and A.3 |
| 6.5.12 Incoming material and energy receipt | Material and energy control | Product cost accounting | <Not detailed in object model> |
| 6.5.13 Quality assurance results | Quality assurance | Production control | 5.4 and 6.3 |
| 6.5.14 Standards and customer requirements | Marketing and sales | Quality assurance | 6.1 and A.1 |
| Quality assurance | Production control |
| 6.5.15 Product and process requirements | Research, development, and engineering | Quality assurance | 6.1 and A.1 |
| 6.5.16 Finished goods waiver | Order processing | Quality assurance | <Not detailed in object model>  Typically unstructured information handled on an *ad hoc* basis |
| 6.5.17 In-process waiver request | Production control | Quality assurance | Described in terms of the material model, 5.4. |
| 6.5.18 Finished goods inventory | Product inventory control | Production scheduling | Described in terms of the material model, 5.4. |
| 6.5.19 Process data | Production control | Quality assurance | 6.3 and A.3 |
| 6.5.20 Pack-out schedule | Production scheduling | Product inventory control | 6.2 and A.2 |
| 6.5.21 Product and process information request | Production control | Research, development, and engineering | <Not detailed in object model> |
| 6.5.22 Maintenance requests | Production control | Maintenance management | 6.2 |
| 6.5.23 Maintenance responses | Maintenance management | Production control | 6.3 |
| 6.5.24 Maintenance standards and methods | Production control | Maintenance management | <Not detailed in object model> |
| 6.5.25 Maintenance technical feedback | Maintenance management | Production control | <Not detailed in object model> |
| 6.5.26 Product and process technical feedback | Production control | Research, development, and engineering | <Not detailed in object model> |
| 6.5.27 Maintenance purchase order requirements | Maintenance management | Procurement | <Not detailed in object model> |
| 6.5.28 Production order | Order processing | Production scheduling | <Not detailed in object model> |
| 6.5.29 Availability | Production scheduling | Order processing | <Not detailed in object model> |
| 6.5.30 Release to ship | Product shipping administration | Product inventory control | <Not detailed in object model> |
| 6.5.31 Confirm to ship | Product inventory control | Product shipping administration | <Not detailed in object model> |

# List of objects

The following tables present a complete list of the objects discussed in this standard.

Table 240 – Common resource objects

| Object | Model |
| --- | --- |
| *personnel class* | Personnel Model |
| *personnel class property* | Personnel Model |
| *Person* | Personnel Model |
| *person property* | Personnel Model |
| *qualification test specification* | Personnel Model |
| *qualification test result* | Personnel Model |
| *equipment class* | Equipment Model |
| *equipment class property* | Equipment Model |
| *Equipment* | Equipment Model |
| *equipment property* | Equipment Model |
| *equipment capability test specification* | Equipment Model |
| *equipment capability test result* | 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 |
| *physical asset capability test specification* | Physical Asset Model |
| *physical asset capability test result* | 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 |
| *material test specification* | Material Model |
| *material test result* | Material Model |
| *material assembly* | Material Model |
| *material definition assembly* | Material Model |
| *material class assembly* | 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 |
| *material segment specification assembly* | Process Segment Model |
| *process segment dependency* | Process Segment 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 |
| *material specification assembly* | Operations Definition Model |
| *operations 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 |
| *material requirement assembly* | 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 |
| *material actual assembly* | Operations Performance Model |
| *operations capability* | Operations Capability Model |
| *personnel capability* | Operations Capability Model |
| *personnel capability property* | Operations Capability Model |
| *equipment capability* | Operations Capability Model |
| *equipment capability property* | Operations Capability Model |
| *physical asset capability* | Operations Capability Model |
| *physical asset capability property* | Operations Capability Model |
| *material capability* | Operations Capability Model |
| *material capability property* | Operations Capability Model |
| *material capability assembly* | Operations Capability Model |
| *process segment capability* | Process Segment Capability 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.

This is a list of minimum criteria for a compliance assessment.

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 ISA-95 abstract model 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 ISA-95.
2. Object lifetime and relationship navigation for a specific implementation is represented in the associated documentation of the implementation (e.g. Proposed ISA-95 Part 8: Manufacturing information exchange profile currently in draft form).
3. The relationship roles from abstract ISA-95 UML models 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 ISA-95 UML model relationships table.
   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.
4. Implementation names are typically represented without spaces and have the first letter of each word capitalized.
5. Object type representation: The structure (type) of an object is represented by an object name without spaces and ‘Type’ suffix.

EXAMPLE 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 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 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 Object name = Material Lot; Object type = Material Lot Type

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 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 *Equipment Parent, Equipment child.*

1. Entry points to an intermediate object relationship (UML Nary/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 *Equipment asset mapping*. *Equipment* is an *equipment asset mapping type* which contains the identifiers and other attributes defining the relationship between objects.

1. Value syntax
   1. Value Syntax

The format for values in value attributes is not defined in this part of ISA-95 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. That 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.

ISA-95.00.01 defines the categories of information that should be exchanged between business systems and manufacturing operations and control systems. Four (4) categories are defined:

* *operations definition*
* *operations capability*
* *operations schedule*

Operations information

* *operations performance*

Each of these four (4) categories relies on the five (5) resources also defined in ISA-95.00.01.

* *personnel*
* *equipment*
* *physical asset*
* *material*
* *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). A class can for example 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, e.g., the class Car has an attribute “License plate” whereas the Instance “Mrs. Mine’s car” has the attribute “license plate= ABC 123”.

EXAMPLE Figure B.1 shows the UML model for Personnel.

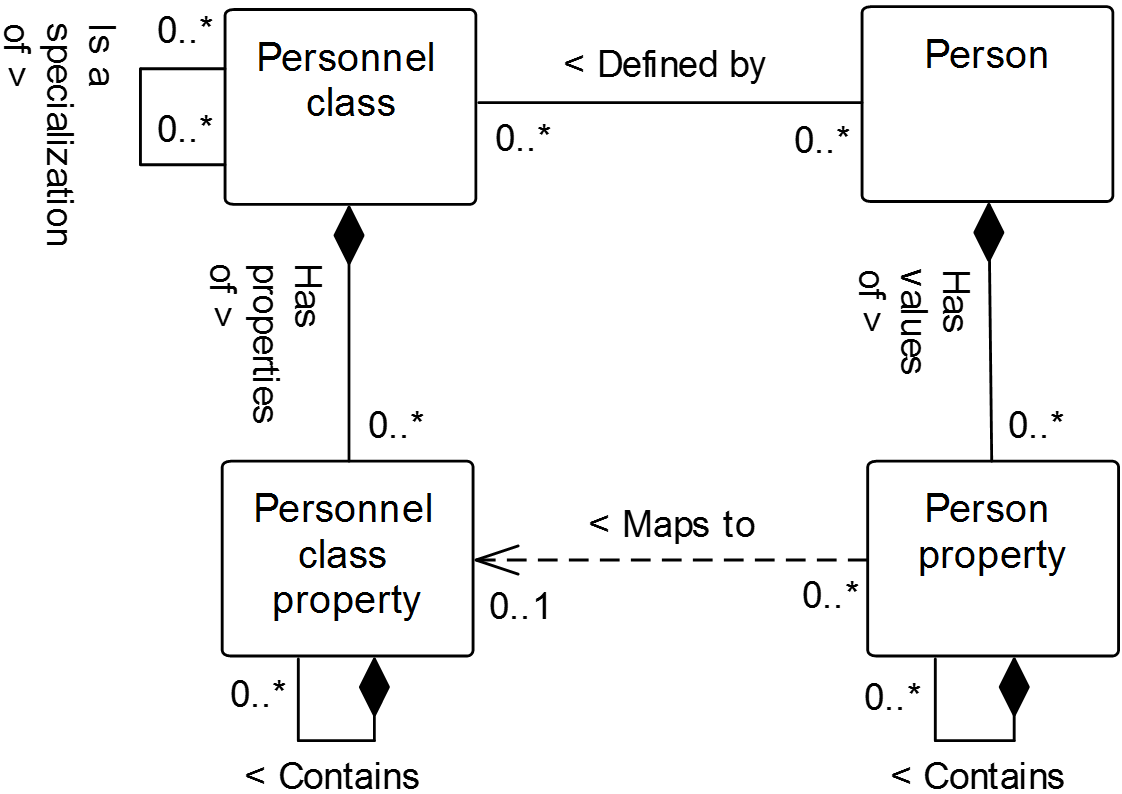


Figure C.1 – Personnel model

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 shows the attributes for *person* (a copy of Table 32).

Table C.1 – 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 shall be 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 |
| 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 e.g. 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 but could be e.g., 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 B.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, e.g., it might be 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, value* and *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 (e.g. *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 (i.e., 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 e.g., a maximum length of property-name, the usage of upper and lower case letters.
* Different systems might be developed in different languages, e.g., 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.2 and C.3 are included as examples of a data base structure that can be used to contain the data. The attribute “Key” indicates a unique value that can be required for relational integrity.

Table C.2 – Database structure for person

|  |  |  |
| --- | --- | --- |
| TABLE: Person | | |
| ID | Description | Name |
|  |  |  |
|  |  |  |

Table C.3 – 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.4 and Table C.5.

Table C.4 – 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.5 – 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 ISA-95.

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 ISA-95.

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 ISA-95.00.01 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 -

Properties

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 -

Properties

ID - Percentage Lean

Description -

Value - 80

Units of Measure – Percentage

Material Test Specification

ID - JackSpratTest1

Description - Test to determine percent of fat.

Version - 1997-04-02

ID - Percentage Fat

Description -

Value - 20

Units of Measure - Percentage

Material Lot

ID - 20000115091345

Description -

Status approved

Properties

ID - Delivery Temperature

Description - Temperature at delivery

Value - 37.5

Units of Measure - Degrees F

Material Test Result

ID - 2000-01-16-4930-TEMP

Description - Internal temperature of pork

Date - 2000-01-16

Result - Failed

Expiration - None

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

Material Test Result

ID - 2000-01-16-4930-SPRAT

Description -

Date - 2000-01-16

Result - Pass

Expiration – None

ID - Lean

Description - Actual Percent Lean

Value - 80

Units of Measure – Percent

Material Test Result

ID - 2000-01-16-4930-SPRAT

Description -

Date - 2000-01-16

Result - Pass

Expiration - None

Material SubLot

ID - 20000115091345-1

Description -

Storage Location - Tote 392, Level 3, Rack 49

Value - 200

Unit of Measure - Pounds

ID - 20000115091345-2

Description -

Storage Location - Tote 852, Level 3, Rack 50

Value - 300

Unit of Measure – Pounds

* 1. Equipment model examples

EXAMPLE 1 Pulp and paper

| 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

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 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

Properties

ID - MTBE Process Certification

Description - Each completed level of certification test

Value - TRUE, FALSE

Units of Measure -

Qualification Test Specification

ID - PC-MTBE-992828

Description - Test to determine level of MTBE certification.

Version - 1997-04-02

ID - PO Refining Process Certification

Description - Each completed level of certification test

Value - TRUE, FALSE

Units of Measure -

Qualification Test Specification

ID - PC- PO-Refining -992828

Description - Test to determine level of PO Refining certification.

Version - 1997-04-02

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

Properties

ID - MTBE Process Certification

Description - Each completed level of certification test

Value - TRUE,

Units of Measure -

Qualification Test results

ID - PC-MTBE-992828-2000-10-12

Description - Test to determine level of MTBE certification.

Result - Passed

Expiration - 2000-12-15

ID - PO Refining Process Certification

Description - Each completed level of certification test

Value - FALSE

Units of Measure -

ID - Push-Up Certification

Description - Operator is temporarily able to perform the higher up function

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

* 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

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

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

Location - Tengiz-Atyrau Pipeline Segment

Type - Area

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

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

Unit of Measure - cp (centipoise)

Material actual property

ID - Entry Temperature

Value - 32.3

Unit of Measure - Deg C

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:**

ISA-95.00.02 does not model the object relationships in ISA-95.00.01, 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 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 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 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 A distillation *process segment* (associated with a distillation column) could process many operations 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 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 | Equipment planning view of operations | Operations planning view of production |
| 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* – i.e. 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 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;*
* *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 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.
* 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 may 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.

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. For example, 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. Representation of material produced and consumed

**Question:**

Why are there two different models for representing the *material produced* and *material consumed* as attributes in some objects (operations capability model and operations definition model) and as separate objects in the operations schedule and operations performance models?

**Answer:**

In the operations schedule and operations performance model, typical implementations had used these as separate objects, and this information was of major importance. In the other models the material information usually refers to material consumed, and only rarely seems to be used to represent produced material. The attribute model was used in these cases so that the object models would be less complex.

* 1. Material produced and the capability model

**Question:**

Why is there a *material produced* type in the capability model?

**Answer:**

In some processes, there are materials that are produced as a side effect of operations, such as wastewater, or recycled materials. These materials can be used in other parts of operations, and their availability can have to be considered in schedules.

* 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 consumed 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 material consumed sublot and material produced 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 a *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 ISA-95 and documenting the extensions.

* 1. Modeling of tools

**Question:**

Are tools modeled as equipment or materials?

**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; for 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 a operations 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:

* a “mixed” *operation schedule* can hold mixed or specialized *operation requests*,
* a “mixed” *operation request* can hold mixed or specialized *segment requirements*,
* 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 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)  
   Abstract 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 have to agree on the meaning of data values.

EXAMPLE *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 ISA-95.00.01 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 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 ANS/ISA-95 is independent of any communication protocol. ANSI/ISA-95.00.02 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 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)Implementation models

The related object naming conventions and relationship types in ISA-95 allow implementation models to be constructed following a standard process. The implementation of the abstract ISA-95 relationships vary depending on the implementation technology applied.

The following historical example list of the implementation methods have applied ISA-95 abstract models. Future advances in implementation methods will expand this limited list.

1. Hierarchical

Related objects in ISA-95 UML models are represented directly as relationship attributes within the parent object. A combination of contained and referenced objects.

EXAMPLE 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 ISA-95 UML models 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

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 ISA-95 object UML models are represented as individual triple entries. Instances represent class membership and values with individual triple entries.

EXAMPLE

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

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

1. OPC Binary specifications
2. OASIS AMQP specification

A binary protocol that allows implementation to specify their own message payload content.

EXAMPLE

1. OASIS MQTT
2. OASIS – AMQP
3. OMG RTPS – DDS - CDR
4. (informative)   
   Abstract to implementation model examples

In this example, an ISA-95 *person* object is presented along with its implementation model counterpart for a number of implementation technologies applied in manufacturing, industrial internet of things, smart manufacturing, military and space craft systems.

Each implementation will have its own representation of transaction objects, only the noun component is depicted in this example and the personnel model has been simplified to allow presentation of the basic transformations that are performed between the abstract model and its implementation model counterparts.

The examples are informative of the type of implementation model performed and may not be indicative of the best practice applied in each environment.

As ISA-95 transactions 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.

The following sections are being validated with individuals as appropriate representations of the technology.

* 1. Personnel abstract model

This example represents parts of the *person* object as represented in the Personnel model presented in Figure 22. A formal description of the Personnel model is presented in Clause 5.

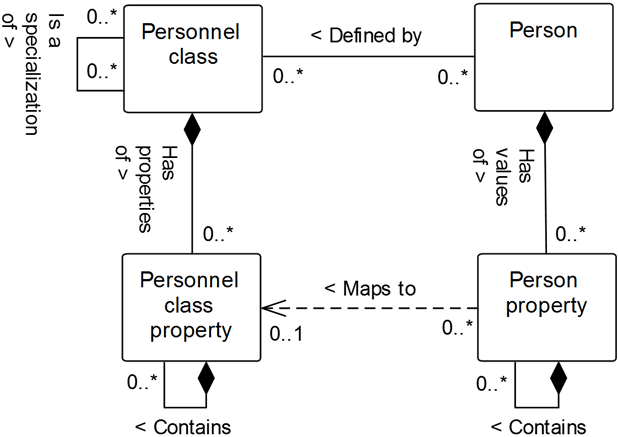


Figure 8 – Logic Model Example: Personnel model

The *person* object has the following relationship and object attributes. The test specification attributes are not shown for the brevity of the explanation and to focus on the topic.

There is no multiplicity value present on *person* object attributes, typically the *ID* is required (multiplicity of 1) which will be represented in a implementation model.

Figure 24 – Example: Personnel class relationships

| Related object | Relationship | | | | Description |
| --- | --- | --- | --- | --- | --- |
| Role | Multiplicity | Name | Type |
| Person | Person | 0..\* | Groups and defines | Association | The *person* objects support this *personnel class*. The *person* objects supports the *personnel class* *properties* associated with this *personnel class*. |
| Personnel class property | Personnel class property | 0..\* | Has properties of > | Composition whole | The *properties* of the *personnel class*. |
| Qualification test specification | Qualification test specification | 0..\* | Is tested by an > | Association | The *qualification test specifications* associated with this *personnel class*. |
| Tested personnel class property | None | 0..\* |  | Ternary | Association of tested *personnel class property* in a *personnel class* element by a *qualification test specification.* |

Figure 25 – 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 defines the scope of the *personnel class* definition, such as the site or area it is defined for. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |

* 1. MESA – B2MML (XSD) implementation model

B2MML represents its types using a number of optional elements. For example, the common identifierType and its derived types such as EquipmentIDType allows a number of 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 standard is utilized in internet and manufacturing applications. This simplified representation of XML validation represents the most common application of XML based ISA-95 information exchanges 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

This standard is applied in manufacturing systems. The OPC Foundation has published the Unified Architecture (UA) specification to allow the formal specification of implementation models across a variety of applications.

<<get Cos to provide the UA representation >>

* 1. Organization for the Advancement of Structured Information Standards (OASIS) – Advanced Message Queuing Protocol (AMQP) implementation model

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. Implementations can use the messaging infrastructure with their own message payload specification such as JSON-Schema.

<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 = "string" category “List” /> // needs clarification

</ 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>

* 1. Flat buffers – Interactive Data Language (IDL) implementation model

The IDL standard is utilized in internet, IOT 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 ISA-95 implementation model specification.

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), Robot Operating System (ROS) message description specifications (MDS)

The open source robotics foundation (OSRF), Robot Operating System (ROS) 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. OASIS - MQ Telemetry Transport (MQTT)

The MQTT implementation adopted in applications where lightweight messaging is required. The payload of a message is a variable length byte stream. MQTT does not provide a validation capability in its specification. A validation techniques specified for other implementation model validation is used in conjunction with the MQTT as a transport.

* 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 ISA-95 implementation model 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

This 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. (informative)  
   Test Examples
   1. Personnel model – qualification test specification examples

Table 213 – Qualification 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 for one or more *person properties*.  For example, this can be the name of a document that describes or defines the qualification test. | Class 1 Widget Assembly Certification Test | Union Renewal Test | LGC Model 1003 Certification Test | Fork Truck Driving Test |
| Description | Additional information and description about the *qualification test specification.* | Identifies the test for Class 1 Widget assembly certification –returns a True or False value for the *Class 1 widget assembly* *certification* property | Renewal for union membership | Identifies test for correct operation of LGC Model 1003 | Identifies test for driving fork truck |
| Hierarchy scope | Identifies where the exchanged information fits within the role based equipment hierarchy.  Optionally defines the scope of the *qualification test specification* definition, such as the site or area it is defined for. | South Shore (Site) / Work Line (Area) | South Shore (SITE) / Packaging (Area) | Mixer Sample Port (Work Unit) | Receiving dock (Work Center) |
| Version | An identification of the version of the *qualification test specification*. | V23 | 01 | A | 23C |

* 1. Role based equipment model – equipment capability test specification examples
  2. Physical asset model – physical asset capability test specification examples
  3. Material model – material test specification examples

Bibliography

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

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

ISO 10303-1, *Industrial automation systems and integration – Product data representation and exchange – Part 1: Overview and fundamental principles*

ISO 14977, *Information Technology – Syntactic metalanguage – Extended BNF*

ISO 15000-5, *Electronic Business Extensible Markup Language (ebXML) – Part 5:ebXML Core Components Technical Specification, Version 2.01(ebCCTS)*

ISO 15704, *Industrial automation systems – Requirements for enterprise-reference architectures and methodologies*

ISO 19439, *Enterprise integration – Framework for enterprise modeling*

ISO 19440, *Enterprise integration – Constructs for enterprise modeling*

ANSI/ISA-95.00.01, *Enterprise-Control System Integration – Part 1: Models and Terminology*

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

MIMOSA OSA-EAI CCOM V3.2 – [www.mimosa.org](http://www.mimosa.org)

ISO/IEC Guide 98-3, Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)

ISO/IEC Guide 99, International vocabulary of metrology – Basic and general concepts and associated terms (VIM)

NIST. Uncertainty of measurement results - http://physics.nist.gov/cuu/Uncertainty/index.html

NIST Technical Note 1297. Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results (1994) - https://www.nist.gov/pml/nist-technical-note-1297

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