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Enterprise-Control System Integration − Part 1: Models and Terminology

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Enterprise-Control System Integration − Part 1: Models and Terminology

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FOREWORD

This foreword, as well as all footnotes and annexes, is included for information purposes and is not part of ANSI/ISA-95.00.01-2010 (IEC 62264-1 Mod).

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This Part 1 standard is structured to follow IEC (International Electrotechnical Commission) guidelines. This revised Part 1 replaces ANSI/ISA-95.00.01-2000.

This document is Part 1 of a multi-part set of standards that defines the information exchange interface between enterprise activities and control activities.

As currently envisioned, the ANSI/ISA-95 series will consist of the following parts under the general title, Enterprise-Control System Integration:

- Part 1: Models and terminology
- Part 2: Objects and attributes for enterprise-control system integration
- Part 3: Activity models of manufacturing operations management
- Part 4: Object models and attributes of manufacturing operations management activities (in development at the time of publication of this standard)
- Part 5: Business-to-manufacturing transactions
- Part 6: Manufacturing operations transactions (in development at the time of publication of this standard)

INTRODUCTION

This is a revision of ISA-95.00.01-2000. The major changes made to this standard from the previous version are:

1. The starting point for the update was IEC 62264-1 Enterprise-control system integration: models and terminology. This is the IEC/ISO version of this standard. IEC 62264-1 includes a new section on the Decision Hierarchy in Clause 5.5.
2. The functional hierarchy in Clause 5.2 was extended using the definitions from IEC 62264-3 Enterprise-control system integration - Part 3: Activity Models of Manufacturing Operations Management.
3. The equipment hierarchy in Clause 5.3 was extended using the definitions from IEC 62264-3.
4. A physical asset equipment model was added in Clause 5.3.
5. The generic model of manufacturing operations management categories in Clause 7 was added using information from IEC 62264-3.
6. The formal UML models that were in Clause 7 were moved to the Part 2 standard in the series and the remaining data definitions are now in Clause 8.
7. The capacity and capability model in Clause 8 was extended.
8. A new Annex A was moved from IEC 62264-3.
9. A new Annex B was moved from IEC 62264-3.
10. Clause 5.5 on the decision hierarchy was removed and a reference added to ISO 15704 which is now available.
11. Old Annex C, DISCUSSIONS OF MODELS, was moved to a Technical Report
12. Old Annex D, SELECTED ELEMENTS OF THE PURDUE REFERENCE MODEL, was moved to a Technical Report.
13. Old Annex E, PRM CORRELATION TO MESA INTERNATIONAL MODEL AND ISA-95.01 MODELS, was moved to a Technical Report

This Part 1 standard is limited to describing the relevant functions in the enterprise and the manufacturing and control domains and which information is normally exchanged between these domains. Subsequent parts will address how this information can be exchanged in a robust, secure, and cost-effective manner preserving the integrity of the complete system. For purposes of this standard the manufacturing and control domain includes manufacturing operations management systems, manufacturing control systems, and other associated systems and equipment associated with manufacturing. The terms “enterprise,” “controls,” “process control,” and “manufacturing” are used in their most general sense and are held to be applicable to a broad sector of industries.

This Part 1 standard provides standard models and terminology for describing the interfaces between the business systems of an enterprise and its manufacturing operations and control systems. The models and terminology presented in this standard

a) emphasize good integration practices of control systems with enterprise systems during the entire life cycle of the systems;

b) can be used to improve existing integration capabilities of manufacturing operations and control systems with enterprise systems; and

c) can be applied regardless of the degree of automation.

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

a) reduce users' times to reach full production levels for new products;

b) enable vendors to supply appropriate tools for implementing integration of control systems to enterprise systems;

c) enable users to better identify their needs;

d) reduce the costs of automating manufacturing processes;

e) optimize supply chains; and

f) reduce life-cycle engineering efforts.

This Part 1 standard is intended for those who are:

a) involved in designing, building, or operating manufacturing facilities;

b) responsible for specifying interfaces between manufacturing and process control systems and other systems of the business enterprise; or

c) involved in designing, creating, marketing, and integrating automation products used to interface manufacturing operations and business systems.

d) involved in specifying, designing or managing product creation, movement and storage within manufacturing enterprises.

It is not the intent of this standard to

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

This Part 1 standard discusses the interface content between manufacturing-control functions and other enterprise functions, based upon the Purdue Reference Model for CIM (hierarchical form) as published by ISA. This standard presents a partial model or reference model as defined in ISO 15704. The first three clauses are normative and present the *scope* of the standard, *normative references*, and *definitions*, in that order.

The scope of this part is limited to describing the relevant functions in the enterprise and the manufacturing and control domain and which information is normally exchanged between these domains. Subsequent parts will address how this information can be exchanged in a robust, secure, and cost-effective manner preserving the integrity of the complete system.

Clause 4 is informative. The intent is to describe the context of the models in Clause 5 and Clause 6. It gives the criteria used to determine the scope of the manufacturing operations and control system domain. Clause 4, being informative, does not contain the formal definitions of the models and terminology but describes the context to understand the other clauses.

Clause 5 is normative. The intent is to describe hierarchy models of the activities involved in manufacturing-control enterprises. It presents in general terms the activities that are associated with manufacturing operations and control and the activities that occur at the business logistics level. It also gives an equipment hierarchy model of equipment associated with manufacturing

operations and control. Clause 5.5 is informative. Clause 5, being normative, contains format definitions of the models and terminology.

Clause 6 is normative. The intent is to describe a general model of the functions within an enterprise which are concerned with the integration of business and control. It defines, in detail, an abstract model of control functions and, in less detail, the business functions that interface to control. The purpose is to establish a common understanding for functions and data flows involved in information exchange.

Clause 7 is normative. The intent is to define in detail the information that makes up the information streams defined in Clause 6. The purpose is to establish a common terminology for the elements of information exchanged. Clause 7, being normative, contains formal definitions of the models and terminology. The attributes and properties are not formally defined in this clause of the standard.

Clause 8 is normative. It provides a description of the categories of information structures that are exchanged between applications at Level 4 and those at Level 3. The clause also provides the information categories that are exchanged between the applications within Level 3.

Clause 9 is normative. It provides statements regarding the conformance of implementations, the compliance of specifications and the completeness of these specifications and implementations relative to Part 1 of this standard.

Annex A is informative. It defines the relationship of this standard with other related standardization work in the manufacturing area.

Annex B is informative. It provides listings of associated standards generally related to enterprise integration.

Annex C is informative. It describes business drivers and key performance indicators that are the reasons for the information exchange between business and control function.

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ENTERPRISE-CONTROL SYSTEM INTEGRATION –

Part 1: Models and terminology

1 Scope

This standard describes the interface content between manufacturing operations and control functions and other enterprise functions. The interfaces considered are the interfaces between Levels 3 and 4 of the hierarchical model defined by this standard. The goals are to increase uniformity and consistency of interface terminology and reduce the risk, cost, and errors associated with implementing these interfaces.

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

The scope of this standard is limited to

a) a presentation of the scope of the manufacturing operations and control domain;

b) a discussion of the organization of physical assets of an enterprise involved in manufacturing;

c) a listing of the functions associated with the interface between control functions and enterprise functions; and

d) a description of the information that is shared between control functions and enterprise functions.

2 Normative references

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

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

ISO/IEC 19501:2005, *Information technology - Open Distributed Processing - Unified Modeling Language (UML) - Version 1.4.2*

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

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Phrases in italic in lines following the preferred term in bold are considered as synonyms.

3.1.1
area
physical, geographical or logical grouping of resources determined by the site

NOTE It can contain process cells, production units, production lines, and storage zones.

3.1.2
available capacity
portion of the production capacity that can be attained but is not committed to current or future production

3.1.3
bill of lading
contract or receipt for goods that a carrier agrees to transport from one place to another and to deliver to a designated person or that it assigns for compensation upon the conditions stated therein

3.1.4
bill of material
listing of all the subassemblies, parts, and/or materials that are used in the production of a product including the quantity of each material required to make a product

NOTE The term product may refer to a finished product or an intermediate product

3.1.5
bill of resources
listing of all resources and when in the production process they are needed to produce a product

NOTE It is also a listing of the key resources required to manufacture a product, organized as segments of production and is often used to predict the impact of activity changes in the master production schedule on the supply of resources.

3.1.6
capability
ability to perform actions, including attributes on qualifications and measures of the ability as capacity

3.1.7
capacity
measure of the ability to take action, an aspect of a capability

EXAMPLE Measures of the production rates, flow rates, mass or volume.

3.1.8
certificate of analysis

certification of conformance to quality standards or specifications for products or materials

NOTE It can include a list or reference of analysis results and process information. It is often required for custody transfer of materials.

3.1.9
committed capacity
portion of the production capacity that is currently in use or is scheduled for use

3.1.10
consumables
resources that are not normally included in bills of material or are not individually accounted for in specific production requests or are not lot tracked

3.1.11
control domain
[see manufacturing operations and control domain]

3.1.12
enterprise
one or more organizations sharing a definite mission, goals and objectives to offer an output such as a product or service

3.1.13
finished goods
final materials on which all processing and production is completed

3.1.14
finished good waivers
approvals for deviation from normal product specifications

3.1.15
in-process waiver requests
requests for waivers on normal production procedures due to deviations in materials, equipment, or quality metrics, where normal product specifications are maintained

3.1.16
manufacturing operations management domain
domain that includes all the activities in Level 3 and information flows to and from levels 1, 2 and 4

NOTE The manufacturing operations management domain is a subset of the manufacturing operations and control domain

3.1.17
manufacturing operations and control domain
control domain

domain that includes all the activities and information flows in Level 3, 2, and 1 and information flows to and from Level 4.

3.1.18
process segment
business process segment

view of a collection of resources with specific capabilities needed for a segment of production, independent of any particular product at the level of detail required to support business processes that may also be independent of any particular product

NOTE 1 This may include material, energy, personnel, or equipment.

NOTE 2 The business process segment synonym is included to reflect the business process oriented aspects of the process segment

3.1.19
product definition
collection of information about resources, production rules and scheduling required to create a product. A product definition has an external reference to a bill of materials, a product production rule, and a bill of resources

3.1.20
product segment
logical grouping of personnel resources, equipment resources, and material specifications required of a process segment to complete a production step for a specific product

3.1.21
production capability
ability of resources to perform production in the enterprise. The production capability includes the capacity of those resources and represents

a) the collection of personnel, equipment, material, and process segment capabilities;

b) the total of the current committed, available, and unattainable capacity of the production facility;

c) the highest sustainable output rate that could be achieved for a given product mix, raw materials, worker effort, plant, and equipment

3.1.22
production control
collection of functions that manages all production within a site or area

3.1.23
production line
work center that is a collection of equipment dedicated to the manufacture of a specific number of products or product families

3.1.24
production rules
information used to instruct a manufacturing operation how to produce a product

3.1.25
production unit
work center that is a set of production equipment that converts, separates, or reacts one or more feedstocks to produce intermediate or final products

3.1.26
physical asset
A physical object uniquely identified and tracked for maintenance and/or financial purposes.

NOTE: This standard addresses physical assets used in equipment roles. There are many other physical assets in an enterprise.

3.1.27
resource
enterprise entity that provides some or all of the capabilities required by the execution of an enterprise activity and/or business process (in the context of this standard, a collection of personnel, equipment, and/or material)

3.1.28
site
a component of a manufacturing enterprise that is identified by physical, geographical, or logical segmentation

3.1.29
storage unit
work unit within a storage zone that is a designated physical space and/or equipment dedicated to the storage of materials and/or equipment

3.1.30
storage zone
work center that is a designated physical space and/or equipment dedicated to the storage of materials and/or equipment

3.1.31
unattainable capacity
portion of the production capacity that cannot be attained

NOTE Typically due to factors such as equipment unavailability, sub-optimal scheduling, or resource limitations.

3.1.32
work cell
a work unit within a production line that consists of equipment grouped together to produce a family of parts having similar manufacturing requirements

3.1.32
work center
an equipment element under an area in a role based equipment hierarchy that performs production, storage, material movement, or any other Level 3 or Level 4 scheduled activity

3.1.33
work unit
an equipment element under a work center in a role based equipment hierarchy that performs production, storage, material movement, or any other Level 3 or Level 4 scheduled activity

3.2 Abbreviations

For the purposes of this standard, the following abbreviations apply.

BOL Bill of lading

BOM Bill of material

CIM Computer integrated manufacturing

COA Certificate of analysis

MESA Manufacturing Enterprise Solutions Association

MO&C Manufacturing operations and control

MOM Manufacturing operations management

MRP Materials requirements planning

PRM Purdue reference model

UML Unified modeling language (ISO/IEC 19501-1)

4 Enterprise-control system integration overview

Successfully addressing the issue of enterprise-control system integration requires identifying the boundary between the enterprise domain and the manufacturing operations and control domain. The boundary is identified using relevant models that represent functions, physical equipment, information within the manufacturing operations and control domain, and information flows between the domains.

Multiple models show the functions and integration associated with manufacturing operations and control systems and enterprise systems.

a) Hierarchy models that describe the levels of functions and domains of control associated within manufacturing organizations are presented in Clause 5. These models are based on *The Purdue Reference Model for CIM*, referenced as PRM; the MESA International Functional Model; and the equipment hierarchy model from IEC 61512-1. Detailed activity models of the manufacturing operations domain are given in Part 3.

NOTE See the Bibliography for reference to the MESA white paper defining MES functionality.

b) A data flow model that describes the functional and data flows within manufacturing organizations is given in Clause 6. This model is also based on The Purdue Reference Model for CIM.

c) An object model that describes the information that may cross the enterprise and control system boundary is given in Part 2.

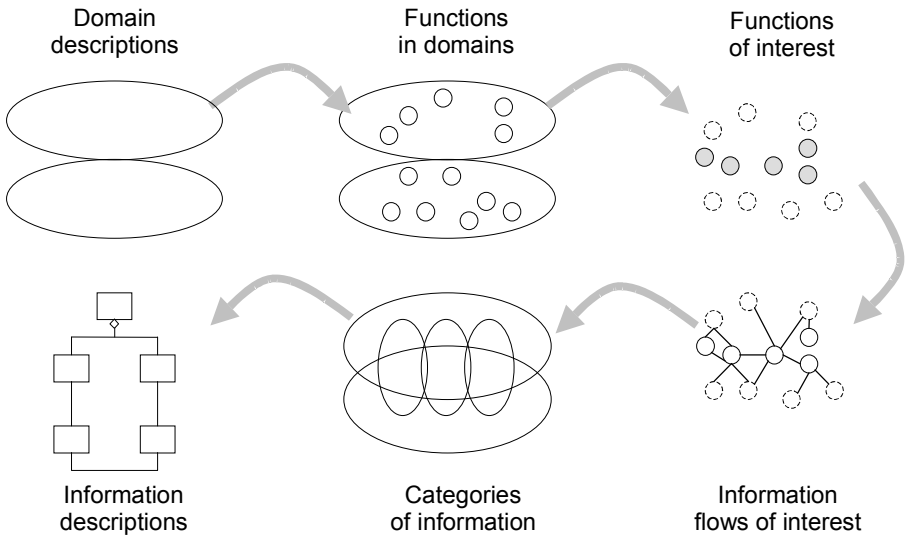


Figure 1 – Outline of models in the standard

This standard provides models and information in multiple levels of detail and abstraction. These levels are illustrated in Figure 1, which serves as a map to the rest of the document. Each model and diagram increases the level of detail presented in the previous model.

The models start with a description of the domain of control systems and the domain of enterprise systems. The domain discussion is contained in Clause 5.

Functions within the domains are presented in Clauses 5 and 6. Functions of interest that are relevant to the standard are also given a detailed description in Clause 6. The information flows of interest between the relevant functions are listed in 6.5.

The categories of information are given in Clause 8. The formal object model of the information of interest is presented in Part 2.

The information that flows between functions identified as being within the MO&C domain and those outside the MO&C domain describe the enterprise-control system boundary. Information exchanged between functions within the MO&C domain and information exchanged between functions outside the MO&C domain is outside the scope of this document. Figure 2 illustrates the enterprise-control system interface, as depicted in the data flow model, between control and non-control functions; the shaded circles indicate functions that exchange information and are described in the data flow model. Functions depicted as white circles and data flows depicted as dashed lines are those considered as outside the scope of this standard. Information flows of interest across the enterprise-control system boundary are given in Part 2 and Part 5. Some information flows within the manufacturing and operations domain are given in Part 4 and Part 6.

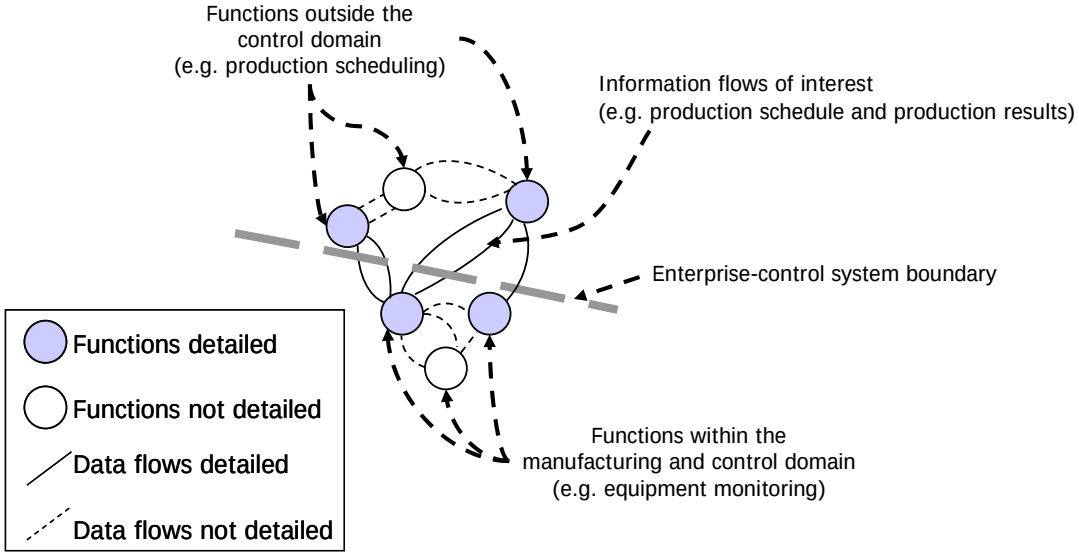


Figure 2 – Enterprise-control system interface

5 Hierarchy models

5.1 Hierarchy model introduction

Clause 5 presents the hierarchy models associated with manufacturing operations and control systems and other business systems. The hierarchy models are, a functional hierarchy, a role based equipment hierarchy, a physical asset equipment hierarchy, and a decision hierarchy.

5.2 Functional hierarchy

5.2.1 Hierarchy levels

Figure 3 depicts the different levels of a functional hierarchy model: business planning and logistics, manufacturing operations and control, and batch, continuous, or discrete control. The levels provide different functions and work in different timeframes. The interface addressed in this standard is between Level 4 and Level 3 of the hierarchy model. This is generally the interface between plant production scheduling and operation management and plant floor coordination.

This standard specifies that each level shall provide the functions listed below and illustrated in Figure 3.

Level 0 defines the actual physical processes.

Level 1 defines the activities involved in sensing and manipulating the physical processes. Level 1 typically operates on time frames of seconds and faster.

Level 2 defines the activities of monitoring and controlling the physical processes. Level 2 typically operates on time frames of hours, minutes, seconds and sub-seconds.

Level 3 defines the activities of the work flow to produce the desired end-products. It includes the activities of maintaining records and coordinating the processes. Level 3 typically operates on time frames of days, shifts, hours, minutes and seconds.

Level 4 defines the business-related activities needed to manage a manufacturing organization. Manufacturing-related activities include establishing the basic plant schedule (such as material use, delivery and shipping), determining inventory levels and making sure that materials are delivered on time to the right place for production. Level 3 information is critical to Level 4 activities. Level 4 typically operates on time frames of months, weeks and days.

NOTE 1: There are other non manufacturing business-related activities that may be in Levels 1 through 4 or higher levels, but these are not defined in this standard, for example security activities.

NOTE 2: The terms function and activity are used as synonyms.

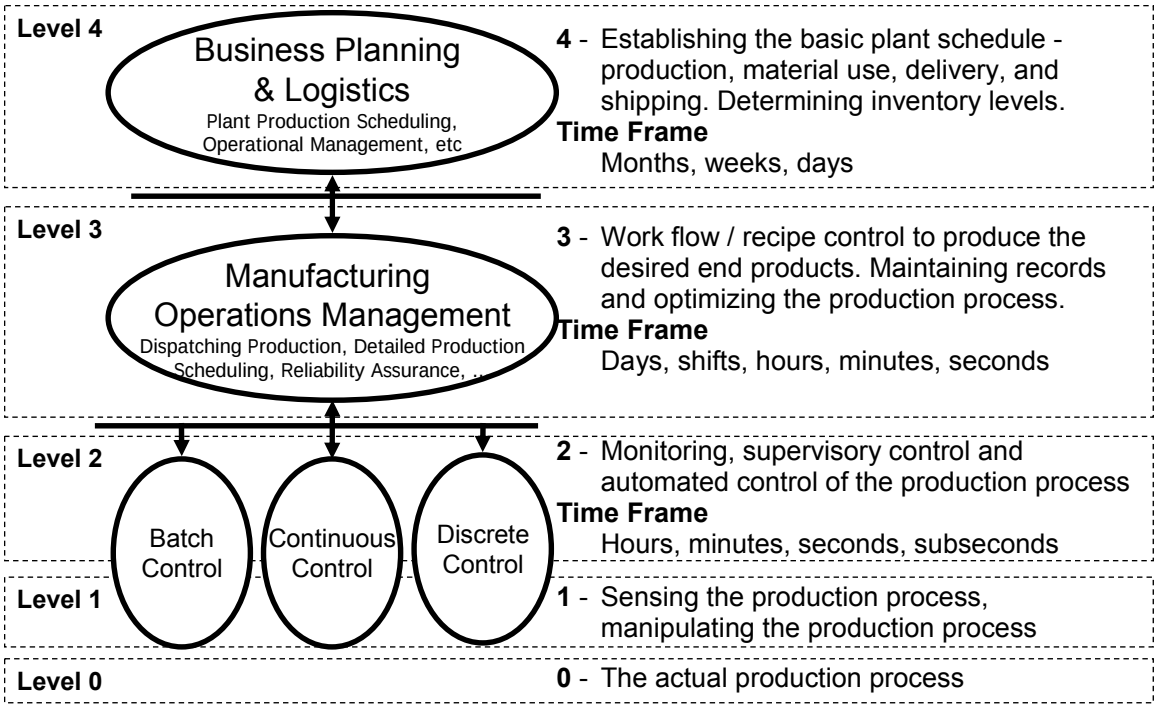


Figure 3 – Functional hierarchy

Levels 2, 1, and 0 present the cell or line supervision functions, operations functions, and process control functions and are not addressed in this standard. The discussion and labeling of levels is based on a historical description. Level 0 indicates the process, usually the manufacturing or production process. Level 1 indicates manual sensing, sensors, and actuators used to monitor and manipulate the process. Level 2 indicates the control activities, either manual or automated, that keeps the process stable or under control. There are several different models for the functions at these levels based on the actual production strategy used.

For purposes of this standard the terminology Manufacturing Operations Management (MOM) defines the Level 3 activities and information flows, and Manufacturing Operations and Control (MO&C) define Level 1, 2, and 3 activities and information flows. The standard assumes all activities not explicitly presented as part of the MO&C domain to be part of the enterprise domain.

5.2.2 Criteria for inclusion in manufacturing operations and control domain

The criterion for defining the activities to be included as a Level 3, 2, or 1 activity shall be that the activity is directly involved in manufacturing and includes information about personnel, equipment, or material and meets any of the following conditions.

a) The activity is critical to plant safety.

b) The activity is critical to plant reliability.

c) The activity is critical to plant efficiency.

NOTE 1 Absolute plant efficiencies may be dependent upon factors that are outside the control of a facility (MRP schedules, product mixes, etc.). These activities are not part of Level 3, 2, or 1.

d) The activity is critical to product quality.

e) The activity is critical to maintaining regulatory compliance.

EXAMPLE Maintaining regional, government and other agency compliance related to products and production.

NOTE 2 This includes such factors as safety, environmental and cGMP (current good manufacturing practices) compliance.

NOTE 3 There are other criteria such as company policy and organizational structure, or the nature of the operations that could expand the scope of manufacturing operations management. See Annex A.

NOTE 4 Such activities as personnel management of salaries and job titles may be important for running a manufacturing business, but they are not considered part of manufacturing operations management.

5.2.3 Level 4

Level 4 activities typically include

a) collecting and maintaining raw material and spare parts usage and available inventory, and providing data for purchase of raw material and spare parts;

b) collecting and maintaining overall energy use and available inventory and providing data for purchase of energy source;

c) collecting and maintaining overall goods in process and production inventory files;

d) collecting and maintaining quality control files as they relate to customer requirements;

e) collecting and maintaining machinery and equipment use and life history files necessary for preventive and predictive maintenance planning;

f) collecting and maintaining manpower use data for transmittal to personnel and accounting;

g) establishing the basic plant production schedule;

h) modifying the basic plant production schedule for orders received, based on resource availability changes, energy sources available, power demand levels, and maintenance requirements;

i) developing optimum preventive maintenance and equipment renovation schedules in coordination with the basic plant production schedule;

j) determining the optimum inventory levels of raw materials, energy sources, spare parts, and goods in process at each storage point. These functions also include materials requirements planning (MRP) and spare parts procurement;

k) modifying the basic plant production schedule as necessary whenever major production interruptions occur;

l) planning production capacity, based on all of the above activities.

5.2.4 Level 3

5.2.4.1 Level 3 activities

Level 3 activities typically include

a) reporting on area production including variable manufacturing costs based on the enterprise standard cost model;

b) collecting and maintaining area data on production, inventory, manpower, raw materials, product quality, spare parts and energy usage;

c) performing of data collection and off-line analysis as required by engineering functions. This may include statistical quality analysis and related control functions;

d) performing needed personnel functions such as: work period statistics (for example, time, task), vacation schedule, work force schedules, union line of progression, and in-house training and personnel qualification;

e) establishing the immediate detailed production schedule for its own area including maintenance, transportation and other production-related needs;

f) locally optimizing the costs for its individual production area while completing the production schedule established by the Level 4 functions;

g) modifying production schedules to compensate for plant production interruptions that may occur in its area of responsibility;

h) managing manufacturing operations;

i) managing maintenance on production equipment;

j) managing laboratory and quality testing of materials;

k) managing movement and storage of materials;

l) transforming the business oriented information used for Level 4-3 data exchanges into the manufacturing operations management oriented information used within Levels 3 and below.

Descriptions of the major functionalities associated with these various Level 3 activities are given in 5.2.4.2 through 5.2.4.13.

5.2.4.2 Resource allocation and control

The MOM domain includes the functionality of managing resources directly associated with control and manufacturing. The resources include machines, tools, labor skills, materials, other equipment, documents, and other entities that are required for work to start and to be completed. The management of these resources may include local resource reservation to meet production-scheduling objectives.

The MOM domain also ensures that equipment is properly set up for processing, including any allocation needed for set-up. The MOM domain is also responsible for providing real-time statuses of the resources and a detailed history of resource use.

5.2.4.3 Dispatching production

The MOM domain includes the functionality of managing the flow of production in the form of jobs, orders, batches, lots, and work orders, by dispatching production to specific equipment and personnel. Dispatch information is typically presented in the sequence in which the work needs to be done and may change in real time as events occur on the factory floor.

The MOM domain may alter the prescribed schedules, within agreed limits, based on local availability and current conditions. Dispatching of production includes the ability to control the amount of work in process at any point through buffer management and management of rework and salvage processes.

5.2.4.4 Data collection and acquisition

The MOM domain includes the functionality of obtaining the operational production and parametric data that are associated with the production equipment and production processes.

The MOM domain also is responsible for providing real-time statuses of the production equipment and production processes and a history of production and parametric data.

5.2.4.5 Quality operations management

The MOM domain includes the functionality of providing real-time measurements collected from manufacturing and analysis in order to assure proper product quality control and to identify problems requiring attention. It may recommend actions to correct the problem, including correlating the symptoms, actions and results to determine the cause.

It includes statistical process control/statistical quality control (SPC/SQC), tracking and management of off-line, on line, or in-line inspection operations, and analysis recorded in laboratory information management systems.

5.2.4.6 Process management

The MOM domain includes the functionality of monitoring production processes and either automatically corrects or provides decision support to operators for correcting and improving in-process functions. These functions may be intra-operational and focus specifically on machines or equipment being monitored and controlled within a single operation, as well as tracking a production process from one operation to the next.

It may include alarm and event management to make sure personnel are aware of process changes that may be outside acceptable tolerances.

5.2.4.7 Production tracking

The MOM domain includes the functionality of providing the status of production and the disposition of work. Status information may include personnel assigned to the work; component materials used in production; current production conditions; and any alarms, rework, or other exceptions related to the product. The functionality includes the capability of recording the production information to allow forward and backward traceability of components and their use within each end product.

5.2.4.8 Performance analysis

The MOM domain includes the functionality of providing up-to-the-minute reporting of actual manufacturing operations results along with comparisons to past history and expected results. Performance results include such measurements as resource utilization, resource availability, product unit cycle time, conformance to schedule, and performance to standards. Performance analysis may include SPC/SQC analysis and may draw from information gathered by different control functions that measure operating parameters.

5.2.4.9 Operations and detailed scheduling

The MOM domain includes the functionality of providing the sequence and the timing of operations based on priorities, attributes, characteristics, and production rules associated with specific production equipment and specific product characteristics, such as shape, color combinations or other requirements that, when scheduled properly in detail, will tend to minimize set-up time and effort, or increase production throughput. Operations and detailed scheduling take into account the finite capacity of resources and consider alternative and/or overlapping/parallel operations when detailing the timing of equipment loading and the particular adjustments to accommodate shift patterns.

5.2.4.10 Document control

The MOM domain includes some of the functionality of controlling records and forms that are maintained with the production unit. The records and forms include work instructions, recipes, drawings, standard operating procedures, part programs, batch records, engineering change notices, shift-to-shift communication, as well as the ability to edit “as planned” and “as built” information. It would also include the control and integrity of regulatory documentation, environmental, health and safety regulations, and SOP information such as corrective action procedures.

5.2.4.11 Labor management

The MOM domain includes some of the functionality of providing status of personnel and may include time and attendance reporting, certification tracking, as well as the ability to track production support functions performed by personnel, such as material preparation or tool room work, and providing the status as a basis for activity-based costing. Labor management may interact with resource allocation to determine personnel assignments intended to optimize production or resource utilization.

5.2.4.12 Maintenance operations management

The MOM domain includes some of the functionality of maintaining equipment and tools. The functions ensure the equipment and tools availability for manufacturing. They also may include scheduling for periodic, preventive, or predictive maintenance as well as responding to immediate problems. Maintenance management maintains a history of past events or problems to aid in diagnosing problems, such as equipment performances, maintenance personnel performances, or instrumentation reliabilities.

5.2.4.13 Movement, storage and tracking of materials

The MOM domain includes some of the functionality of managing and tracking the movement and storage of materials, in-process items and finished products, as well as, the transfers between and within work centers. In some instances, these functions may also include receipt of material, certain types of material testing, processing or conversion and preparing material for shipment.

5.3 Role based equipment hierarchy

5.3.1 Role based equipment hierarchy model

The assets of an enterprise involved in manufacturing are usually organized in a role based hierarchical fashion as illustrated in Figure 4. Lower-level groupings are combined to form higher levels in the role based hierarchy. In some cases, a grouping within one level may be incorporated into another grouping at that same level.

NOTE 1 The term role based is applied to the equipment model to indicate that the hierarchy is defined in terms of the Level 3 and 4 functions and activities that equipment entities may perform. The actual physical location, composition, and relationships of the equipment entities are defined in a physical asset equipment hierarchy.

This model shows the areas of responsibility for the different function levels defined in the functional hierarchical model of Figure 3. The role based equipment hierarchy model additionally describes some of the objects utilized in information exchange between functions.

The models may be collapsed or expanded as required for specific applications.

NOTE 2 Specific rules for collapsing and expanding these models are not defined in this standard. The following guidelines should be considered for collapsing and expanding the models.

1. Collapsing – Elements in the models may be omitted as long as the models remain consistent and the functions of the elements combined or removed are taken into account.
2. Expanding – Elements may be added to, or divided within, the models. When they are added between related elements, the integrity of the original relationship should be maintained. Elements may be divided to separately manage the resulting smaller elements.

The UML role based equipment model defined in Part 2 of this standard is used to define the role based equipment hierarchy information. The Part 2 UML model contains the rules used to construct the hierarchical models used in different manufacturing operations management scenarios.

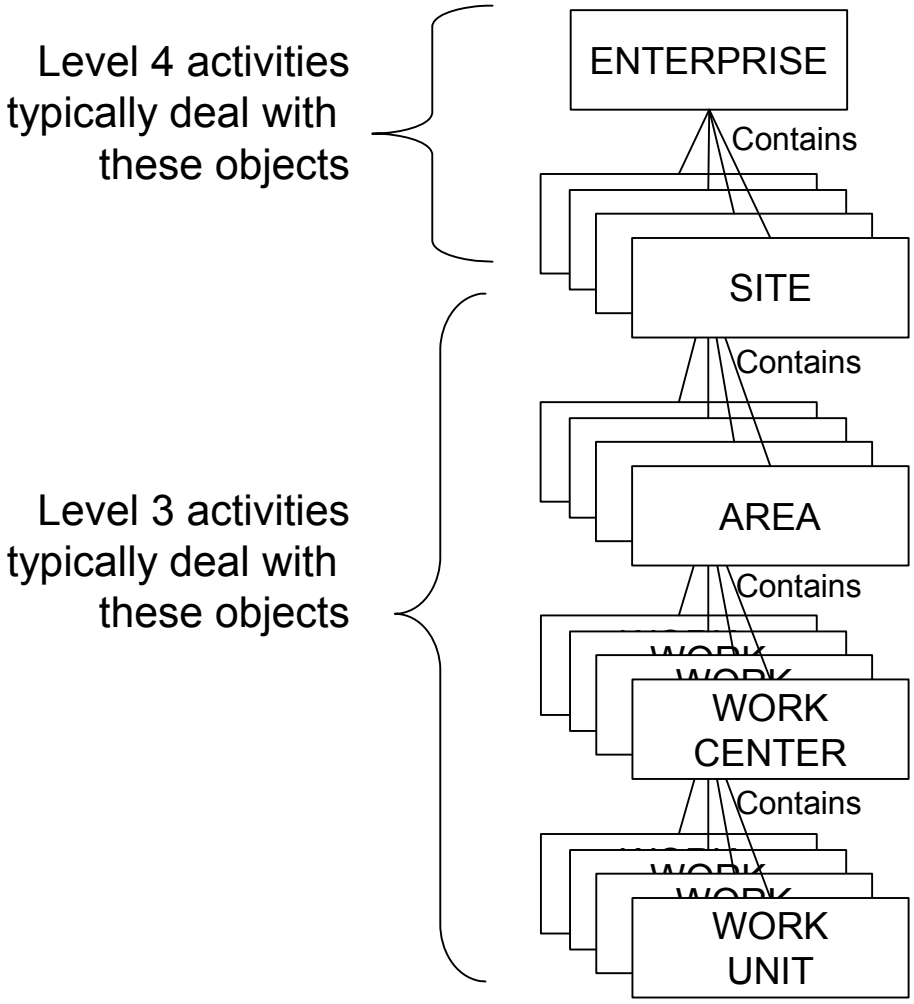


Figure 4 – Role based equipment hierarchy

5.3.2 Enterprise

An enterprise is a collection of sites and areas and represents the top level of a role based equipment hierarchy. The enterprise is responsible for determining what products will be manufactured, at which sites they will be manufactured, and in general how they will be manufactured.

Level 4 functions are generally concerned with the enterprise and site levels. However, enterprise planning and scheduling may involve areas, work centers, or work units within an area.

5.3.3 Site

A site is a physical, geographical, or logical grouping determined by the enterprise. It may contain areas, production lines, process cells, and production units. The Level 4 functions at a site are involved in local site management and optimization. Site planning and scheduling may involve work centers or work units within the areas.

A geographical location and main production capability usually identifies a site. Sites generally have well-defined manufacturing capabilities.

NOTE For example, site identifiers from various industries are Dallas Expressway Plant, Deer Park Olefins Plant and Johnson City Manufacturing Facility. Sites are often used for rough-cut planning and scheduling.

5.3.4 Area

An area is a physical, geographical, or logical grouping determined by the site. It may contain work centers such as process cells, production units, production lines, and storage zones. Most Level 3 functions occur within the area. The main production capability and geographical location within a site usually identify areas.

NOTE For example, area identifiers from various industries are CMOS Facility, North End Tank Farm and Building 2 Electronic Assembly.

Areas generally have well-defined manufacturing capabilities and capacities. The capabilities and capacities are used for Level 3 and Level 4 planning and scheduling.

An area is made up of lower-level elements that perform the manufacturing functions. An area may have one or more of any of the lower-level elements depending upon the manufacturing requirements.

EXAMPLE 1 Many areas will have a combination of production lines for the discrete operations, production units for the continuous processes, and process cells for batch processes.

EXAMPLE 2 A beverage manufacturer may have an area with continuous mixing in a production unit, which feeds a batch process cell for batch processing, feeding a bottling line for a discrete bottling process.

Depending on the planning and scheduling strategy selected, the Level 4 functions may stop at the area level, or they may schedule the functions of the lower-level elements within the areas.

5.3.5 Work center and work unit

Work centers are elements of the equipment hierarchy under an area. The term work center may be used when the specific type of the equipment element is not significant for the purpose of the discussion.

For manufacturing operations management there are specific terms for work centers and work units that apply to batch production, continuous production, discrete or repetitive production, and for storage and movement of materials and equipment.

A work center is any equipment element subordinate to an area that may be defined by the user in an extension to the role based equipment hierarchy model. See Figure 4. Types of work centers specifically defined in this part are process cells, production units, production lines, or storage zones, as shown in Figure 5.

The types of work centers may be extended when required for application specific role based equipment hierarchies where the defined types do not apply. When a new type is added it shall

maintain the same relationship within the hierarchy as the defined work center types (within an area and contains work units).

EXAMPLE 1 A new work center type represents a distinct grouping of work units (a single Work Unit cannot belong to more than one Work Center).

EXAMPLE 2 Additional work center types are:

- Laboratory – used in quality operations
- Mobile Equipment Pool
- Unused Equipment Store – used in maintenance operations
- Transportation Center

NOTE 1 The role based equipment hierarchy is an expansion of the equipment hierarchy model described in ANSI/ISA 88.01 and IEC 61512-1 and includes the definition of assets for discrete and continuous manufacturing, and for material storage.

NOTE 2 Extended work center types are outside the scope of this standard and applications built using the extensions may not be interoperable.

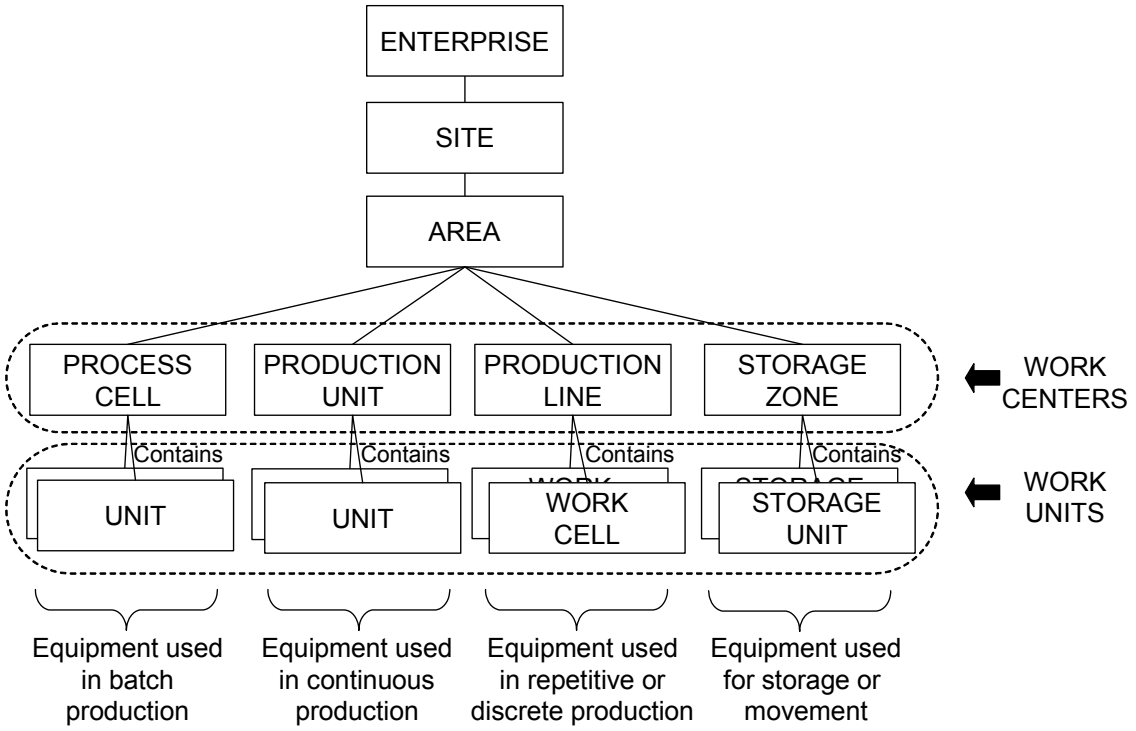


Figure 5 – Example of defined types of work centers and work units

NOTE 3 Material is also temporarily stored in process cells, production units and production lines. This material is typically considered WIP and is usually distinct from inventory managed materials.

A work unit is any element of the equipment hierarchy under a work center. Work units are the lowest form of elements in an equipment hierarchy that are typically scheduled by Level 3 functions. See Figure 5.

Work centers are typically the grouping of equipment scheduled by the Level 4 or Level 3 functions. Work centers have well-defined capabilities and capacities and these are used for

Level 3 functions. The capacities and capabilities are also often used as input to Level 4 business processes. Scheduling functions may identify specific work units.

5.3.6 Production unit and unit

Production units and units are the lowest level of equipment typically scheduled by the Level 4 or Level 3 functions for continuous manufacturing processes. Production units are composed of units and units are composed lower level elements, such as equipment modules, sensors, and actuators, but definitions of these are outside the scope of this standard. A production unit generally encompasses all of the equipment required for a segment of continuous production that operates in a relatively autonomous manner. It generally converts, separates, or reacts one or more feed stocks to produce intermediate or final products.

The major processing activity or product generated often identifies the production unit.

NOTE For example, production unit identifiers from various industries are Catalytic Cracker #1, Steam Cracker #59 and Alkylation Unit 2.

Production units and units have well-defined processing capabilities and throughput capacities and these are used for Level 3 functions. The capacities and capabilities are also often used as input to Level 4 scheduling, even if the units are not scheduled by the Level 4 functions.

5.3.7 Production line and work cell

Production lines and work cells are the lowest levels of equipment typically scheduled by the Level 4 or Level 3 functions for discrete manufacturing processes. Work cells are usually only identified when there is flexibility in the routing of work within a production line. Production lines and work cells may be composed of lower-level elements, but definitions of these are outside the scope of this document.

The major processing activity often identifies the production line.

NOTE For example, production line identifiers from various industries are Bottling Line #1, Capping Line #15, CMOS Line #2 and Water Pump Assembly Line #4.

Production line and work cells have well-defined manufacturing capabilities and throughput capacities and these are used for Level 3 functions. The capacities and capabilities are also often used as input to Level 4 scheduling, even if the production lines and work cells are not scheduled by the Level 4 functions.

5.3.8 Process cell and unit

Process cells and units are the lowest level of equipment typically scheduled by the Level 4 and Level 3 functions for batch manufacturing processes. Units are usually only identified at Level 3 and 4 if there is flexibility in the routing of the product within a process cell. The definitions for process cells and units are contained in IEC 61512-1.

The major processing capability or family of products produced often identifies the process cell.

NOTE For example, process cell identifiers from various industries are Mixing Line #5, West Side Glue Line and Detergent Line 13.

Process cells and units have well-defined manufacturing capabilities and batch capacities and these are used for Level 3 functions. The capacities and capabilities may also be used as input data for Level 4 scheduling, even if the process cells or units are not scheduled by the Level 4 functions.

5.3.9 Storage zone and storage unit

Storage zones and storage units are the lowest level of material movement equipment typically scheduled by the Level 4 and Level 3 functions for discrete, batch and continuous manufacturing processes. A storage zone is a type of work center and a storage unit is a type of work unit that is organized as elements within an area. These are the lower-level elements of an equipment hierarchy used in material storage and movement activities.

A storage zone typically has the capability needed for the receipt, storage, retrieval, movement and shipment of materials. This may include the movement of materials from one work center to another work center within or between enterprises.

NOTE Material is also temporarily stored in process cells, production units and production lines. This material is typically considered WIP and is usually distinct from inventory managed materials.

Storage units are typically managed at a finer level of detail than a storage zone. The physical location of a storage unit may change over time; for example, for goods in transit.

Storage units may be dedicated to a given material, group of materials, or method of storage.

Storage units can be further divided to address any hierarchical storage management scheme.

5.3.10 Storage zone and storage unit examples

Table 1 lists examples of a hierarchy of storage zones and the associated storage units.

Table 1 – Storage zone and storage unit examples

Storage zone	Storage unit
Warehouse	Rack/Bin/Slot
Trailer yard	Trailer, container
Tank farm	Tank, pipe section, headers, shared equipment
Silo farm	Silo, pipe section, headers, shared equipment
Ship terminal	Ship, ship's hold, container, barrel, tank
Rail yard	Railcar
Holding area	Pallet, barrel

5.4 Physical asset equipment hierarchy

The physical assets of an enterprise involved in manufacturing are usually also organized in a physical asset equipment hierarchy that may be related to financial or cost center control. Lower-level groupings are combined to form higher levels in the physical asset hierarchy. In some cases, a grouping within one level of the physical asset equipment hierarchy may be incorporated into another grouping at that same level.

The UML formal physical asset equipment model defined in Part 2 of this standard is used to define the physical asset equipment hierarchy information. The Part 2 UML model contains the rules used to construct the hierarchical models used in different operational scenarios.

The physical asset hierarchy and the role based equipment hierarchy may overlap at any level; however the physical asset hierarchy often contains additional levels that correspond to either a cost center hierarchy or a physical assembly hierarchy, levels in the physical asset hierarchy may also have different names than the role hierarchy, such as Site Asset, as illustrated in Figure 6. Terminology for levels in the physical asset hierarchy is not defined in this Part.

NOTE 1 The physical asset equipment hierarchy usually has a reference to an accounting hierarchy in a chart of accounts. A chart of accounts is a listing of accounts in a financial system and is used as the basis for preparing financial reports from an accounting system.

NOTE 2 Single use equipment may be considered as equipment or material, which is consumed, depending upon the application. For example load carriers such as containers and pallets may be single use equipment.

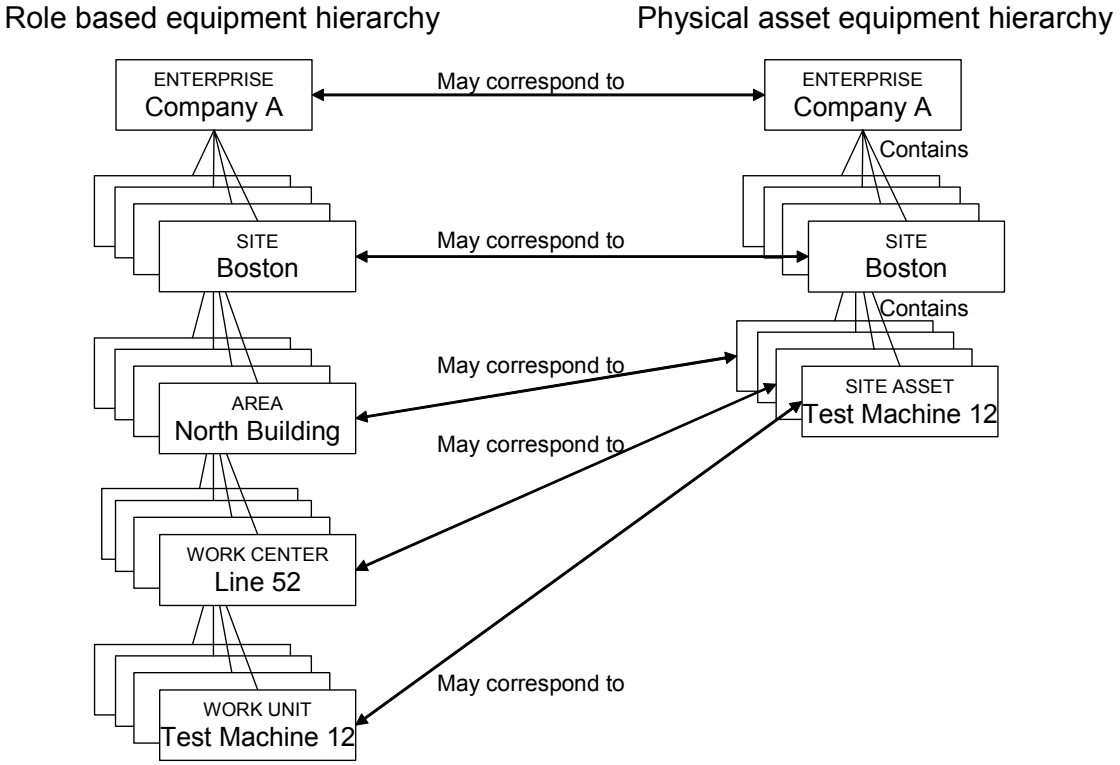


Figure 6 – Example of a physical asset hierarchy related to role based equipment hierarchy

5.5 Decision hierarchy (Informative)

In addition to the hierarchy of activities, there is also a hierarchy of decision-making and associated scheduling involved in enterprise-to-control integration. The decision hierarchy is defined in ISO-15704 Industrial automation systems — Requirements for enterprise-reference architectures and methodologies.

6 Functional data flow model

6.1 Functional data flow model contents

The functional data flow model shall identify and relate the following:

a) functions of an enterprise involved with manufacturing;

b) information flows between the functions that cross the enterprise-control system boundary.

NOTE: These functions and flows are extracted from the Purdue Reference Model and are used to define a realistic and comprehensive set of functions and data flows used to build the models defined in other parts of this standard.

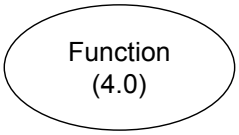
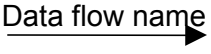
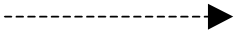
- The data structures for enterprise-control system integration information are described in Part 2.
- The functions of the Level 3 manufacturing operations management (MOM) are described in Part 3.
- The data structures for manufacturing operations and control integration information are described in Part 4.
- The data flows for enterprise-control system integration information are described in Part 5.
- The data flows for manufacturing operations and control integration information are described in Part 6.

6.2 Functional data flow model notation

The enterprise-control interface is described using a data flow model. The model uses the Yourdon-DeMarco notational methodology (see Bibliography).

Table 2 shows the Yourdon notation used in the functional model.

Table 2 – Yourdon notation used

Symbol	Definition
	A function is represented as a labeled ellipse. A function is a group of tasks that are classified as having a common objective. Each function can be further decomposed in terms of detailed functions, at a more granular level. Functions at any level of decomposition are identified with a name and a level designation, for example, 3.1.3. The successive numbers in a designation represent the depth of detail of an identified function in the functional hierarchy level. .
	A solid line with an arrow represents a grouping of data that flows between functions, data stores, or external entities. The data are defined in the enterprise-control integration model. All solid lines have a name for the data flows. A data flow at one level of the functional hierarchy may be represented by one or more flows at the lower level of the hierarchy.
	A dashed line with an arrow represents a grouping of data that flows between functions, data stores, or external entities. The data are not pertinent to the enterprise-control integration model but are shown to illustrate the context of functions. Dashed-line data flows without names are not identified in this model.

6.3 Functional model

The functional model is depicted in Figure 7. The wide dotted line illustrates the boundary of the enterprise-control interface. The line is equivalent to the Level 3/Level 4 interface presented in 5.1. The manufacturing operations and control side of the interface includes most of the functions in production control and some of the activities in the other major functions. The labeled lines indicate information flows of importance to manufacturing operations and control.

The wide dotted line intersects functions that have sub-functions that may fall into the MO&C domain or the enterprise domain depending on organizational policies. This is a combination of a function view and an information view of the enterprise, as defined in ISO 15704.

The model structure does not reflect an organizational structure within a company but an organizational structure of functions. Different companies will place the functions in different organizational groups.

The detailed information in the information flows is presented in Part 2.

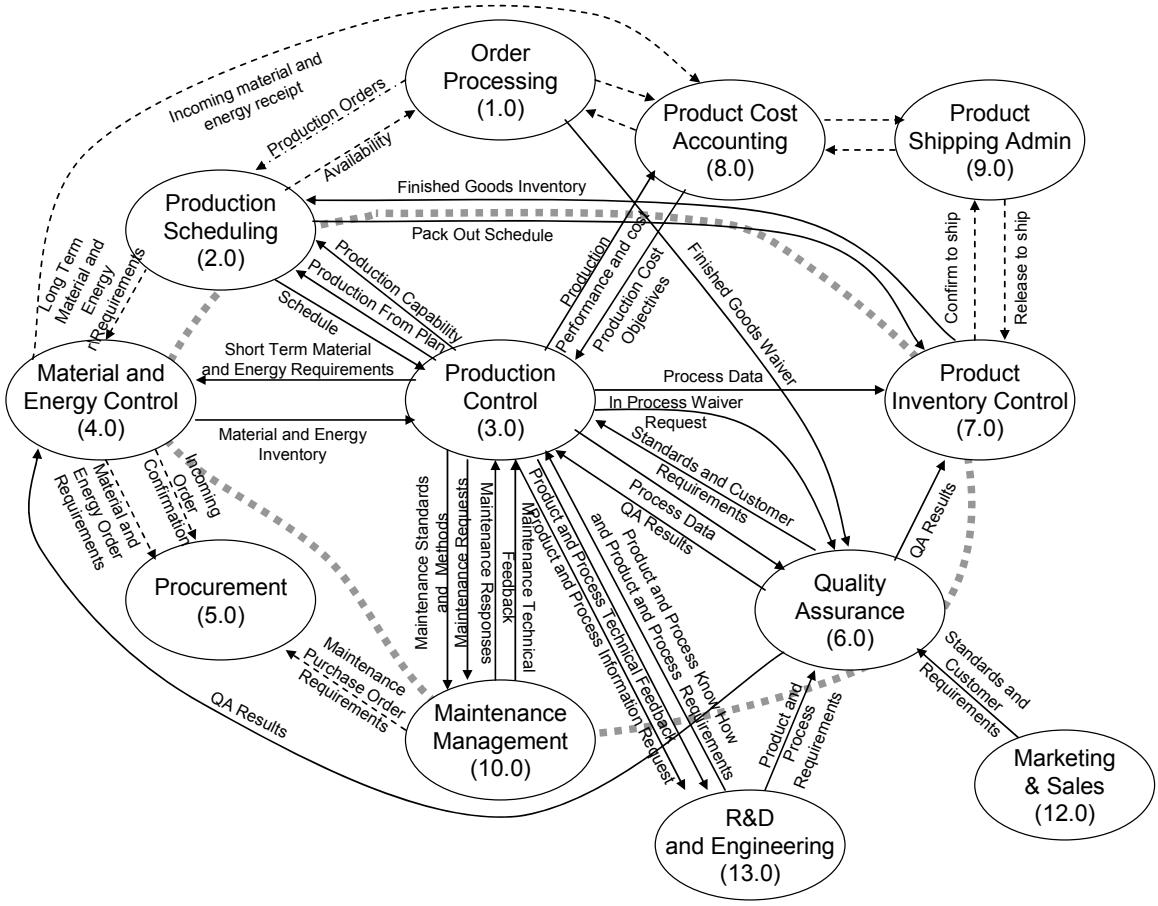


Figure 7 – Functional model

6.4 Functions

6.4.1 Order processing (1.0)

The general functions of order processing typically include

a) customer order handling, acceptance and confirmation;

b) sales forecasting;

c) waiver and reservation handling;

d) gross margin reporting;

e) determining production orders.

There is generally no direct interface between the functions of order processing and the manufacturing operations and control functions.

6.4.2 Production scheduling (2.0)

Production scheduling functions interface to the manufacturing operations and control system functions through a production schedule, actual production information, and production capability information. This information exchange is presented in the production control functions.

Detailed scheduling, within an area, is considered to be a control function.

The general functions of production scheduling typically include

a) the determination of production schedule;

b) the identification of long-term raw material requirements;

c) the determination of the pack-out schedule for end-products;

d) the determination of the available product for sales.

The information generated or modified by the production scheduling functions includes

1) the production schedule;

2) the actual production versus the planned production;

3) the production capacity and resource availability;

4) the current order status.

6.4.3 Production control (3.0)

6.4.3.1 Production control main functions

The production control functions encompass most of the functions associated with manufacturing operations and control. The functions of production control typically include

a) controlling the transformation of raw materials into the end-product in accordance with the production schedule and production standards;

b) performing plant engineering activities and updating of process plans;

c) issuing requirements for raw materials;

d) producing reports of performance and costs;

e) evaluating constraints to capacity and quality;

f) self-testing and diagnosis of production and control equipment;

g) creating production standards and instructions for SOPs (standard operating procedures), recipes, and equipment handling for specific processing equipment.

The main functions in production control include process support engineering, operations control, and operations planning.

6.4.3.2 Process support engineering

The functions of process support engineering typically include

a) issuing requests for modification or maintenance;

b) coordinating maintenance and engineering functions;

c) providing technical standards and methods to operations and maintenance functions;

d) following up on equipment and process performance;

e) providing technical support to operators;

f) following up on technological developments.

The functions of process support engineering generate or modify the following information for use in other control functions.

1) Minor equipment and process modifications; this may include new design drawings.
2) Instructions on how to handle equipment; this may include standard operating procedures.
3) Instructions on how to make products; this includes production rules and the standard materials, equipment, and other resources used.
4) Material safety data sheets (MSDS).
5) Instructions on how to install equipment; this may include vendor equipment.
6) Environmental and safety operating limits and constraints.
7) Engineering standards for process equipment design techniques and process operational methods, and online operating instructions.

6.4.3.3 Production operations control

Production operations control is the collection of functions that manages all production within a site or area.

The functions of production operations control typically include

a) producing the product according to the schedule and specifications;

b) reporting production, process, and resource information;

c) monitoring equipment, validating operational measurements, and determining the need for maintenance;

d) preparing equipment for maintenance and returning it to service after maintenance;

e) performing diagnostics and self-check of production and control equipment;

f) balancing and optimizing production within the site or area;

g) possible local site or area labor management and document management.

The functions of production control typically generate or modify the following information for use in other control functions.

1) Status of production requests.
2) Selected production data, such as data to calculate production cost and performance.
3) Selected process data, such as equipment performance feedback.
4) Status of resources.
5) Status of maintenance work order requests.
6) Requests for maintenance.
7) Diagnostic and self-test results.
8) Process history.
9) Requests for process support engineering support.
10) Requests for analysis of material.

6.4.3.4 Production Operations planning

The functions of production operations planning typically include

a) setting up a short-term production plan based on the production schedule;
b) checking the schedule against raw material availability and product storage capacity;
c) checking the schedule against equipment and personnel availability;
d) determining the per cent of capacity status;
e) modifying the production plan hourly to account for equipment outage, manpower and raw materials availability.

The functions of production operations planning typically generate or modify the following information for use in other control functions.

1) Material and energy inventory report.
2) Material and energy requirements required to meet the production plan.
3) Site or area production plan for operations control.
4) Available capability of the production resources.

6.4.4 Material and energy control (4.0)

The functions of materials and energy control typically include

a) managing inventory, transfers, and quality of material and energy;
b) generating requests for purchasing of materials and energy based on short- and long-term requirements;
c) calculating and reporting inventory balance and losses of raw material and energy utilization;
d) receiving incoming material and energy supplies and requesting quality assurance tests;
e) notifying purchasing of accepted material and energy supplies.

The functions of materials and energy control typically generate or modify the following information for use in other control functions.

1) Material and energy order requests.
2) Incoming confirmation of received materials and energy.

3) Material and energy inventory report.

4) Manual and automated transfer instructions for operations control.

Some of the functions within material and energy control may be inside the MO&C domain, based on local organizational structures. Therefore, selected data flows into and out of material and energy control are presented because they may cross the enterprise-control system boundary.

6.4.5 Procurement (5.0)

The functions of procuring resources typically include

a) placing orders with suppliers for raw materials, supplies, spare parts, tools, equipment and other required materials;

b) monitoring progress of purchases and reporting to requisitioners;

c) releasing incoming invoices for payment after arrival and approval of goods;

d) collecting and processing of unit requests for raw materials, spare parts, etc., for order placement to vendors.

The functions of procurement typically generate or modify the expected material and energy delivery schedules for use in other control functions.

6.4.6 Quality assurance (6.0)

The functions of quality assurance typically include

a) testing and classification of materials;

b) setting standards for material quality;

c) issuing standards to manufacturing and testing laboratories in accordance with requirements from technology, marketing and customer services;

d) collecting and maintaining material quality data;

e) releasing material for further use (delivery or further processing);

f) certifying that the product was produced according to standard process conditions;

g) checking of product data versus customer's requirements and statistical quality control routines to assure adequate quality before shipment;

h) relaying material deviations to process engineering for re-evaluation to upgrade processes.

The functions of quality assurance typically generate or modify the following information for use in other control functions.

1) Quality assurance test results.

2) Approval to release materials or waivers on compliance.

3) Applicable standards and customer requirements for material quality.

Some of the functions within quality assurance may be inside the MO&C domain, based on local organizational structures; for example, quality assurance requests. Therefore, selected data flows into and out of quality assurance are addressed because they may cross the enterprise-control system boundary.

6.4.7 Product inventory control (7.0)

The functions of product inventory control typically include

a) managing the inventory of finished products;

b) making reservations for specific product in accordance with product selling directives;

c) generating the pack-out end product in accordance with delivery schedule;

d) reporting on inventory to production scheduling;

e) reporting on balance and losses to product cost accounting;

f) arranging physical loading/shipment of goods in coordination with product shipping administration.

The functions of product inventory control typically generate or modify the following information for use in other control functions.

1) Finished goods inventory.

2) Inventory balances.

3) Pack-out schedule.

4) Release to ship.

5) Confirm to ship.

6) Storage requirements.

Some of the functions within product inventory control may be inside the MO&C domain, based on local organizational structures. Therefore, selected data flows into and out of product inventory control are used because they may cross the enterprise-control system boundary.

6.4.8 Product cost accounting (8.0)

The functions of cost accounting typically include

a) calculating and reporting on total product cost;

b) reporting cost results to production for adjustment;

c) setting cost objectives for production;

d) collecting raw material, labor, energy and other costs for transmission to accounting;

e) calculating and reporting on total production cost, reporting cost results to production for adjustment;

f) setting cost objectives for materials and energy supply and distribution.

The functions of cost accounting typically generate or modify the following information for use in other control functions.

1) Cost objectives to production.

2) Performance and costs from production.

3) Parts and energy incoming to accounting from material and energy control.

6.4.9 Product shipping administration (9.0)

The functions of product shipping administration typically include

a) organizing transport for product shipment in accordance with accepted orders requirements;

b) negotiating and placing orders with transport companies;

c) accepting freight items on site and releasing material for shipment;

d) preparing accompanying documents for shipment (BOL, customs clearance);

e) confirming shipment and releasing for invoicing to general accounting;

f) reporting on shipping costs to product cost accounting.

6.4.10 Maintenance management (10.0)

The functions of maintenance management typically include

a) providing maintenance for existing installations;

b) providing a preventative maintenance program;

c) providing equipment monitoring to anticipate failure, including self-check and diagnostic programs;

d) placing purchase order requests for materials and spare parts;

e) developing maintenance cost reports, and coordinating outside contract work effort;

f) providing status and technical feedback on performance and reliability to process support engineering.

The functions of maintenance management typically generate or modify the following information for use in other control functions.

1) Maintenance schedules that specify the plan for future work orders.

2) Maintenance work orders that specify specific equipment to be taken out of service and made available for maintenance functions.

3) Diagnostic and self-test requests to be performed on the equipment.

Some of the functions within maintenance management may be inside the MO&C domain, based on local organizational structures. Therefore, selected data flows into and out of maintenance management are shown because they may cross the enterprise-control system boundary.

6.4.11 Marketing and sales (12.0)

The general functions of marketing and sales typically include

a) generating sales plans;

b) generating marketing plans;

c) setting pricing;

d) determining customer requirements for products;

e) determining requirements and standards for products;

f) interacting with customers.

6.4.12 Research, development, and engineering (13.0)

The general functions of research, development and engineering typically include

a) development of new products;

b) definition of process requirements;

c) definition of product requirements, as related to the production of the products.

d) definition of equipment and resource requirements, as related to the production of the products

6.5 Information flows

6.5.1 Information flow descriptions

The information flows between the functions that are labeled in Figure 7 are listed below.

6.5.2 Schedule

The schedule information flows from the production scheduling (2.0) functions to the production control (3.0) functions.

This typically contains the information, to production, on what product is to be made, how much is to be made, and when it is to be made. Details of the schedule information are defined in the Part 2 object models.

6.5.3 Production from plan

The production-from-plan information flows from the production control (3.0) functions to the production scheduling (2.0) functions.

This contains information about the current and completed production results from execution of the plan. It typically contains what was made, how much was made, how it was made, and when it was made. Details of the production-from-plan information are defined the Part 2 object models.

6.5.4 Production capability

The production capability information flows from the production control (3.0) functions to the production scheduling (2.0) functions.

Production capability information is the current committed, available, and unattainable capacity of the production facility. This typically includes materials, equipment, labor, and energy. Details of the production capability information are defined in the Part 2 object models.

6.5.5 Material and energy order requirements

The material and energy order requirement information flows from the material and energy control (4.0) functions to the procurement (5.0) functions.

Material and energy order requirements define future requirements for materials and energy required to meet short-term and long-term requirements based on the current availability.

There are no object models for the material and energy order requirements, but the information may use the definitions relating to material and energy defined in the Part 2 object models.

6.5.6 Incoming order confirmation

The incoming order confirmation information flows from the material and energy control (4.0) functions to the procurement (5.0) functions.

Incoming order confirmations are the notification that the material or energy has been received.

This information is not defined in the Part 2 object models because it does not cross the interface between the enterprise and MO&C domains.

6.5.7 Long-term material and energy requirements

The long-term material and energy requirements information flows from the production scheduling (2.0) functions to the material and energy control (4.0) functions.

The long-term material and energy requirements are typically time-sequenced definitions of material and energy resources that will be needed for planned production.

There are no object models for the long-term material and energy requirements, but the information may use the definitions relating to material and energy defined in the Part 2 object models.

6.5.8 Short-term material and energy requirements

The short-term material and energy requirements information flows from the production control (3.0) functions to the material and energy control (4.0) functions.

The short-term material and energy requirements are requirements for resources that are needed for currently scheduled or executing production. These typically include

a) requests for materials that may include deadlines;

b) reservations for materials;

c) indications of actual consumption;

d) release of reservations;

e) adjustments to consumption.

Material and energy requirements are defined in the Part 2 object models.

6.5.9 Material and energy inventory

The material and energy inventory information flows from the material and energy control (4.0) functions to the production control (3.0) functions.

The material and energy inventory information flows are the currently available material and energy that is used for short-term planning and for production. This information typically deals with raw materials. Material and energy inventory information is defined in the Part 2 object models.

6.5.10 Production cost objectives

The production cost objectives information flows from the product cost accounting (8.0) functions to the production control (3.0) functions.

Production cost objectives are the production performance targets in terms of resources. This could be related to a product or to a process. This typically includes materials, labor hours, energy, equipment usage, or actual costs. Elements of the production cost objectives are defined in the Part 2 object models.

6.5.11 Production performance and costs

The production performance and costs information flows from the production control (3.0) functions to the product cost accounting (8.0) functions.

Production performance and costs are the actual use and results associated with specific production activities. This typically includes materials, labor hours, energy, and equipment usage. Results are typically identified by products, by-products, co-products, and scrap. This information would be in sufficient detail to identify all costs by product, co-products, and scrap. Production performance is defined in the Part 2 object models.

6.5.12 Incoming material and energy receipt

The incoming material and energy receipt information flows from the material and energy control (4.0) functions to the product cost accounting (8.0) functions.

Incoming material and energy receipt is the notification that the material or energy has been received and additional information needed for cost accounting. This may include the BOL, material safety data sheet (MSDS), and COA. This information is coordinated with the incoming order confirmation (6.5.6) information flow.

This information is not detailed in the Part 2 object models because it generally does not cross the interface between the enterprise and MO&C domains.

6.5.13 Quality assurance results

The quality assurance (QA) results information flows from the quality assurance (6.0) functions to the product inventory control (7.0) functions, material and energy control (4.0) functions, and the production control, operations control (3.2) functions.

Quality assurance results are typically the results from QA tests performed on raw materials, in-process materials, or products. Quality assurance results may concern tests performed in the product or in-process tests performed in a particular segment of production. Quality assurance results may include granting of in-process waivers.

A positive QA result may be required before product inventory management may ship a product. A positive QA result may be required before production control transfers product-to-product inventory control.

Details of quality assurance results are defined in the Part 2 object models.

6.5.14 Standards and customer requirements

The standards and customer requirements information flows from the marketing and sales (12.0) functions to the quality assurance (6.0) functions, and from quality assurance (6.0) to production control (3.0).

Standards and customer requirements are the specific values for attributes of the product that satisfy the customer needs. This typically includes specific processing specifications as well as material properties. This information may result in changes in or additions to material, equipment, and personnel properties and associated tests.

Details of standards and customer requirements are not defined in the Part 2 object models.

6.5.15 Product and process requirements

The product and process requirements information flows from the research, development and engineering (RD&E) (13.0) functions to the production control (3.0) functions and the quality assurance (6.0) functions.

The product and process requirements define how to make a product. These typically correspond to general or site recipes in batch manufacturing, bills of materials, assembly instructions and drawings in discrete manufacturing, and process descriptions in continuous manufacturing. Information about specific equipment, personnel, and material requirements may be specified according to the object models defined in Part 2.

Details of product and process requirements are defined in the Part 2 object models for product definitions.

6.5.16 Finished goods waiver

Finished goods waiver information flows from the order processing (1.0) functions to the quality assurance (6.0) functions.

Finished goods waivers are approvals for deviation from normal product specifications. Finished goods waivers may be negotiated customer deviations from specifications defined in the standards and customer requirements (6.5.14).

Details of finished goods waiver are not defined in the Part 2 object models.

6.5.17 In-process waiver request

In-process waiver request information flows from production control (3.0) to the quality assurance (6.0) functions.

In-process waiver requests are requests for waivers on normal production procedures due to deviations in materials, equipment, or quality metrics, where normal product specifications are maintained. The response to the request is in the quality assurance results.

Details of in-process waiver requests are not defined in the Part 2 object models.

6.5.18 Finished goods inventory

The finished goods inventory information flows from the product inventory control (7.0) functions to the production scheduling (2.0) functions.

The finished goods inventory is information on the current inventory of finished goods that is maintained by product inventory control. This typically includes quantity, quality, and location information that is used for the scheduling of new production, and as feedback on previously scheduled production. This is the total finished product available for distribution or shipment. Finished goods inventory is defined in the Part 2 object models.

6.5.19 Process data

The process data information flows from the production control (3.0) functions to the product inventory control (7.0) functions and the quality assurance (6.0) functions.

Process data is information about production processes, as related to specific products and production requests, and is described in the Part 2 object models. Typical uses of process data are by quality assurance as part of the QA functions, and by product inventory control where this information is needed as part of the finished product deliverables.

6.5.20 Pack-out schedule

The pack-out schedule information flows from the production scheduling (2.0) functions to the product inventory control (7.0) functions.

A pack-out schedule is the consolidation of produced items of one or more stock-keeping unit for delivery to customers, inventory, or others.

Details of pack out schedules are defined in the Part 2 object models.

6.5.21 Product and process information request

The product and process information request flows from the production control (3.0) functions to the RD&E (13.0) functions.

A product and process information request is a request for new or modified product definitions and process definitions.

Details of product and process information requests are defined in the Part 2 and Part 5 object models.

6.5.22 Maintenance requests

The maintenance request information flows from the production control (3.0) functions to the maintenance management (10.0) functions.

Maintenance requests are requests for a maintenance function. This may be a planned request or an unplanned request due to an unplanned event, such as a lightning strike on a transformer.

Details of maintenance request information are defined in the Part 2 object models.

6.5.23 Maintenance responses

The maintenance response information flows from the maintenance management (10.0) functions to the production control (3.0) functions.

Maintenance responses are the logged status or completion of routine, scheduled, or unplanned maintenance.

Details of maintenance responses information are defined in the Part 2 object models.

6.5.24 Maintenance standards and methods

Maintenance standards and methods information flows from the production control (3.0) functions to the maintenance management (10.0) functions.

Maintenance standards and methods are typically accepted practices and procedures that maintenance uses in performing its functions.

Details of maintenance standards and methods information are defined in the Part 2 object models.

6.5.25 Maintenance technical feedback

Maintenance technical feedback information flows from the maintenance management (10.0) functions to the production control (3.0) functions.

Maintenance technical feedback is typically information about the performance and reliability of production equipment and may include reporting on performed maintenance. Reports on maintenance may include scheduled, preventive, or predictive.

Details of maintenance technical feedback information are defined in the Part 2 object models.

6.5.26 Product and process technical feedback

Product and process technical feedback information flows from the production control (3.0) functions to the RD&E (13.0) functions.

Product and process technical feedback is information about the performance of production equipment and product. This information generally results from performance tests and study requests to operations control.

Details of product and process technical feedback information are defined in the Part 2 object models.

6.5.27 Maintenance purchase order requirements

Maintenance purchase order requirements information flows from the maintenance management (10.0) functions to the procurement (5.0) functions.

Maintenance purchase order requirements are information about materials and supplies required to perform maintenance tasks.

Details of maintenance purchase order requirements information are not defined in the Part 2 object models.

6.5.28 Production order

Production order information flows from order processing (1.0) functions to production scheduling (2.0) functions.

Production order is information about accepted customer orders that defines work for the plant.

Details of production order information are defined in the Part 2 object models.

6.5.29 Availability

Availability information flows from the production scheduling (2.0) functions to the order processing (1.0) functions.

Availability is information about the plant's ability to fulfill the order.

Details of availability information are defined in the Part 2 object models.

6.5.30 Release to ship

Release to ship information flows from the product shipping administration (9.0) functions to the product inventory control (7.0) functions.

Release to ship is information about the permission to ship the product.

Details of release to ship information are defined in the Part 2 object models.

6.5.31 Confirm to ship

Confirm to ship information flows from the product inventory control (7.0) functions to the product shipping administration (9.0).

Confirm to ship is information about the actual shipment of product.

Details of confirm to ship information are defined in the Part 2 object models.

7 Manufacturing operations

7.1 Manufacturing operations management

The activities of manufacturing operations management are those activities of a manufacturing facility that coordinate the personnel, equipment, material and energy in the conversion of raw materials and/or parts into products. Manufacturing operations management includes activities that may be performed by physical equipment, human effort and information systems.

Manufacturing operations management shall encompass the activities of managing information about the schedules, use, capability, definition, history and status of all of the resources (personnel, equipment and material) within, and associated with, the manufacturing facility.

NOTE Resources associated with the manufacturing facility but not within it may include, among others, government inspectors, regulatory certifications, resource coordination with other entities, outsourced activities and processes.

7.2 Manufacturing operations management categories

The manufacturing operations management activities correspond to the activity set defined in 6.3. These are the activities contained within the heavy dotted line shown in Figure 8. The heavy dotted line is equivalent to the Level 3/Level 4 interface defined in 5.2.1. Manufacturing operations management shall be modeled using four categories: production operations management, maintenance operations management, quality operations management and inventory operations management, as shown in shaded areas in Figure 8.

NOTE 1 There are also other activities of a manufacturing facility, not shown in Figure 8, but described in Annex A.

NOTE 2 The model structure and categories do not reflect a business organizational structure within a company but is a model of activities. Different companies assign responsibilities for categories, activities or sub-activities to different business organizational groups. Refer to Part 3 for a generic activity model which can be applied to other categories of activities.

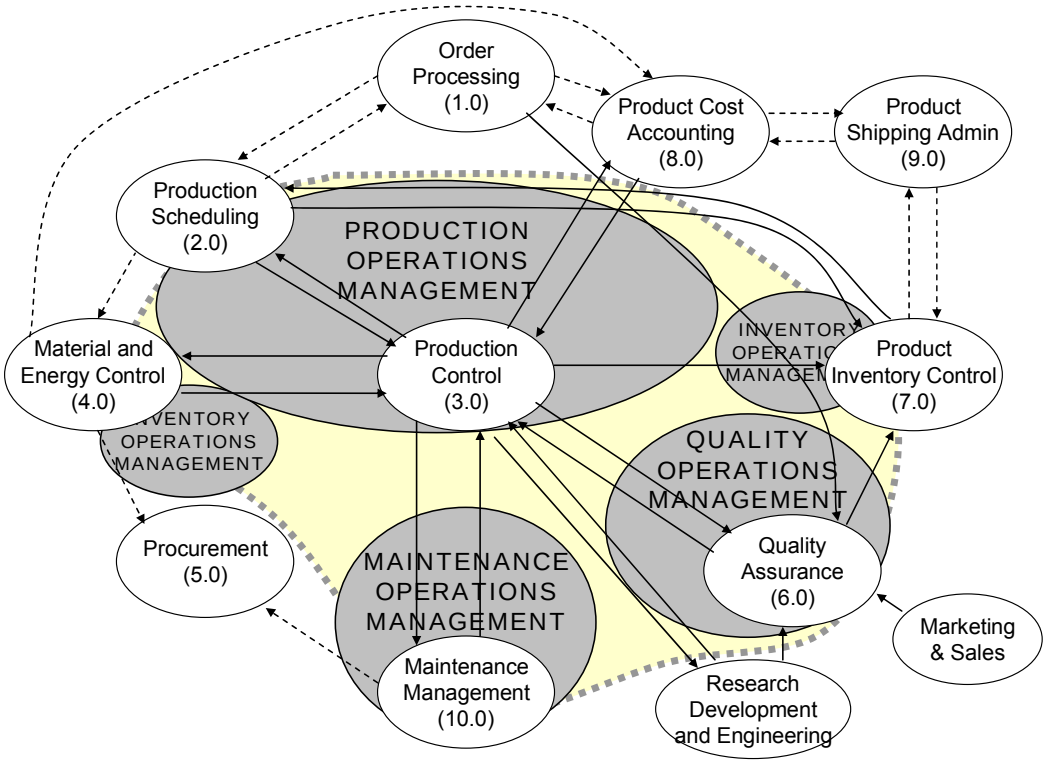


Figure 8 – Manufacturing operations management model

7.3 Other activities within manufacturing operations management

In addition to the activities of production operations, maintenance operations, quality operations, and inventory operations management there are many supporting management activities that occur in manufacturing operations. Elements of these supporting activities may occur in any of the production, maintenance, quality operations, or inventory operations management activities. Elements of these supporting activities may not be unique to manufacturing operations in an enterprise, but typically also apply to many other areas of the enterprise.

These supporting activities include:

a) Management of security within manufacturing operations.

b) Management of information within manufacturing operations.

c) Management of configurations within manufacturing operations.

d) Management of documents within manufacturing operations.

e) Management of regulatory compliance within manufacturing operations.

f) Management of incidents and deviations within manufacturing operations.

The definition of the supporting activities is not in the scope of this standard, because they often are enterprise wide, however requirements for the activities as they relate to manufacturing operations are briefly described in Annex A.

7.4 Manufacturing operations management resources

A resource is an entity that provides some or all of the capabilities required by the execution of the enterprise activities and/or business processes. The resources involved in manufacturing operational management are; personnel, material, equipment and process segments.

- Personnel: the personnel involved in manufacturing operations management
- Material: the material involved in manufacturing operations management
- Equipment: the equipment (role based and physical asset) involved in manufacturing operations management
- Process segment: a process segment specifies the capabilities needed for a segment of production, maintenance, inventory or quality activity at the level of detail required to support business processes. The process segment is independent of any particular product definition or operation definition. This may include material, energy, personnel, or equipment capabilities as described in Part 2. Business Process Segment is a synonym for Process Segment.

8 Information model

8.1 Model explanation

Subclause 8.2 is an overview of the information contained in the object model and provides a context for the object models. It includes the general categories of information formally defined in Part 2.

The production schedule, production performance, product definition, and production capability information for production operations management are defined in additional detail in Subclause 8.3 and later.

There are equivalent information structures for maintenance, quality test and inventory operations management that are of importance for manufacturing operations and are defined in Part 2 using a generic model.

The methods and activities associated with conversion and transformation within Level 3 of the business representations to the Level 3 detailed work representations are defined in Part 3.

8.2 Manufacturing operations information

There are four categories of manufacturing operations information that correspond to the four categories of manufacturing operations activities. The information corresponds to four major types of information as shown in Figure 9:

a) Schedule and request information – Information about requests to perform work within one or more categories of activities.

b) Performance and response information – Information about work performed within one or more categories of activities.

c) Capability information – Information about the capabilities to perform work within one or more categories of activities.

d) Definition information – Information about the definition of work that could be performed within one or more categories of activities.

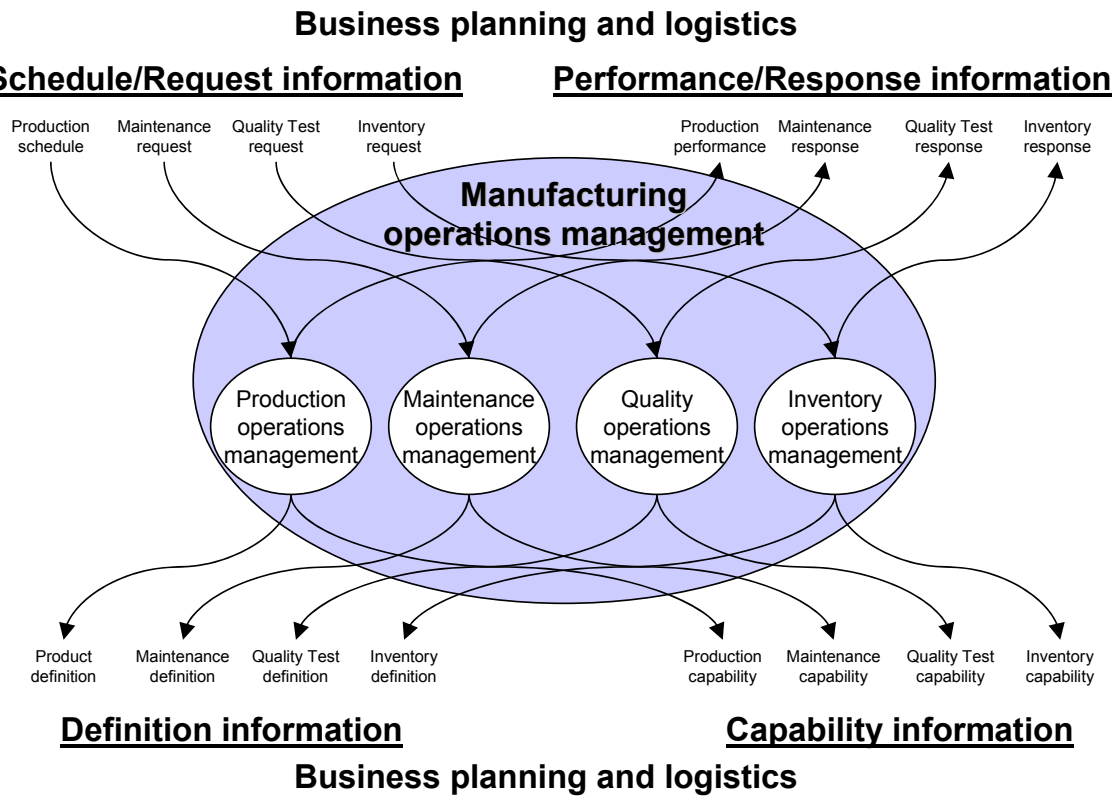


Figure 9 – Manufacturing operations information

8.3 Segment relationships

Figure 10 depicts the relationship of segments:

- a process segment is an identification of resources with specific capabilities needed for a segment of production, independent of any particular product,

- a product segment is an equivalent name of an operation segment that is specific for production and is defined in this Part, an operation segment is an identification of personnel resources, equipment resources, and material specifications required of a process segment to complete an operational step for a specific product (defined in Part 2).

- a segment requirement is an identification of the personnel resources, equipment resources, and material specifications required for scheduled operations (defined in Part 2),

- a segment actual is an identification of the personnel resources, equipment resources, and material specifications actually used in operations (defined in Part 2).

There is a relationship among segments. A product segment references a process segment known to production, a segment requirement references a known product segment of the product being manufactured or a process segment, and a segment actual references a known product segment of the product manufactured or a process segment.

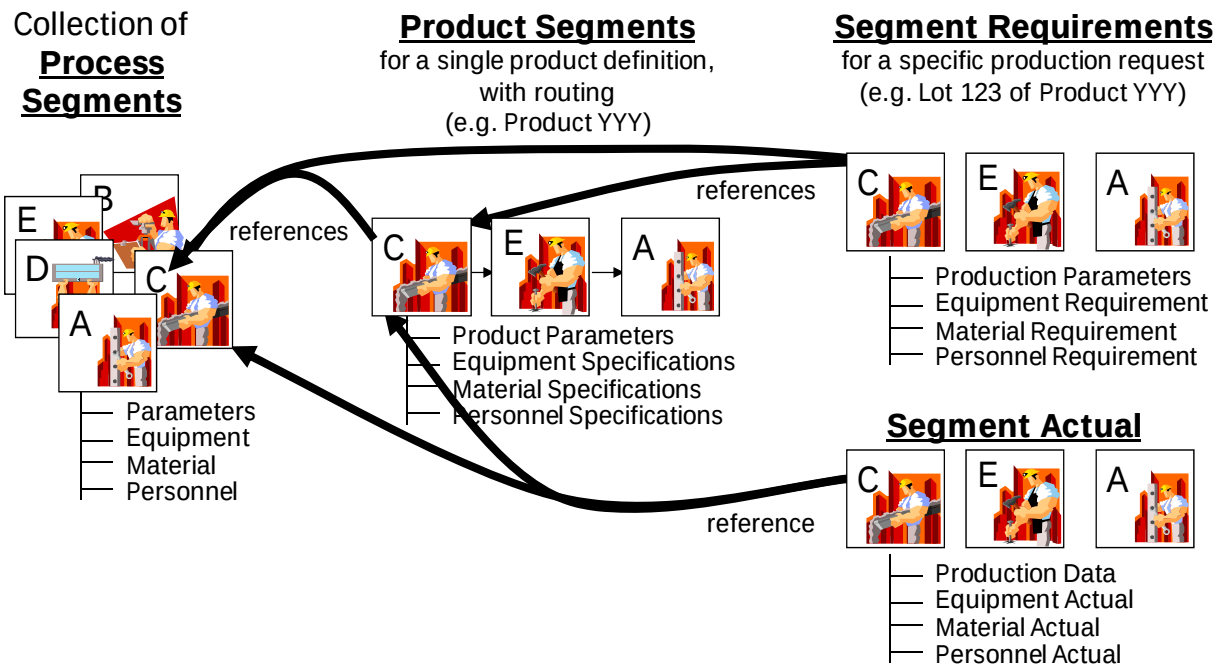


Figure 10 – Segment relationships

8.4 Categories of production operations management information

8.4.1 Information areas

Most of the production operations management information described in the Clause 6 model fall into the following four main areas.

a) Production schedule: Information about schedules for production of the product.

b) Production performance: Information about actual production of the product

c) Production capability: Information about the capability to produce a product.

d) Product definition: Information required to produce a product.

Part 2 contains a complete mapping of Clause 6 information elements to Part 2 object models.

Clause 8.4 describes the categories of information structures that are exchanged between production oriented applications at Level 4 and those at Level 3.

This section is based on the production operation management category to illustrate the different information structures and categories that can also be applied to other operation categories (inventory, quality, maintenance) as described in Part 2.

This information is a subset of the information shown in Figure 9 and is identified in Figure 11.

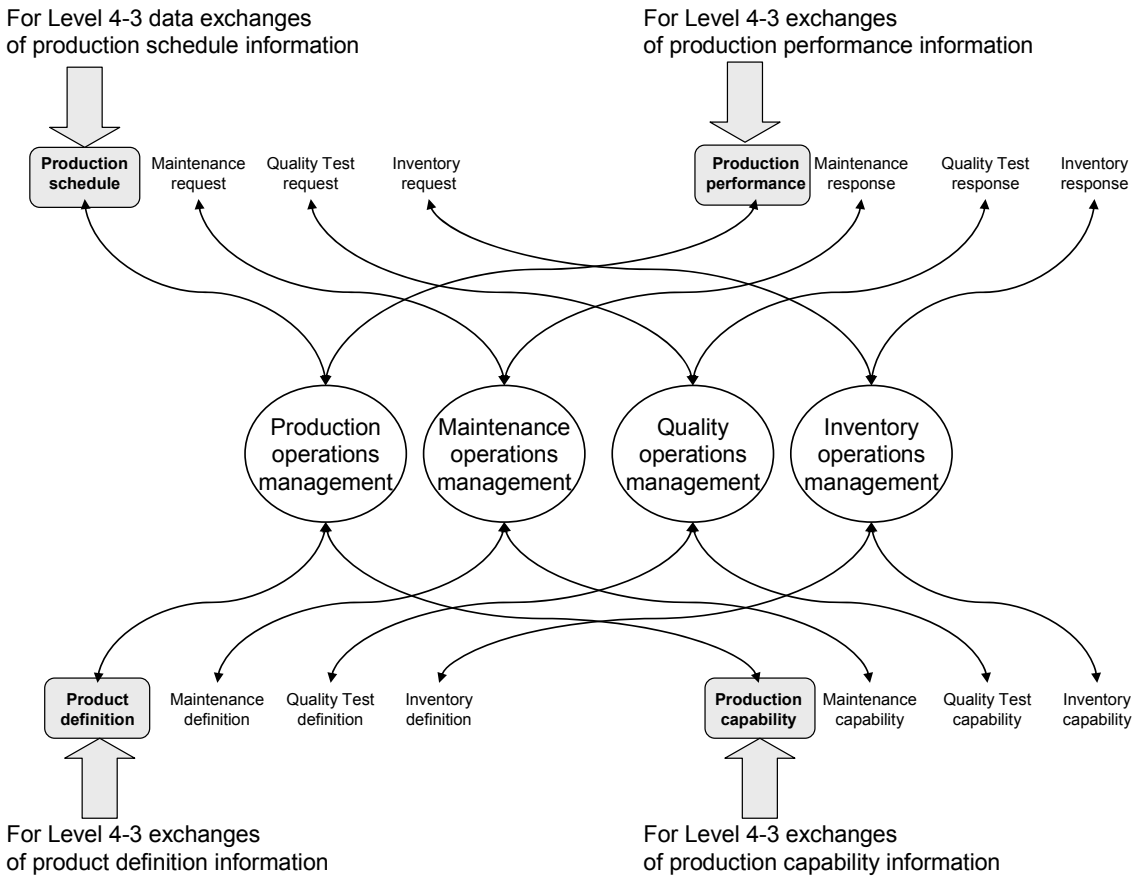


Figure 11 – Production operations management information

Some information in each of these four areas is shared between the manufacturing operations and control systems and the other business systems, as illustrated Figure 12. Venn diagrams are used to illustrate the overlap of information. This standard is only concerned with the overlapping information in the Venn diagrams, and with presenting a model and common terminology for that information.

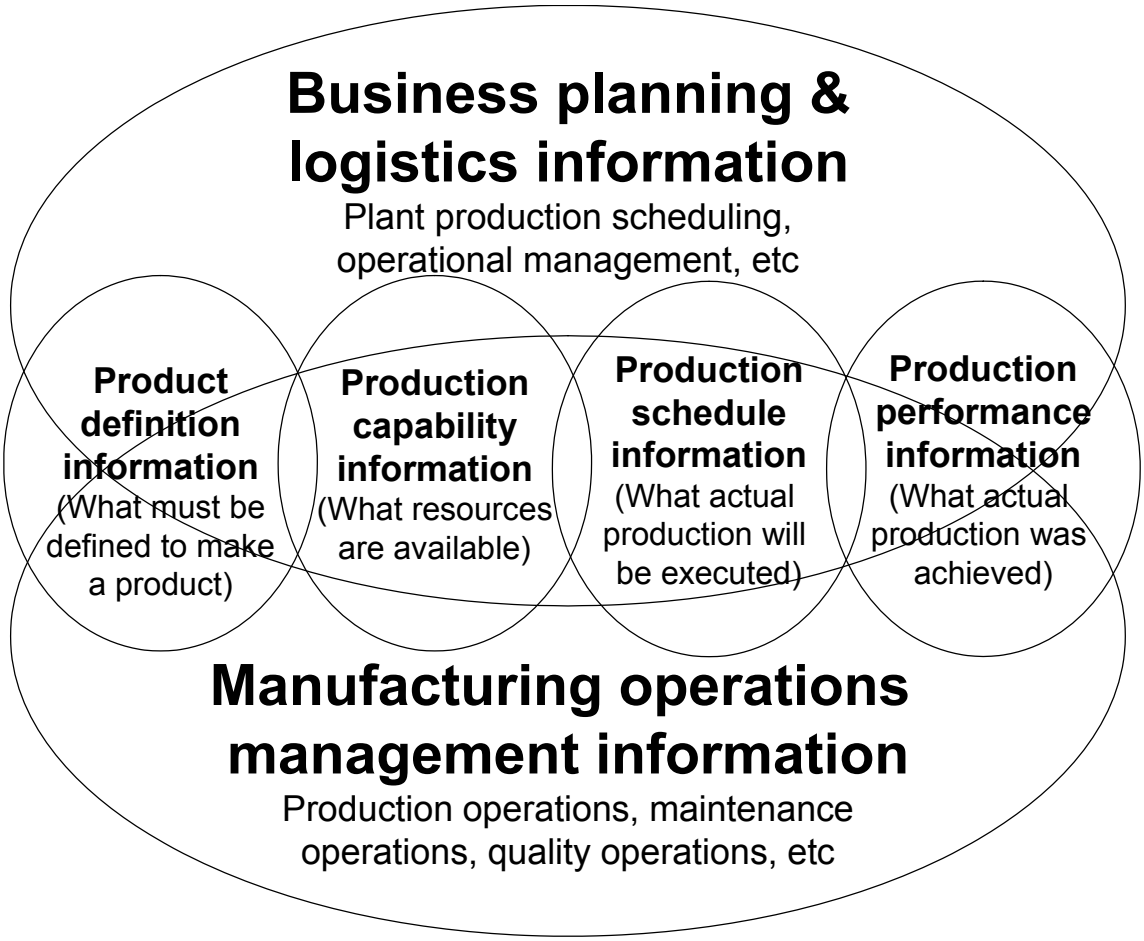


Figure 12 – Areas of information exchange

8.4.2 Production capability information

8.4.2.1 Production capability information categories

There are three main areas of information about the production capability that have significant overlap. The three areas of information are production capability information, maintenance information, and capacity scheduling information. Figure 13 illustrates the overlapping information.

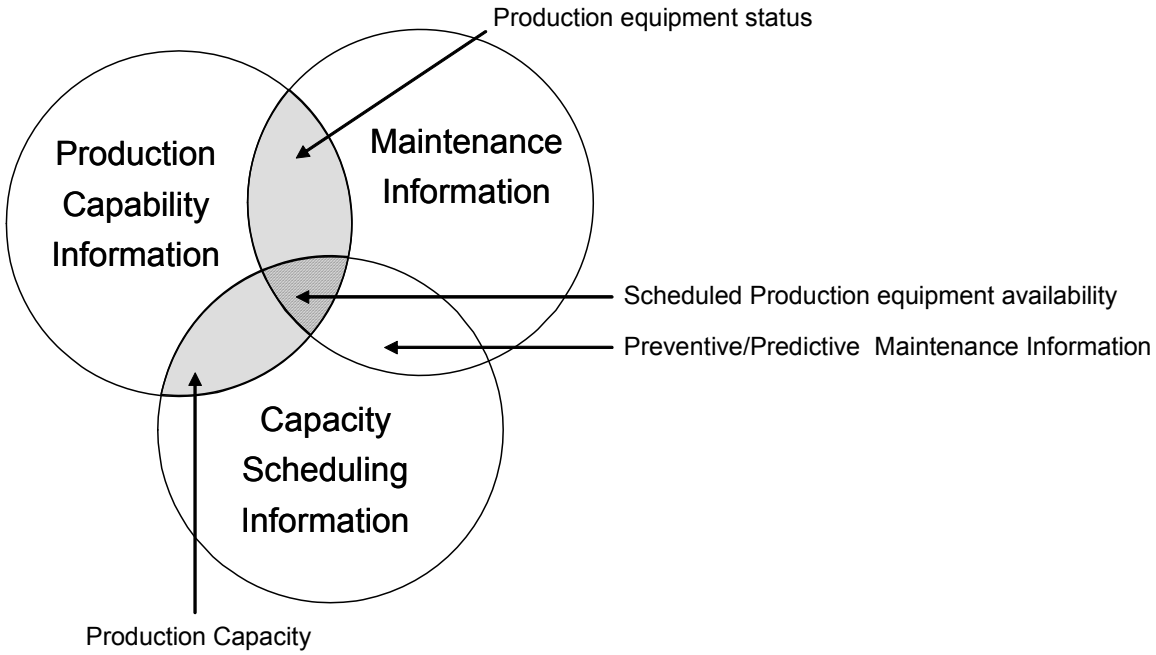


Figure 13 – Production capability information

8.4.2.2 Production capability information

For each site, area, and element within the area there is a presentation of the production capability of the personnel, equipment, and materials.

The production capability information includes the current capacity, the future expected capacity of the resource, and a history of capacity of the resource.

8.4.2.3 Production capacity types

The collection of predicted or forecast available capacity, committed capacity, and unattainable capacity shall be shown as production capacity, as depicted in Figure 14.

The production capacity is the theoretical maximum capability available for use in production.

Past capacity that represents actual use history shall be shown as used or unused capacity

EXAMPLE 1 Used capacity may be compared against predicted committed capacity to visualize time dependent efficiencies.

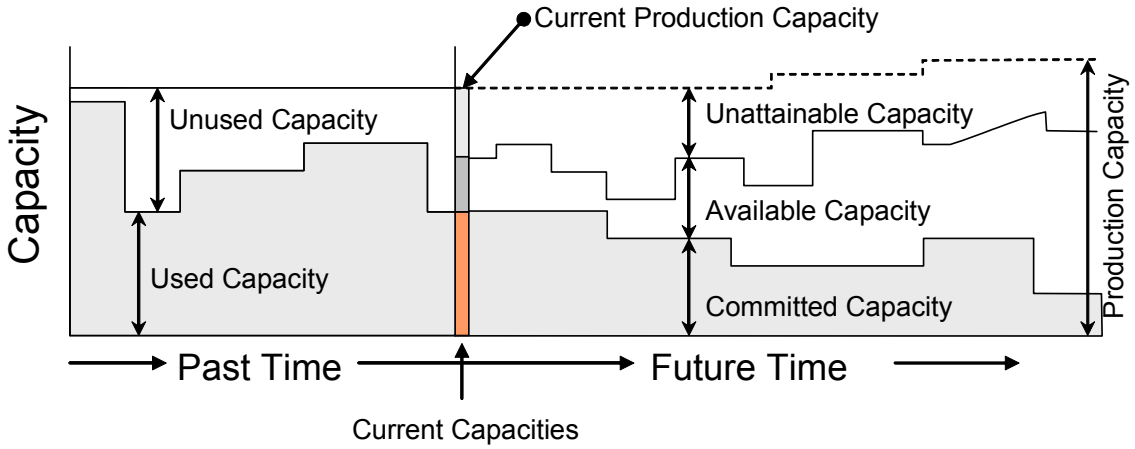


Figure 14 – Current and future capacities

a) The capability includes the capacity of the resource.

b) A capacity may be identified as current, may be identified for future times, or may be defined for past times, as depicted in Figure 14.

NOTE 1 Future production capacity may change over time as equipment, material, and personnel capability is added, modified, or removed.

c) Committed capacity defines resources that are committed to future production or were committed to past production, usually due to existing schedules and/or materials in production.

Unattainable capacity defines resources that are not attainable for future production given the equipment condition, equipment utilization, personnel availability, and material availability.

EXAMPLE 2 Unattainable equipment capacity due to equipment condition may occur because of equipment out of service for maintenance

EXAMPLE 3 Unattainable equipment capacity due to equipment utilization may occur because 75 % of a vessel is filled and the other 25 % is not available for other products

EXAMPLE 4 Unattainable personnel capacity may occur because of vacation schedules

Available capacity defines the resources that are available for additional future production and not committed to production.

Capacities may have a confidence factor, as illustrated in Figure 15.

NOTE 2 Confidence factors may be used by planning and scheduling in the development of possible and alternate schedules based on an acceptable level of risk.

Used Capacity is a historical value that defines the portion of the production capacity that was used to make acceptable quality product.

Unused Capacity is a historical value that defines the portion of the production capacity that was not used to make acceptable quality product. An unused capacity may have one or more reasons for the unused capacity, as illustrated in Figure 16.

EXAMPLE 5 One portion of an unused capacity may be unused because of no scheduled production. Another portion of the unused capacity may be unused because of production of unacceptable quality product. Another portion may be unused because of equipment not available.

NOTE 3 Unused Capacity (no scheduled production) or Unused Capacity (Quality Unacceptable) may be a concern for some entities and respective Key Performance Indicators may show resources available but not utilized to manufacture a viable product.

Committed, Unattainable, and Available capacity may be defined for past times, as a history of expected use, and for future times, as a prediction. Used and unused capacity may be defined for past times.

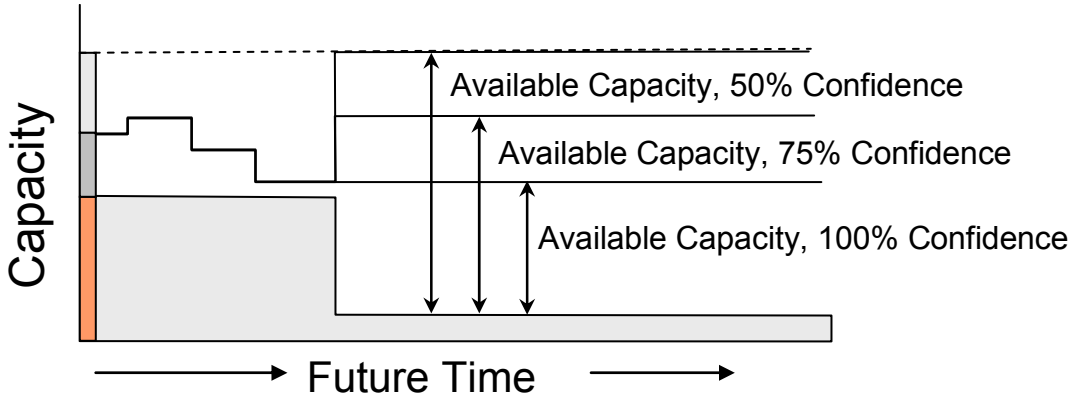


Figure 15 – Future capacity confidence factor

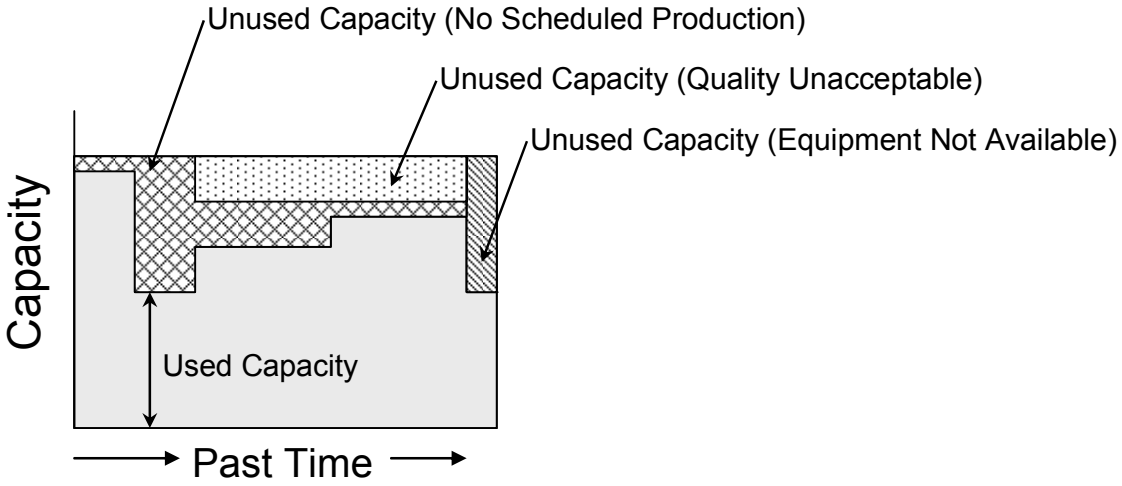


Figure 16 – Past capacity unused capacity reasons

8.4.2.4 Maintenance information

For each site, area, and element within the area there is a listing of the equipment as required for maintenance. This includes maintenance records and other information that is not part of the production capability model.

The maintenance information includes the current maintenance state of the equipment.

8.4.2.5 Capacity scheduling information

The capacity scheduling information contains the process segments available for the production unit, process cell, or production line.

For each site, area, and equipment element within the area there is a presentation of the production capacity of the personnel, equipment, and materials needed for scheduling of production.

8.4.2.6 Production equipment status

Production equipment status is information derived from the capability information of the equipment and the maintenance information. This includes the listing of the equipment, the current status of the equipment, and the usage history of the equipment.

8.4.2.7 Production capacity

Production capacity is defined as the information derived from production capability information and (product specific) capacity scheduling information. This includes the listing of the capacity scheduling product definition information and current status and expected future status of the personnel, equipment, and materials capabilities.

8.4.2.8 Scheduled production equipment availability

Scheduled production equipment availability is a dynamic interaction of production capability information, maintenance information, and capacity scheduling information that allows forecasting of scheduled production equipment availability.

8.4.2.9 Preventive/predictive maintenance information

Preventive/predictive maintenance information is the correlation of equipment health and maintenance requirements with capacity scheduling information so as to align maintenance processes and adjust the capacity scheduling information during the maintenance processes.

8.4.2.10 Process segment capability

A capability may be given in terms of a process segment. Process segments show the business view of a part of the manufacturing process. The capabilities may specify specific capabilities or the class of capability (such as class of equipment) needed for the process segment. Figure 17 illustrates how capabilities relate to process segments.

– A manual process segment may define the class of materials and class of personnel needed for production.
– A semi-automated process segment may define the class of materials, personnel, and equipment needed.
– A non-material process segment, such as an equipment set-up segment, may define the class of equipment and personnel used.
– An automated process segment may only define the material and equipment classes needed.

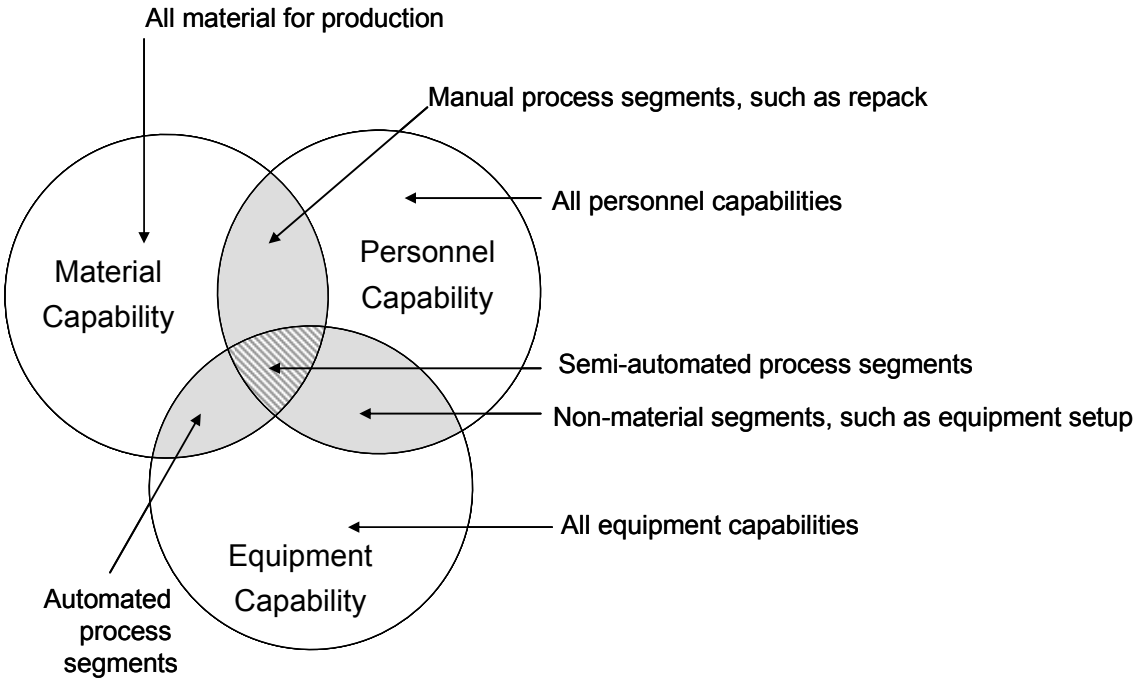


Figure 17 – Process segment capabilities

8.4.3 Product definition information

8.4.3.1 Product definition information categories

There are three main areas of information required for the production of a specific product that have significant overlap. The three areas are information for scheduling, material information, and production rules. Figure 18 illustrates the overlapping information.

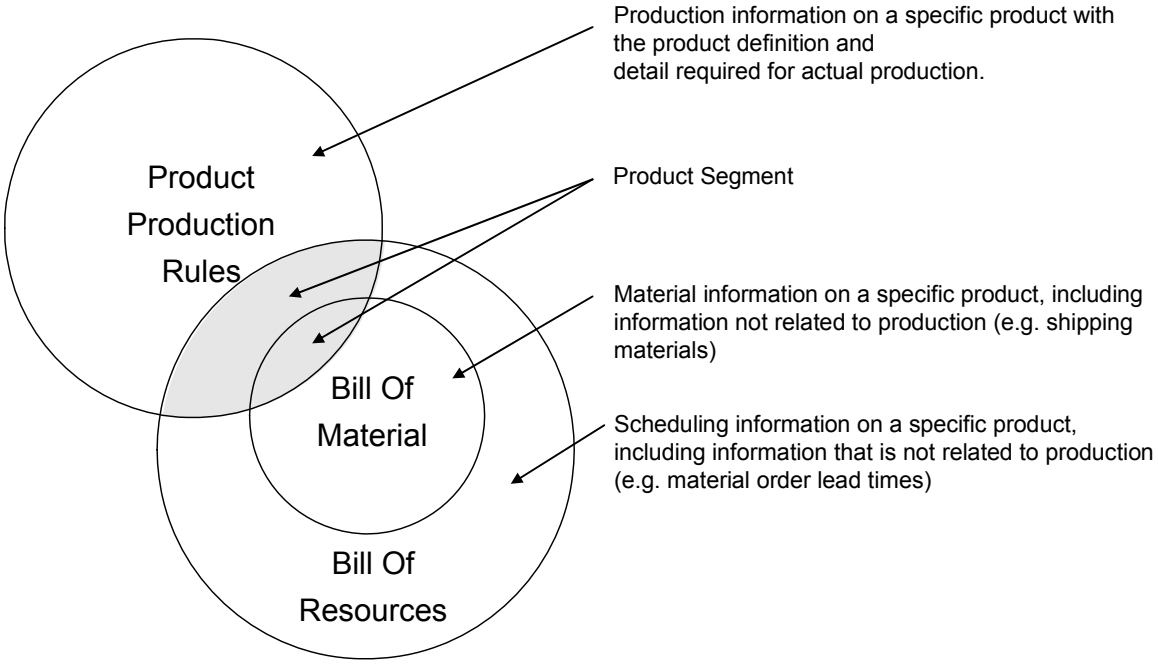


Figure 18 – Production information definition

8.4.3.2 Product production rules

Product production rules are the information used to instruct a manufacturing operation how to produce a product.

NOTE: Examples of product definition rules are a general site or master recipe (IEC 61512-1 definitions), product data AP (application protocol) as defined in ISO 10303-1, standard operating procedure (SOP), standard operating conditions (SOC), routing, or assembly steps based on the production strategy used.

8.4.3.3 Bill of material

The BOM is a list of all materials required to produce a product showing the quantity of each required. These may be raw materials, intermediate materials, subassemblies, parts, and consumables. This list does not contain the breakdown of where the materials are used or when they are needed, but it may be organized in a hierarchical manner that maps to some of the production steps. The bill of material often includes material that is not related to production of the product, such as shipping materials or included documentation. The bill of material is a subset of the bill of resources.

The manufacturing bill is the subset of the bill of material that is related to production.

8.4.3.4 Bill of resources

The bill of resources is the list of all resources required to produce a product. Resources may include materials, personnel, equipment, energy, and consumables. The bill of resources does not contain the specific production steps, but it may be organized in a hierarchical manner that maps to some of the production steps.

8.4.3.5 Product segment

Product segment is the overlap of information between product production rules and the bill of resources. It describes a job or task consisting of one or more work elements, usually carried out

essentially in one location. A product segment is the most detailed process view for the business system to control material, labor, resource usage, cost, and quality in order to control the production.

A product segment shall reference a process segment. This relationship is illustrated in Figure 19.

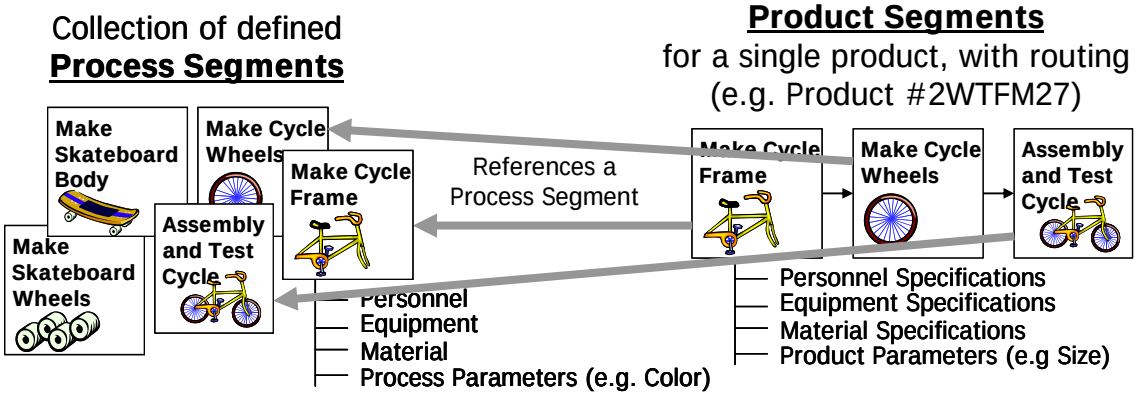


Figure 19 – Product segment relation to process segment

Product segments may correspond to

a) IEC 61512-1 process stages, process operations, unit procedures, or operations for batch manufacturing;

b) production unit operations for continuous manufacturing;

c) assembly steps and assembly actions for discrete manufacturing;

d) other types of identifiable time spans for other types of manufacturing.

The example in Figure 20 illustrates nested product segments in a Gantt-type chart with time on the horizontal axis and each box corresponding to a different product segment.

Production routing is the overlap of information between the product production rule information and bill of resources information without the bill of material information. It represents all of the non-material aspects of production such as equipment, labor, and energy. Production routings include an ordered sequence of product segments.

Material routing is the overlap of information between the production rule information and the bill of material information. It represents both the production material inputs and where they are used in product segments.

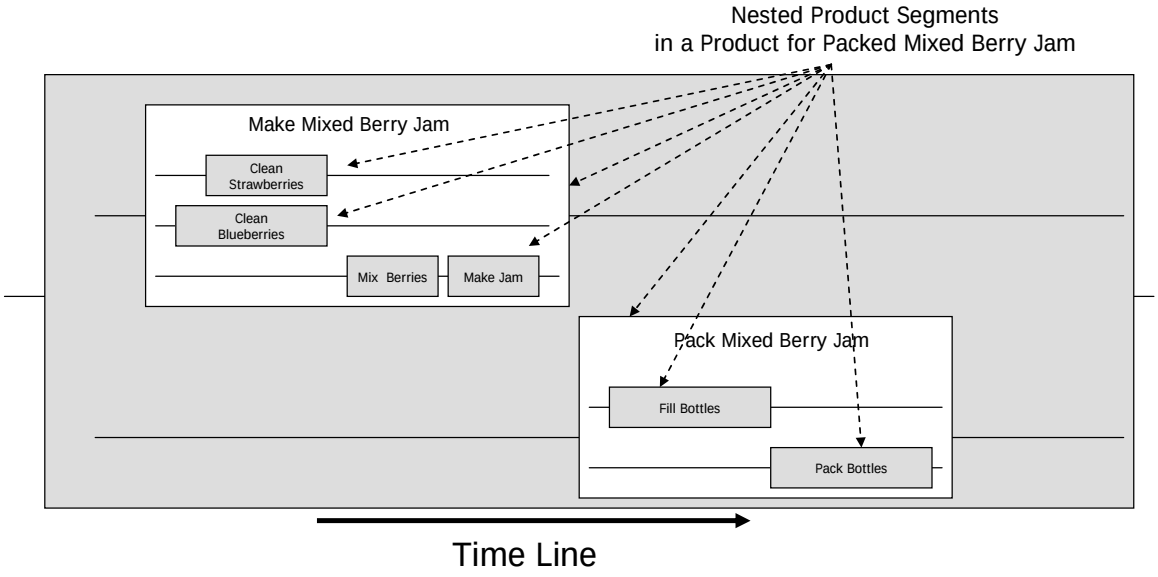


Figure 20 – Example of nested product segments

8.4.3.6 Use of product and process segments

Product and process segments map the business view of the processes and are not intended to represent the detailed view required for manufacturing operations management within Level 3.

8.4.3.7 Overlapping areas

Figure 18 illustrates the overlap of information between different areas but is not meant to represent the amount or importance of the information. Different manufacturing and business strategies will have different amounts of information shared between the different areas. Figure 21 illustrates the amount of information in two examples. The left side of the figure shows an example where the manufacturing systems maintain most of the information required for a product. The right side of the figure shows an example where the business systems maintain most of the information.

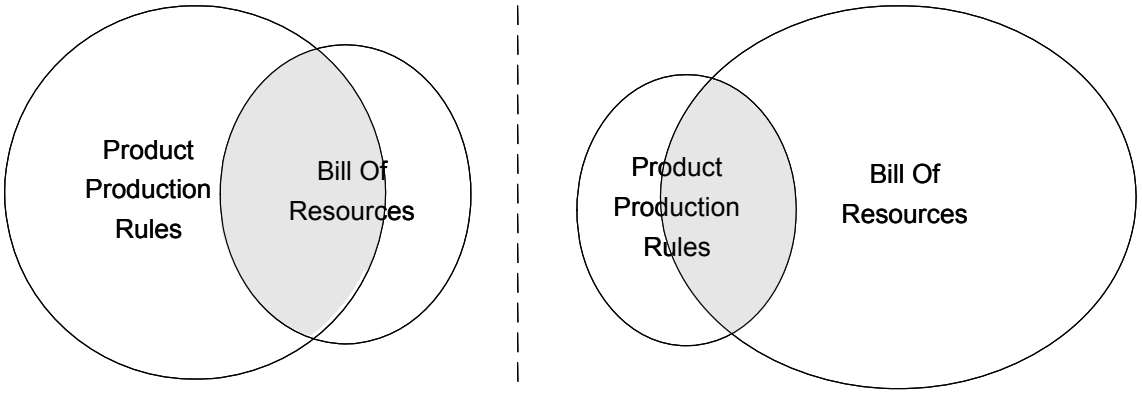


Figure 21 – Possible information overlaps

8.4.4 Production schedule and production performance information

8.4.4.1 Production information categories

There are three main areas of information about actual production that have significant overlap. These three areas are production history information, production resource information, and the production scheduling information. Figure 22 shows the overlap between the areas of information.

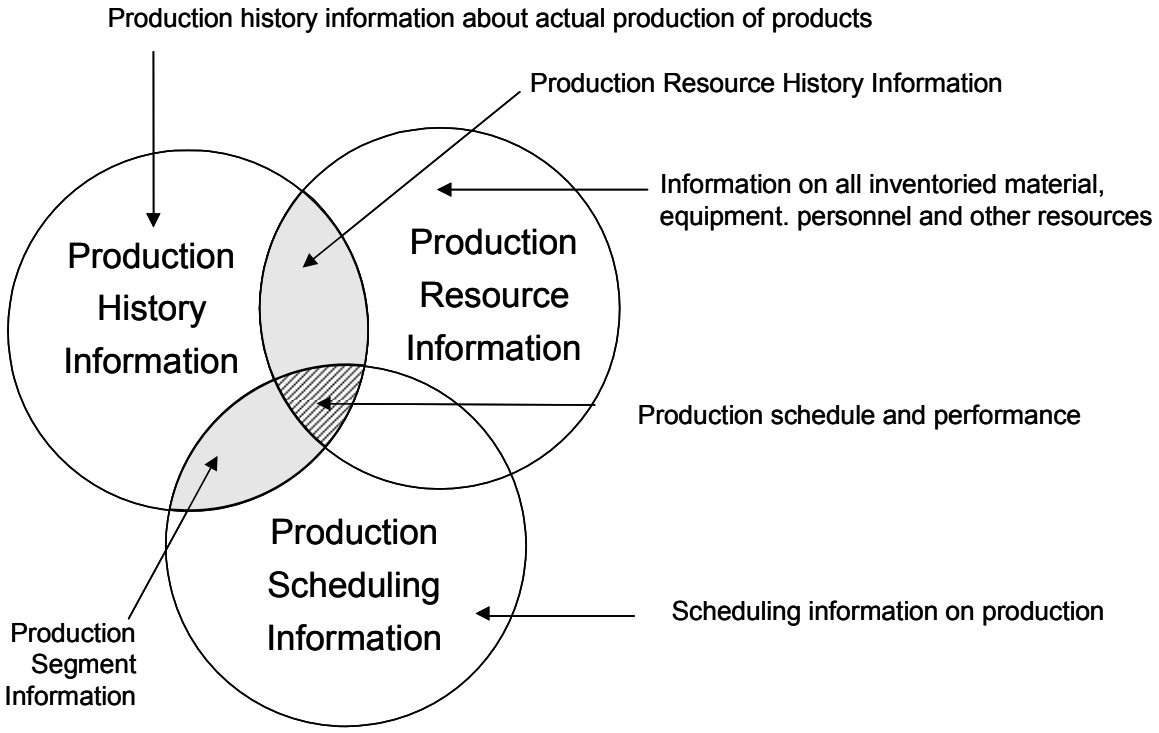


Figure 22 – Production information

8.4.4.2 Production history information

Production history information is all of the information recorded about the production of a product. This may be called by many names, such as the batch journal, product log, or traveller.

8.4.4.3 Production resource information

Production resource information is all of the information about inventoried materials, equipment, personnel, and other resources.

Typically, all consumed and produced materials are maintained in the production resource information, and sometimes intermediates are maintained if they are needed for financial evaluation. In some industries this may include energy information.

8.4.4.4 Production scheduling information

The scheduling model contains all of the information about the execution of scheduled production runs.

8.4.4.5 Production segment information

The production segment information is history information about a segment of a schedule.

8.4.4.6 Production resource history information

The production resource history information is the part of the production history information that contains information on resources that has been used in Production.

8.4.4.7 Production schedule and performance

Production schedule and performance information is shared among production information, inventory information, and scheduling information. This includes the listing of the raw materials consumed, materials produced, and materials scrapped. It also includes the discussion of how long segments of production actually took and how much material was produced and consumed by specific segments of production. This information is generally used to track actual production against production requests and as feedback to the scheduling cycle.

9 Completeness, compliance and conformance

9.1 Completeness

There are no completeness criteria for this Part.

9.2 Compliance

a) Any assessment of the degree of compliance of a specification shall be qualified by a statement of the degree to which they then conform partially or totally to definitions.

b) In the event of partial compliance, areas of non-compliance shall be explicitly identified.

NOTE: This part of the standard does not enumerate compliance points sufficient to form a conformity assessment scheme. Additional specifications are required to define specific compliance elements needed to meet a specific technical regulation or directive.

9.3 Conformance

Any assessment of the degree of conformance of an application shall be qualified by the documentation to which the definitions conform.

In the event of partial conformance, areas of non-conformance shall be explicitly identified.

NOTE: This part of the standard does not enumerate or group the conformance points sufficient to form a conformity assessment scheme. Additional specifications are required to define specific conformance requirements suitable for conformance tests.

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Annex A
(informative)

Other enterprise activities affecting manufacturing operations

A.1 Other areas

In addition to the major activities already described, there are other activities that are used within manufacturing operations, but are not necessarily unique to the manufacturing element of a company. These supporting activities include, but are not limited to,

a) management of security within manufacturing operations;

b) management of information within manufacturing operations;

c) management of configurations within manufacturing operations;

d) management of documents within manufacturing operations;

e) management of regulatory compliance within manufacturing operations;

f) management of incidents and deviations within manufacturing operations.

Figure A.1 illustrates the concept of the supporting activities and their relationship with the major manufacturing operations activities. For example, there may be an aspect of management of information used in production data collection, production resource management, production tracking, production definition management, maintenance definition management and quality test data collection.

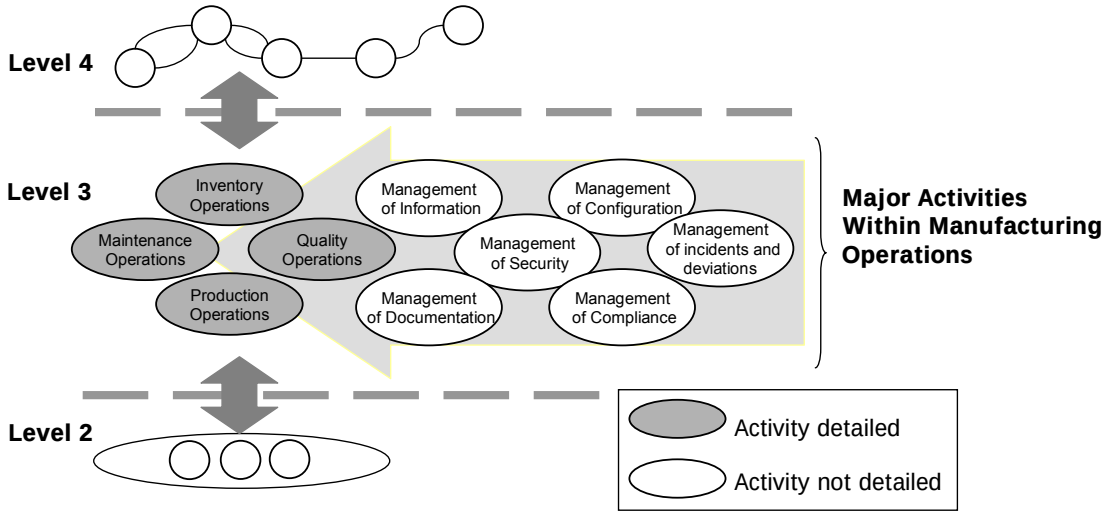

Figure A.1 – Other enterprise activities affecting manufacturing operations

A.2 Management of security

Management of security is an enterprise function and is not defined in this standard but does impact manufacturing operations management. Security management functions include physical (site and area) security, information security and computer security. The basic role of security in manufacturing operations is to make sure that only authorized personnel may make changes or affect manufacturing in allowed ways. This typically involves physical security to limit access to facilities, control of information flows out of a facility to protect intellectual property and control of communications to ensure that unauthorized remote access does not affect operations.

NOTE Management of security is often combined with management of networks. The current recommend practice is to ensure that networks used in production operations, especially those involved in physical control of processes, are separate from non-real-time networks. This separation may be physical, through different networks or network standards, or virtual through protocols, firewalls and routers. Real-time control requires predictable network responsiveness and latency, which is best accomplished through the separation of networks.

When policies and procedures for management of security do not exist on a company-wide basis, then security control can be considered a manufacturing operations activity, for manufacturing security.

Potentially relevant standards for security relating to communications and computer systems are listed in Annex B.

A.3 Management of information

Management of information is an enterprise function and not defined in this standard but does impact manufacturing operations management. In fact, most of the manufacturing operations activities consume and generate information as part of their function. Many functions must exchange information with other functions that are not listed this standard.

When policies and procedures for management of information do not exist on a company-wide basis, then information control can be considered a manufacturing operations activity, for manufacturing information.

Management of information involves management of information storage, transmission, backup, recovery and redundancy. These are often corporate-level functions that follow corporate, industry, national, or international standards.

A.4 Management of configuration

Management of configuration is often an enterprise function and is not defined in this standard but does impact manufacturing operations management. Management of configuration includes configuration management and change control procedures that should be considered in manufacturing operations. This function may be required any place there is a semi-permanent data storage and actions can be taken based on the stored data. Often audit trails and revision management procedures are required.

EXAMPLE 1: This may include product definitions, work instruction, standard operating procedures, product and process definitions, resource class definitions.

EXAMPLE 2: This may include management of Level 2 information such as PLC programs and DCS configurations.

When policies and procedures for management of configurations do not exist on a company-wide basis, then configuration control can be considered a manufacturing operations activity, for manufacturing configurations.

One aspect of configuration management involves the processes and procedures necessary to implement changes to configuration elements that may comprise the production operations. This includes identification, surveillance and control of changes to these configurable items. This includes, but is not limited to,

a) equipment hardware identification and change procedures;

b) Level 2 and Level 3 software identification and change procedures;

c) data and record management for Level 2 and Level 3 records;

d) version control of the configuration elements.

One aspect of change control involves processes or procedures by which changes are initiated and managed. These procedures often include the following:

1. requests for change;
2. analysis of the change request;
3. impact analysis of the change;
4. approval of the change;
5. implementation of the change;
6. review and approval of the change implementation;
7. monitoring of the change.

Potentially relevant standards for management of configuration include are listed in Annex B.

A.5 Management of documents

Management of documents is often an enterprise function and is not defined in this standard but does impact manufacturing operations management. Manufacturing operations need to manage a wide range of documents. These include items such as SOPs, work instructions, recipes, control system programmes, drawings, batch records, engineering change notices, alarm logs and exception reports. Management of this information is often required for regulatory, environmental, health and safety, or certification reasons. Generally companies have a set of procedures, policies and software tools in place to manage all corporate documents.

When policies and procedures for management of documents do not exist on a company-wide basis, then document control can be considered a manufacturing operations activity, for manufacturing documentation.

Document management also involves an aspect of disaster recovery. Many manufacturing systems are based on confidence in the delivery systems. However, natural or man-made disasters can delay delivery of raw materials, delivery of final products and make manufacturing facilities temporarily or permanently unavailable. Companies with significant operations typically develop a disaster-recovery plan that includes information about production. It should also contain documentation on core manufacturing processes. Aside from recovering data, entire processes may have to be recreated that must map to machine, automated systems, physical layout, production sequences and part inventory systems. The information should be available

after disasters so that operators can physically recreate production lines in the event of unforeseen disasters.

Potentially relevant standards for document management are defined in Annex B.

A.6 Management of regulatory compliance

The broad footprint of management of regulatory compliance means that many areas of the enterprise can be significantly affected. Failures in regulatory compliance can stop production, force product recalls and potentially cause safety problems. Where management of regulatory compliance activities involves the quality and safety of production, then the activities are in the scope of production operations.

When policies and procedures for management of regulatory compliance do not exist on a company-wide basis, then compliance control can be considered a manufacturing operations activity, for manufacturing compliance.

Figure A.2 illustrates some of the aspects of regulatory compliance and general activities associated with each aspect.

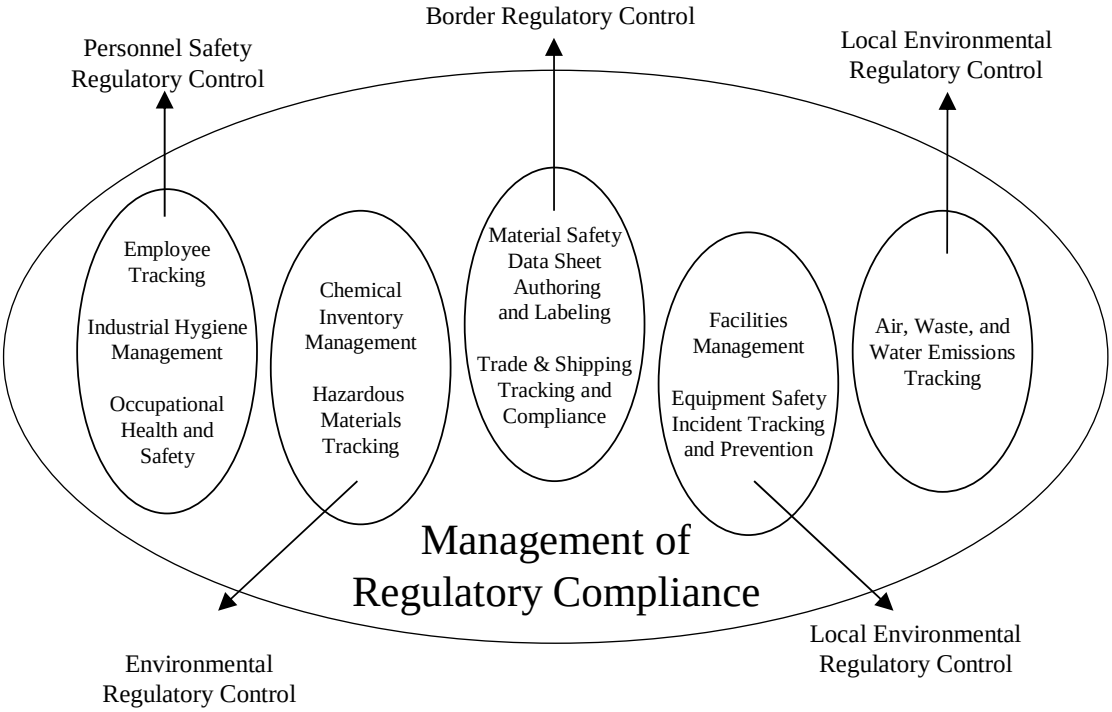

Figure A.2 – Functions in management of regulatory compliance

Typical environmental activities include

a) permit requirements related to planning/construction and operations;

b) air pollution control including emissions limitation/control and permits;

c) water pollution control including wastewater and effluent discharges and storm water runoff;

d) waste management of solids, hazardous material and packaging;

e) notification, classification, packaging and labelling of hazardous materials. This also includes storage of such material;

EXAMPLE: Special handling of asbestos, PCBs and pesticides.

f) liability and management practices including civil and criminal liability and contaminated land liability;

g) typical health and safety activities including

h) handling, classification, packaging and labelling of hazardous substances including safety data sheets;

i) disaster planning including emergency planning and response and fire safety;

j) hazard communication in the form of warning signs, training and advice;

k) occupational health surveillance in the form of occupational exposure controls (including chemical, physical, biological agents and noise);

l) medical surveillance of personnel;

m) process safety in the form of machinery safety, lifting equipment, pressure systems, confined space entry/work permits/access control;

n) management of functional safety;

o) electrical safety;

p) ergonomics including office work, manual handling of loads and the like;

q) first aid.

Potentially relevant standards related to regulatory compliance are defined in Annex B.

A.7 Management of incidents and deviations

Management of incidents, deviations, corrective actions and preventative actions is often an enterprise function and is not defined in this standard, but does impact manufacturing operations management. Management of incidents, deviations, corrective actions and preventative actions is often associated with maintenance of regulatory compliance or with continuous improvement processes. These activities are also often performed in conjunction with other manufacturing operations management activities.

Management of incidents: Maintaining plant operation often requires that unexpected events, called incidents, are recorded and that the response to the incident is recorded. Incidents are typically unexpected events related to maintaining plant operations, safety, regulatory compliance, or security. Incident management typically involves investigation to determine the root cause of the incident and may lead to preventive actions to prevent future incidents.

EXAMPLE 1: An unexpected release of a chemical into the environment may generate an incident and the incident report may have to be sent to the appropriate regulatory agency, such as the US EPA.

EXAMPLE 2: An unexpected pump failure from a newly installed pump may generate an incident and the incident response may be to investigate and potentially change the supplier.

Management of deviations: Maintaining plant operations often requires that deviations that have been detected because of normal conditions are recorded and that the response to the deviation is recorded. Deviations are typically measured differences between an observed value and an expected or normal value, or an anomaly from a documented standard or process. Deviation management typically involves determination of the root cause of the deviation and may lead to corrective actions to remove the source of the deviation.

Management of corrective actions and preventive actions: Maintaining plant operations often requires that corrective actions, typically in response to an incident, deviation, or failure, are recorded and managed and that the results of the corrective action are recorded. Clear, appropriate and implementable corrective actions should be identified at the conclusion of any investigation. Tracking and follow-up should be managed to ensure that the corrective actions are implemented and verified.

EXAMPLE 3: Corrective actions may include improving procedures, adding maintenance procedures for equipment, or implementing retest or revalidation procedures.

Preventative actions are typically managed in a similar fashion, in order to prevent possible future incidents or deviations.

EXAMPLE 4: Batch cycle times on a process cell may not meet the rated value and this is identified as a deviation; then, a preventive action is created to reduce the batch cycle time.

Recommended actions are managed in a similar function. Recommended actions are predefined sets of actions to occur in the event of an incident or deviation.

Annex B
(informative)

Associated standards

B.1 Management of security

The following standards may apply to the common enterprise activities of management of security.

ISO/IEC 9798-1:1007, *Information technology – Security techniques – Entity authentication mechanisms – Part 1: General*

ISO/IEC 10164-7:1992, *Information technology – Open Systems Interconnection – Systems Management: Security alarm reporting function*

ISO/IEC 10164-8:1993, *Information technology – Open Systems Interconnection – Systems Management: Security audit trail function*

ISO/IEC 10164-9:1995, *Information technology – Open Systems Interconnection – Systems management: Objects and attributes for access control*

ISO/IEC 10181-1:1996, *Information technology – Open Systems Interconnection – Security frameworks for open systems: Overview*

ISO/IEC 10181-2:1996, *Information technology – Open systems interconnection – Security frameworks for open system: Authentication framework*

ISO/IEC 10181-3:1996, *Information technology – Open Systems Interconnection – Security frameworks for open systems: Access control framework*

ISO/IEC 10181-4:1997, *Information technology – Open Systems Interconnection – Security frameworks for Open Systems: Non-repudiation framework*

ISO/IEC 10181-5:1996, *Information technology – Security frameworks for open systems: Confidentiality framework*

ISO/IEC 10181-6:1996, *Information technology – Open Systems Interconnection – Security frameworks for open systems: Integrating frameworks*

ISO/IEC 10181-7:1996, *Information technology – Open Systems Interconnection – Security frameworks for open systems: Security audit and alarms framework*

ISO/IEC 10745:1995, *Information technology – Open Systems Interconnection – Upper layers security model*

ISO/IEC 11586-1:1996, *Information technology – Open Systems Interconnection – Generic upper layers security: Overview, models and notation*

ISO/IEC 11586-2:1996, *Information technology – Open Systems Interconnection – Generic upper layers security: Security Exchange Service Element (SESE) service definition*

ISO/IEC 11586-3:1996, *Information technology – Open Systems Interconnection – Generic upper layers security: Security Exchange Service Element (SESE) protocol specification*

ISO/IEC 11586-4:1996, *Information technology – Open Systems Interconnection – Generic upper layers security: Protecting transfer syntax specification*

ISO/IEC 13335-1:2004, *Information technology – Security techniques – Management of information and communications technology security – Part 1: Concepts and models for information and communications technology security management*

ISO/IEC 13335-3:1998, *Information technology – Guidelines for the management of IT security – Part 3: Techniques for the management of IT security*

ISO 7498-2:1989, *Information processing systems – Open Systems Interconnection – Basic Reference Model – Part 2: Security Architecture*

ANSI/ISA-TR99.00.01, *Security Technologies for Manufacturing and Control Systems*

ANSI/ISA-TR99.00.02, *Integrating Electronic Security into the Manufacturing and Control Systems Environment*

B.2 Management of configurations

The following standards may apply to the common enterprise activities of management of configurations.

ANSI/EIA-649-A, *National Consensus Standard for Configuration Management*

OSHA 29 CFR 1910.119, *Process safety management of highly hazardous chemicals*

FDA 21 CFR Part 11, *Electronic records; electronic signatures*

FDA 21 CFR Part 210, *Current Good Manufacturing Practice in Manufacturing, Processing, Packaging, or Holding of Drugs; General*

ISPE, *GAMP Guide for Validation of Automated Systems*

B.3 Management of documentation

The following standards may apply to the common enterprise activities of management of documentation. Potentially relevant standards for document management include the following.

IEC 60417, *Graphical symbols for use on equipment* IEC 60617, *Graphical symbols for diagrams*

IEC 60848:2002, *GRAFCET specification language for sequential function charts*

IEC 61082-1:2006, *Preparation of documents used in electrotechnology – Part 1: Rules*

IEC 61175:2005, *Industrial systems, installations and equipment and industrial products – Designations for signals and connections*

IEC 61286:2001, *Information technology – Coded graphic character set for use in the preparation of documents used in electrotechnology and for information interchange*

IEC 61346-1:1996, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 1: Basic rules*

IEC 61346-4:1998, *Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations – Part 4: Discussions of concept*

IEC 61355:1997, *Classification and designation of documents for plants, systems and equipment*

IEC 61360-1:2002, *Standard data element types with associated classification scheme for electric components – Part 1: Definitions – Principles and methods*

IEC 61360-2:2002, *Standard data element types with associated classification scheme for electric components – Part 2: EXPRESS dictionary schema*

IEC 61360-4, *Standard data element types with associated classification scheme for electric components – Part 4: IEC reference collection of standard data element types and component classes*

IEC 61506:1997, *Industrial-process measurement and control – Documentation of application software*

IEC 61666:1997, *Industrial systems, installations and equipment and industrial products – Identification of terminals within a system*

IEC 61734:2006, *Application of symbols for binary logic and analogue elements*

IEC 62023:2000, *Structuring of technical information and documentation*

IEC 81714-2:2006, *Design of graphical symbols for use in the technical documentation of products – Part 2: Specification for graphical symbols in a computer sensitive form, including graphical symbols for a reference library, and requirements for their interchange*

IEC 81714-3:2004, *Design of graphical symbols for use in the technical documentation of products – Part 3: Classification of connect nodes, networks and their encoding*

IEC 82045-1:2001, *Document management – Part 1: Principles and methods*

ISO 81714-1:1999, *Design of graphical symbols for use in the technical documentation of products – Part 1: Basic rules*

B.4 Management of regulatory compliance

The following standards may apply to the common enterprise activities of management of regulatory compliance.

ISO 14001:2004, *Environmental management systems – Requirements with guidance for use*

ISO 14004:2004, *Environmental management systems – General guidelines on principles, systems and support techniques*

ISO 14015:2001, *Environmental management – Environmental assessment of sites and organizations (EASO)*

ISO 14020:2000, *Environmental labels and declarations – General principles*

ISO 14021:1999, *Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)*

ISO 14024:1999, *Environmental labels and declarations – Type I environmental labelling – Principles and procedures*

ISO 14025:2006, *Environmental labels and declarations – Type III environmental declarations – Principles and procedures*

ISO 14031:1999, *Environmental management – Environmental performance evaluation – Guidelines*

ISO 14032:1999, *Environmental management – Examples of environmental performance evaluation (EPE)*

ISO 14040:2006, *Environmental management – Life cycle assessment – Principles and framework*

ISO 14041:1998, *Environmental management – Life cycle assessment – Goal and scope definition and inventory analysis*

ISO 14042:2000, *Environmental management – Life cycle assessment – Life cycle impact assessment*

ISO 14043:2000, *Environmental management – Life cycle assessment – Life cycle interpretation*

ISO 14047:2003, *Environmental management – Life cycle assessment – Examples of application of ISO 14042*

ISO 14048:2002, *Environmental management – Life cycle assessment – Data documentation format*

ISO 14049:2000, *Environmental management – Life cycle assessment – Examples of application of ISO 14041 to goal and scope definition and inventory analysis*

ISO 14050:2002, *Environmental management – Vocabulary*

ISO 14061:1998, *Information to assist forestry organizations in the use of Environmental Management System standards ISO 14001 and ISO 14004*

ISO 14062:2002, *Environmental management – Integrating environmental aspects into product design and development*

ISO 19011:2002, *Guidelines for quality and/or environmental management systems auditing*

29 CFR 1910, *Occupational safety and health standards*

B.5 Related standards on quality

ISO 9000:2005, Quality management systems – Fundamentals and vocabulary

ISO 9001:2000, Quality management systems – Requirements

ISO 9004:2000, Quality management systems – Guidelines for performance improvements

ISO 10005:2005, Quality management – Guidelines for quality plans

ISO 10006:2003, Quality management systems – Guidelines for quality management in projects

ISO 10007:2003, Quality management systems – Guidelines for configuration management

ISO 10012:2003, Measurement management systems – Requirements for measurement processes and measuring equipment

ISO 10013:2001, Guidelines for quality management system documentation

ISO 10014:2006, Quality management – Guidelines for realizing financial and economic benefits

ISO 10015:1999, Quality management – Guidelines for training

ISO 10017:2003, Guidance on statistical techniques for ISO 9001:2000

ISO 19011:2002, Guidelines for quality and/or environmental management systems auditing

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Annex C
(informative)

Business drivers and key performance indicators

C.1 Purpose

This annex contains a collection of business drivers and key performance indicators (KPI) or issues that have been defined, and used as the potential touch points into the business processes of the users of the standard. These are also called Critical Success Factors. The drivers were used to test the informational content included within the standards. They determined if the communications model adequately addressed the business issue associated with integration.

These business drivers are identified as being critical to the success of the operations of manufacturing companies across a variety of industries. The drivers have been clarified and validated with operating companies and vendors companies. The drivers provide users with the basis from which to determine the usage of the standard based on their particular industry and information system needs.

C.2 History

Key business drivers are the areas of performance that are most critical to an organization's success. Key business driver is a term used in connection with strategic planning and related goal setting. Key business drivers refer to principal organization-level requirements (similar to Mission Essential Task List, or METL, in tactical units), derived from short- and long-term strategic planning. They include customer-driven quality requirements and operational requirements such as productivity, cycle time, deployment of new technology, strategic alliances, supplier development, and research and development. In simplest terms, key business drivers are those things the organization has to do well for its strategy to succeed (see Bibliography).

C.3 Drivers and issues

Business drivers, in a manufacturing facility, generate the need for information to flow between the executive offices and the process or manufacturing floor. Enterprises focus on these business drivers to meet competitive requirements in the marketplace. Business drivers subsequently influence information sent to the production floor or are influenced by information gathered from the production floor.

Business drivers and some information demands have been identified. Additional research and work may be required to clarify the scope and definition of the drivers and information demands for particular user requirements.

There is always some business process that needs information from production, or needs to exercise control of production that drives the need for integration. Integration requires that the production information can be mapped back to the business information.

C.4 Value of standard to business

Manufacturing enterprises are typically dynamic entities. There are continual changes in business processes to meet changing business and legal environments. There are also usually continual changes in production processes, as new technologies and advances in production capabilities emerge. The purpose of this standard is to aid in the separation of the business processes from the production processes. The standard describes information in a way that is business-process independent and production-process independent. Figure E.1 illustrates this concept of a common model that bridges the different business and production processes.

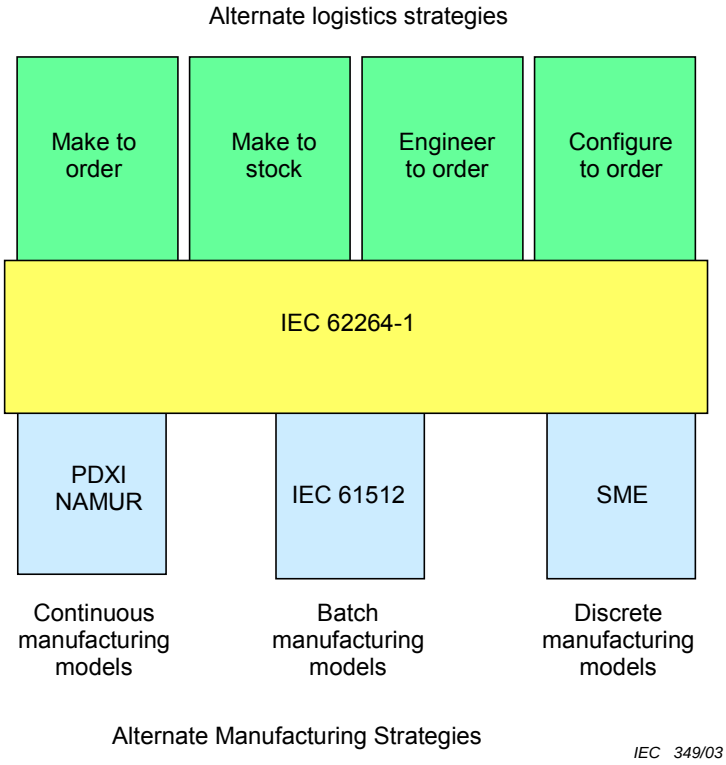

Figure C.1 – Multiple business and production processes

C.5 Vendor-independent exchange

Another value of the standard to business is the separation of exchanged information from specific implementations of manufacturing operations and control systems and specific implementations of business management systems. Manufacturing operations and control systems change when the production processes change, when factories are bought or sold, or when control equipment is updated or replaced. Likewise, business management systems change due to corporate mergers, sell-offs, technology changes, or business or legal changes.

This standard provides vendor-independent methods of describing the information exchanged that can be consistent across changes to manufacturing systems and IT business systems.

C.6 Business drivers

Some terms or labels that describe such business drivers include the following.

C.6.1 Available to promise

Automated available-to-promise is achieved by giving order takers access to inventory and capacity information, and in some cases even vendor information, so that they are able to commit to reliable delivery dates while the customer is still on the telephone.

Information needed for automated available-to-promise:

– current finished goods inventory;
– current production plan for that product;
– realistic capacities of the production facility of that product;
– raw material inventories; or
– raw material purchasing capability.

C.6.2 Reduced cycle time

Cycle time is defined as the time it takes to produce a product from the time the order is placed.

Cycle time refers to responsiveness and completion time measures – the time required to fulfill commitments or to complete tasks (see Bibliography).

The reason that businesses concentrate on minimizing the total cycle time is generally to increase inventory turns. This has the net result of increasing a business's ROA (return on assets).

To reduce cycle time a business identifies areas where most of the delay and waiting occurs and addresses them appropriately. In most cases, the time needed to plan and react to changes is much longer than the time to build. Response time improvement requires all aspects of the planning, scheduling and execution to be taken into account. Reducing the time to plan allows more frequent analysis of forecasts and less dependence on forecasting data.

C.6.3 Asset efficiency

Asset efficiency is a focus on maximizing the effective and cost-effective use of assets in the production of products. The information obtained from the production environment will deliver to an enterprise realistic information on the production capabilities of the plant, train, unit, work cell, etc. Asset efficiency is the desire to better utilize the assets of a company. It usually involves all assets of a company, production, service, administration, support, sales, and marketing. Asset efficiency improves a company's ROA.

Asset efficiency may imply

c) operating to capacity, with timely maintenance;
d) operating equipment efficiently in terms of its operating parameters and its maintenance;
e) measurements such as counter readings per operating hours;
f) time, temperature, pressure/vibration, status or other detailed data;

g) maintenance schedules, operating/maintenance specifications, procedure times.

C.6.4 Agile manufacturing

Agile manufacturing is the ability to reconfigure production assets to meet market demand quickly. This requires the ability to change production using existing plants and equipment.

Agility in manufacturing is the ability to thrive in a manufacturing environment of continuous and often unanticipated change and to be fast to market with customized products. Agile manufacturing uses concepts geared toward making everything reconfigurable.

Agile enterprises may be supported by a networked infrastructure that can link multi-company teams into an integrated virtual corporation.

Agile manufacturing requires that production can quickly respond to changes in product definition and sometimes even change product production processes in mid-stream.

C.6.5 Supply chain optimization

The aim of supply chain management (SCM) is for each player in the supply chain to conduct business with the latest and best information from everyone else in the chain, guiding supply and demand into a more perfect balance. The purpose is to move product from the point of origin to that of consumption in the least amount of time and at the smallest cost.

Supply chain management helps managers do such things as integrate retail channels with manufacturing, drive demand from the point of sale, or eliminate inventory buffers in the distribution chain. SCM extends beyond the walls of the enterprise to suppliers and distributors.

Supply chain management moves to supply chain optimization when the supply chain is used to maximize the effectiveness of the whole, as well as maximizing the effectiveness of the individual parts.

Supply chain optimization involves making complex tradeoffs to satisfy business objectives of reducing operational costs and inventory, improving delivery reliability and response time, and service to the customer.

C.6.6 Quality and traceability

Quality and traceability can be a business driver in some businesses. This may be required by factors such as regulatory compliance, service cost measurement per product improvement, reliability to customers, and human resources tracking of exposure to hazardous items.

Quality and traceability requires that information that is typically kept within a manufacturing system be made available to other parts of an enterprise. This often requires integration of production control and quality assurance, with a corporate quality system.

C.6.7 Operator empowerment

Moving more decision-making to operations sometimes provides a competitive advantage, where operator decisions can have directly measurable financial impacts. The operations floor thus requires a significant increase in information that was accessible only from business offices in the past.

Empowerment: A condition whereby employees have the authority to make decisions and take action in their work areas without prior approval. The act of vesting appropriate authority in the hands of the people nearest the problems needs to be solved.

C.6.8 Improved planning

Improved planning is a key business driver for companies with expensive inventory, time-consuming production but fast customer changes, and variable demand. Improved planning requires access and use of information from throughout the corporation to move planning output from production requests and closer to production schedules.

Improved planning requires continual feedback on actual production and material consumption, as well as continual feedback on demand and inventories.

C.6.9 Summary

The business driver list is not all-inclusive. Any business driver that impacts cost, capacity, compliance, time, or analysis could be added to the list. Additionally, informational components of one business driver will also often be required when addressing other business drivers. The example in Clause B.6 is a basic situation that may provide a starting point for various business drivers.

C.7 Example business driver and information flow

An example of how business drivers and associated production functions generate the need for information flow throughout the business enterprise is described as follows.

The first business driver, available to promise, is a basic business driver. We assume a manufacturing business. In this business, there are certain functional steps that generate information flow between the business enterprise (office) and the production floor (control systems).

We will consider this business to be a general manufacturing facility. In a typical business day, we have customers who are requesting to buy our product. Armed with information from our sales personnel, we progress to the manufacturing floor. Here, information generation may be outlined in the following steps.

h) **Current state**: Where are we right now? Every business requires knowledge of its current manufacturing and business situation. This information is defined as *production from plan* and production performance and costs in the standard's data flow model.

i) **Target state**: Where do we want to go? In the normal course of business, new orders may be received, legal requirements change, and even the weather may have an informational impact through the business. So, there is information that flows between the business practices and manufacturing practices. This information is defined as *schedule* and *pack- out schedule* in the standard's data flow model.

j) **Transition state**: Prior to a change, there is a significant amount of information generated to anticipate how the changes will be managed. And when things actually change, there is history gathering of how the changes actually occur. This information is defined as production performance in the standard's object model.

k) **Planning/Scheduling**: For this business, the need for information regarding current state, target state and transition environment may occur may times per week, day or operations shift. The frequency of schedule update and the frequency of information uploads will depend

on industry needs. A grouping or series of steps A, B, and C may be described as a schedule for the manufacturing floor. Or, the business offices may regard this as a plan. Either way, there is information that has to flow between the two to reconcile issues. This information is defined as *production schedule* in the standard's object model.

l) **Planned versus actual**: At certain times, a typical business has to review the actions in steps A through C to see if the business requires adjustments.

This is one method of describing steps that generate information flow between the business offices and the production floor in an available-to-promise enterprise.

Regardless of the specific business driver and associated functions identified, some of the steps described in the make-to-order example above are required to meet all business drivers. For example, many business drivers require the business to know what the current state of its business is.

C.8 Definitions

This clause presents terms sometimes used in describing key business drivers.

C.8.1 Current state reporting

Current state reporting is a collection of information that characterizes the current activity and conditions that exist in the manufacturing environment. This information is collected for the purpose of decision support. This information allows you to understand where you are in relation to current commitments. This information is described in the standard in the current production capability information. Some other terms often used in current state reporting include

a) production request: information on the current production schedule with respect to the actual product that has been requested for production;

b) production quantity: how much of the current production request has been completed (cumulative versus request)?;

c) current rate: what is the instantaneous rate of production of the product requested?;

d) quality: measure of the effectiveness of production - this measurement of product quality, yields data, waste, loss, yield, material, and energy balance);

e) physical equipment status: information on the maintenance state of the equipment, work cells, trains, etc., to determine the current and future availability of that equipment for the production of the next product;

f) predictive maintenance: a predictive determination of when equipment will need maintenance, and a mechanism to perform maintenance on the equipment at or before its expected error or failure time;

g) preventative maintenance: performing maintenance before an error or failure occurs, and a mechanism to perform maintenance, usually on a fixed-time or run-time schedule;

h) inventory status: data on materials that will impact the decision to proceed with the next product’s production.

C.8.2 Turnaround time

Turnaround time is the time required to change a production mechanism for the purpose of producing a different product or the same product with different characteristics. The information that will determine the turnaround time includes

a) the current state of all items and current state of the production facility;

b) historical transition times, given the current state of the production facility;

c) standard operating procedures required for switchover;

d) resource requirements versus available (labor, material, equipment).

C.8.3 Campaigning

Campaigning is the planning of the execution of production based on the existing capacity, raw material, resources and production request. A campaign is usually a limited run of product through the production process. Campaigns can last from days to months depending on the products, processes, and production requirements. Control strategy and physical process changes may accompany campaigns.

One important aspect of campaigning is letting production know the sequence of events or scheduled runs ahead of time.

Campaigns generally deal with a single product, or a set of products with compatible processing or product requirements. Campaign planning has to also address previous product characteristics to maximize the agility of the change.

Campaigning is addressed in the standard through production schedules and production requests.

C.8.4 New targets

New targets describe what to make in the next time sequence and when to start – mainly an information demand that the control system places on the enterprise for a production order. New targets are handled in the standard through the production parameters in a production request.

The type of information required for new targets depends on the industry. New targets can be fixed numbers in a discrete environment and can be variable values, such as tables or functions, in continuous environments.

New targets may include the product quality characteristics.

C.9 Data reconciliation

Data reconciliation is a serious issue for enterprise-control integration. The data have to be valid to be useful for the enterprise system. The data are often determined from physical measurements that have associated error factors. This is usually converted into exact values for the enterprise system. This conversion may require manual or intelligent reconciliation of the converted values. Additional problems occur when the type of physical measurement, such as volume, is used to calculate information based on a related value, such as weight. For example, in the refining industry the operations floor changes the density of products, but measures by volume, then uses inference to calculate density and weight.

Systems have to be set up to ensure that accurate data are sent to production and from production. Inadvertent operator or clerical errors may result in too much production, too little production, the wrong production, incorrect inventory, or missing inventory.

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Annex D
(informative)

Questions and answers about this standard

D.1 Introduction

This section contains notes about this standard, basically recorded as notes and emails between committee members.

D.2 Purdue Reference Model (PRM)

QUESTION:

What happened to the information on the Purdue Reference Model that was in the original part one Annex?

ANSWER:

This annex was moved to a new ISA95 Technical Report that was in development at the time of this publication.

D.3 Role based equipment hierarchy and physical asset hierarchy

QUESTION:

What exactly is the role based equipment and physical asset hierarchy? Is it different from how it relates to the ISA88 equipment physical hierarchy? If so, how?

ANSWER:

The role based equipment hierarchy is just a new name for the equipment hierarchy. It is the same as the ISA88 physical hierarchy. As we added the maintenance activities in Part 3, we realized that there are two different aspects of equipment, one the control aspect, which is basically the control role that the equipment performs, and the physical role, which is associated with the maintenance of the physical equipment.

A lot of people were trying to use the ISA95 (and ISA88) equipment hierarchy in defining the physical aspect of the equipment, and this resulted in a lot of confusion. For example, a pump may be considered as a control module in ISA88 and part of a unit in ISA95. However, if the physical pump was switched out with a different pump, the ISA88/95 equipment hierarchy did not change (it performed the same role), but the serial number, maintenance record, etc. went with the old pump.

Another way to think of the two identifiers is using your car as an example. Your car has a VIN (Vehicle Identification Number) and performs a role (your means of transportation). If you sell your car and get another, you still have a car performing a role, but the physical car is now different. Your old car may still exist, and be performing a similar role for someone else.

We identified another hierarchy, the physical asset hierarchy, to handle identification, tracking, and collections of physical equipment in the maintenance activities. The physical asset hierarchy matches the hierarchy in the MIMOSA standard.

D.4 Physical asset hierarchy

QUESTION:

How is the physical asset equipment hierarchy different from the ISA88 physical equipment hierarchy?

ANSWER:

The ISA88 equipment hierarchy is a combination of equipment and control. The equipment is, however, usually identified by role (for example: Tag Number), so it is the same as the ISA95 role based equipment hierarchy. The ISA95 physical asset hierarchy is identified by the actual physical equipment (for example: equipment identified by serial number).

D.5 Chart of account hierarchy

QUESTION:

What is the significance of the physical asset equipment hierarchy to the standard; is it related to financial or cost control? Note 1 states that the physical asset equipment hierarchy usually has a reference to an accounting hierarchy in a chart of accounts

ANSWER:

At one time we had a table of all of the different types of equipment hierarchies in an enterprise. One of these was the allocation of a physical asset to an account (which department “owns” the equipment) from a chart of accounts. The chart of accounts hierarchy was out of scope, but the maintenance hierarchy was in scope.

D.6 Decision hierarchy

QUESTION:

What is the purpose and significance of decision hierarchy to the standard?

ANSWER:

The decision hierarchy was added by IEC in the IEC 62264-1 standard. After IEC/ISO 62264-1 was released, the decision hierarchy was defined in ISO 15704 Industrial automation systems — Requirements for enterprise-reference architectures and methodologies. The ISA95 update was based on the IEC 62264-1 standard. However, because there is now a complete standard on the decision hierarchy it was removed from this standard, but a reference is now made to the ISO 15704 standard.

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