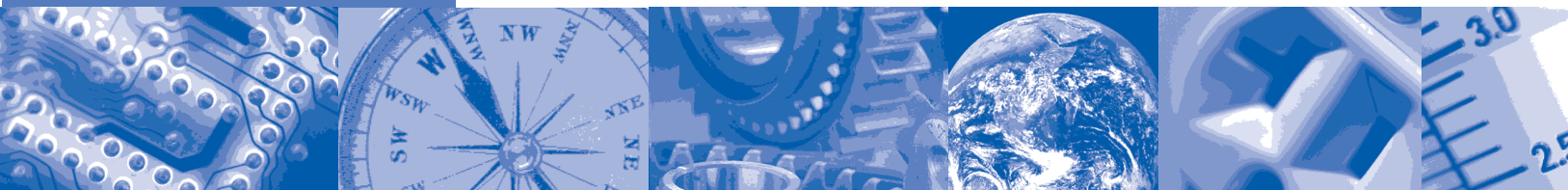


ANSI/ISA-95.00.03-2005



Enterprise-Control System Integration Part 3: Activity Models of Manufacturing Operations Management



**ISA—The Instrumentation,
Systems, and
Automation Society**

Approved 6 June 2005



Documents

Document Sharing Hub

ANSI/ISA-95.00.03-2005

Enterprise-Control System Integration Part3: Activity Models of Manufacturing Operations Management

ISBN: 1-55617-955-3

Copyright © 2005 by ISA—The Instrumentation, Systems, and Automation Society. All rights reserved. Not for resale. Printed in the United States of America. No part of this publication may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means (electronic, mechanical, photocopying, recording, or otherwise), without the prior written permission of the Publisher.

ISA
67 Alexander Drive
P. O. Box 12277
Research Triangle Park, North Carolina 27709
USA



Documents
Document Sharing Hub

PREFACE

This preface, as well as all footnotes and annexes, is included for information purposes and is not part of ANSI/ISA-95.00.03-2005.

The standards referenced within this document may contain provisions which, through reference in this text, constitute requirements of this document. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the standards indicated within this document. Members of IEC and ISO maintain registers of currently valid International Standards. ANSI maintains registers of currently valid U.S. National Standards.

This document has been prepared as part of the service of ISA—The Instrumentation, Systems, and Automation Society, toward a goal of uniformity in the field of instrumentation. To be of real value, this document should not be static but should be subject to periodic review. Toward this end, the Society welcomes all comments and criticisms and asks that they be addressed to the Secretary, Standards and Practices Board; ISA; 67 Alexander Drive; P. O. Box 12277; Research Triangle Park, NC 27709; Telephone (919) 549-8411; Fax (919) 549-8288; E-mail: standards@isa.org.

The ISA Standards and Practices Department is aware of the growing need for attention to the metric system of units in general, and the International System of Units (SI) in particular, in the preparation of instrumentation standards. The Department is further aware of the benefits to USA users of ISA standards of incorporating suitable references to the SI (and the metric system) in their business and professional dealings with other countries. Toward this end, this Department will endeavor to introduce SI-acceptable metric units in all new and revised standards, recommended practices, and technical reports to the greatest extent possible. *Standard for Use of the International System of Units (SI): The Modern Metric System*, published by the American Society for Testing & Materials as IEEE/ASTM SI 10-97, and future revisions, will be the reference guide for definitions, symbols, abbreviations, and conversion factors.

It is the policy of ISA to encourage and welcome the participation of all concerned individuals and interests in the development of ISA standards, recommended practices, and technical reports. Participation in the ISA standards-making process by an individual in no way constitutes endorsement by the employer of that individual, of ISA, or of any of the standards, recommended practices, and technical reports that ISA develops.

CAUTION — ISA ADHERES TO THE POLICY OF THE AMERICAN NATIONAL STANDARDS INSTITUTE WITH REGARD TO PATENTS. IF ISA IS INFORMED OF AN EXISTING PATENT THAT IS REQUIRED FOR USE OF THE STANDARD, IT WILL REQUIRE THE OWNER OF THE PATENT TO EITHER GRANT A ROYALTY-FREE LICENSE FOR USE OF THE PATENT BY USERS COMPLYING WITH THE STANDARD OR A LICENSE ON REASONABLE TERMS AND CONDITIONS THAT ARE FREE FROM UNFAIR DISCRIMINATION.

EVEN IF ISA IS UNAWARE OF ANY PATENT COVERING THIS STANDARD, THE USER IS CAUTIONED THAT IMPLEMENTATION OF THE STANDARD MAY REQUIRE USE OF TECHNIQUES, PROCESSES, OR MATERIALS COVERED BY PATENT RIGHTS. ISA TAKES NO POSITION ON THE EXISTENCE OR VALIDITY OF ANY PATENT RIGHTS THAT MAY BE INVOLVED IN IMPLEMENTING THE STANDARD. ISA IS NOT RESPONSIBLE FOR IDENTIFYING ALL PATENTS THAT MAY REQUIRE A LICENSE BEFORE IMPLEMENTATION OF THE STANDARD OR FOR INVESTIGATING THE VALIDITY OR SCOPE OF ANY PATENTS BROUGHT TO ITS ATTENTION. THE USER SHOULD CAREFULLY INVESTIGATE RELEVANT PATENTS BEFORE USING THE STANDARD FOR THE USER'S INTENDED APPLICATION.

HOWEVER, ISA ASKS THAT ANYONE REVIEWING THIS STANDARD WHO IS AWARE OF ANY PATENTS THAT MAY IMPACT IMPLEMENTATION OF THE STANDARD NOTIFY THE ISA STANDARDS AND PRACTICES DEPARTMENT OF THE PATENT AND ITS OWNER.

ADDITIONALLY, THE USE OF THIS STANDARD MAY INVOLVE HAZARDOUS MATERIALS, OPERATIONS OR EQUIPMENT. THE STANDARD CANNOT ANTICIPATE ALL POSSIBLE APPLICATIONS OR ADDRESS ALL POSSIBLE SAFETY ISSUES ASSOCIATED WITH USE IN HAZARDOUS CONDITIONS. THE USER OF THIS STANDARD MUST EXERCISE SOUND PROFESSIONAL JUDGMENT CONCERNING ITS USE AND APPLICABILITY UNDER THE USER'S PARTICULAR CIRCUMSTANCES. THE USER MUST ALSO CONSIDER THE APPLICABILITY OF ANY GOVERNMENTAL REGULATORY LIMITATIONS AND ESTABLISHED SAFETY AND HEALTH PRACTICES BEFORE IMPLEMENTING THIS STANDARD.

THE USER OF THIS DOCUMENT SHOULD BE AWARE THAT THIS DOCUMENT MAY BE IMPACTED BY ELECTRONIC SECURITY ISSUES. THE COMMITTEE HAS NOT YET ADDRESSED THE POTENTIAL ISSUES IN THIS VERSION.

The following individuals served as voting members of ISA-SP95 during the development of ANSI/ISA-95.00.03-2005.

NAME	COMPANY
Keith Unger*	Rockwell Automation and Stone Technologies Inc.
William Bosler**	Texas Consultants Inc.
Donald Clark**	Invensys Process Systems
Dennis Brandl***	BR&L Consulting, Inc.
Chris Monchinski****	Automated Control Concepts, Inc.
Gary Addison	Lyondell – Equistar Chemicals LP
David Adler	Eli Lilly & Co
Lynn Craig	MAA Inc
Eric Cosman	Dow Chemical
Paresh Dalwalla	OpteBiz
Dennis Delaney	Accenture
Em delaHostria	Rockwell Automation
Stefano Dighero	Siemens
David Emerson	Yokogawa Corp. of America
Charlie Gifford	GE Fanuc America
Les Hastings	ProsCon Ltd
Gavan Hood~	Rockwell Automation
Jay Jeffreys~	Invensys Wonderware
Charlotta Johnsson	Siemens and Lund Institute of Technology
Alan Johnston	MIMOSA
Marc Leroux	ABB Inc.
Richard Martin	Aspen Technology
Yasuyuki Nishioka	Hosei University
Saroj Patnaik	Emerson Process Automation
Costantino Pipero	Invensys Wonderware
Anne Poorman~	ABB Automation Inc.
Leif Poulsen	Novo Nordisk Engineering, A/S
Leon Steinocher	Fluor Enterprises, Inc.
Swarandeep Singh~	ABB AS
Jean Vieille	Consultant
Ray Walker	DuPont Engineering
Theodore Williams	Purdue University

* Chairman

** Vice Chairman

*** Editor

**** Secretary

~ Alternate

The following individuals also participated in the development of ANSI/ISA-95.00.03-2005:

NAME	COMPANY
Jon Barry	Queue Systems Inc.
Rafael Batres	Toyohashi University of Technology
Bernadine Brown	E I du Pont de Nemours and Co.
Rudy Bunker	BC Consulting
Yves Carrier	Keops Technologies Inc.
Anthony Chandler	Proscon Ltd
David A. Chappell	Procter & Gamble
David Connelly	Open Applications Group
David Cornel	Procter & Gamble
Russ Dickenson	Dow Chemical
Llorenç Domingo	Aspen Technology
Steve Downs	Applied Creative Technologies
Bernard Dumortier	Schneider Electric
Daniel Dziadiw	Schering Plough Corp.
Joseph Faccenda	Aspen Technology
Christine Hermetet-Filez	AFNOR
Kevin Fitzgerald	Invensys
Tony Gallo	Adelphia
Alistair Gillanders	Aspen Technology
Boyd Gochenour	Aspen Technology
Mike Grasley	ASECO
Steve Graham	Dow Chemical
Graeme Hall	Aspen Technology
William Hawkins	HLQ Ltd.
Girish Joglekar	Purdue University
Hansil Kim	University of Ulsan
Eugene Lambert	Wunderlich-Malec
Jim Luth	OPC Foundation
Kishen Manjunath	Honeywell Process Solutions
Jean-Jacques Michel	IDPI Conseil
Mark Muroski	ABB Automation, Inc.
Paul Nowicki	Rockwell Automation
Ashok Rao	Aspen Technology
Gary Rathwell	Enterprise Consultants
Tom Reed	EnteGreat Inc.
Marty Richards	ABB Automation, Inc.
Thorsten Ruehl	Camstar
Nate Schallert	Eli Lilly & Co
Paul Schiller	BP America
Bianca Scholten	TWP and Ordina
Dave Shorter	IT Focus
Leng Shan	Southeast University
Bryan Singer	Rockwell Automation
Jeremy Suratt	SSA Global
Arne Svendsen	Arla Foods
Jason Toschlog	Flexware Innovation
Steve Williams	Aspen Technology
Gregory Winchester	NEMA
Chunhua Zhao	Purdue University

Copyright 2005 ISA All rights reserved.

The following members served on the Standards & Practices Board and approved this standard on 1 June 2005.

NAME

I. Verhappen, President
F. Amir
D. Bishop
M. Coppler
B. Dumortier
W. Holland
E. Içayan
A. Iverson
R. Jones
K. P. Lindner
T. McAviney
A. McCauley
G. McFarland
R. Reimer
J. Rennie
N. Sands
H. Sasajima
T. Schnaare
A. Summers
J. Tatera
R. Webb
W. Weidman
J. Weiss
M. Widmeyer
C. Williams
M. Zielinski

COMPANY

Synchrude Canada, Ltd.
E I Du Pont Co.
Consultant
Ametek Inc.
Schneider Electric
Consultant
ACES Inc.
Ivy Optiks
Consultant
Endress + Hauser Process Solutions
Jacobs Engineering Group
Chagrin Valley Controls Inc.
Emerson Process Management
Rockwell Automation
Consultant
E I Du Pont Co.
Yamatake Corp.
Rosemount Inc.
SIS-TECH Solutions LLC
Tatera & Associates
Consultant
Parsons Energy and Chemicals
KEMA Inc.
Stanford Linear Accelerator Center
Eastman Kodak Co.
Emerson Process Management

Copyright 2005 ISA All rights reserved.



CONTENTS

1	Scope	15
2	Normative references	15
3	Definitions and abbreviations	15
3.1	Definitions	15
3.2	Abbreviations	17
4	Manufacturing operations management overview	18
4.1	Manufacturing operations management	18
4.2	Functional hierarchy	19
4.3	Manufacturing operations management elements	20
4.4	Criteria for defining activities below Level 4	20
4.5	Activity relationships	21
4.6	Expanded categories of information	21
4.7	Manufacturing operations information	22
4.8	Other activities within manufacturing operations management	23
5	Structuring models	24
5.1	Generic template for categories of manufacturing operations management	24
5.2	Interaction among generic activity models	25
5.3	Expanded equipment hierarchy model	26
6	Production operations management	29
6.1	General activities in production operations management	29
6.2	Production operations management activity model	30
6.3	Information exchange in production operations management	31
6.4	Product definition management	31
6.5	Production resource management	33
6.6	Detailed production scheduling	37
6.7	Production dispatching	40
6.8	Production execution management	44
6.9	Production data collection	45
6.10	Production tracking	47
6.11	Production performance analysis	49
7	Maintenance operations management	54
7.1	General activities in maintenance operations management	54
7.2	Maintenance operations management activity model	54
7.3	Information exchanged in maintenance operations management	55
7.4	Maintenance definition management	57

7.5	Maintenance resource management	58
7.6	Detailed maintenance scheduling.....	58
7.7	Maintenance dispatching	59
7.8	Maintenance execution management.....	59
7.9	Maintenance data collection	59
7.10	Maintenance tracking.....	59
7.11	Maintenance analysis	60
8	Quality operations management	61
8.1	General activities in quality operations management.....	61
8.2	Quality test operations activity model	63
8.3	Information exchanged in quality test operations management.....	64
8.4	Quality test definition management	66
8.5	Quality test resource management.....	67
8.6	Detailed quality test scheduling	67
8.7	Quality test dispatching.....	68
8.8	Quality test execution management	68
8.9	Quality test data collection.....	69
8.10	Quality test tracking	70
8.11	Quality performance analysis	70
8.12	Supported activities	71
9	Inventory operations management.....	72
9.1	General activities in inventory operations management.....	72
9.2	Inventory operations management activity model	73
9.3	Information exchanged in inventory operations management.....	73
9.4	Inventory definition management	75
9.5	Inventory resource management.....	75
9.6	Detailed inventory scheduling.....	76
9.7	Inventory dispatching.....	77
9.8	Inventory execution management	77
9.9	Inventory data collection	78
9.10	Inventory tracking	79
9.11	Inventory analysis	79
10	Other enterprise activities affecting manufacturing operations	81
10.1	Other areas	81
10.2	Management of security	81
10.3	Management of information.....	82
10.4	Management of configuration	82



10.5	Management of documents	83
10.6	Management of regulatory compliance	83
10.7	Management of incidents and deviations	85
10.8	Completeness	86
10.9	Compliance	86
10.10	Conformance	86
Annex A – Technical and responsibility boundaries		87
Annex B - Scheduling hierarchy		93
Annex C - Associated Standards		95
Annex D – Frequently asked questions		99

Copyright 2005 ISA. All rights reserved.



FIGURES

Figure 1 – Manufacturing operations management model	19
Figure 2 - Multi-level functional hierarchy of activities	20
Figure 3 - Activity relationships	21
Figure 4 – Categories of information exchange	22
Figure 5 - Manufacturing operations information	23
Figure 6 - Generic activity model of manufacturing operations management	25
Figure 7 – Typical expanded equipment hierarchy	26
Figure 8 - Work centers and work units	29
Figure 9 - Activity model of production operations management.....	30
Figure 10 - Product definition management activity model interfaces	32
Figure 11 – Production resource management activity model interfaces	34
Figure 12 - Resource management capacity reporting.....	35
Figure 13 - Detailed production scheduling activity model interfaces.....	37
Figure 14 - Splitting and merging production schedules to detailed production schedules.....	39
Figure 15 - Detailed production schedule	40
Figure 16 – Production dispatching activity model interfaces	41
Figure 17 - Sample production dispatch list.....	42
Figure 18 - Work dispatching for mixed process facility	43
Figure 19 - Production execution management activity model interfaces	44
Figure 20 - Production data collection activity model interfaces	46
Figure 21 - Production tracking activity model interfaces	47
Figure 22 - Merging and splitting production tracking information	48
Figure 23 - Production performance analysis activity model interfaces	49
Figure 24 - Activity model of maintenance operations management.....	55
Figure 25 – Activity model of quality test operations management	64
Figure 26 - Activity model of inventory operations management.....	73
Figure 27 – Inventory data collection activity model	79
Figure 28- Other enterprise activities affecting manufacturing operations	81
Figure 29 - Functions in management of regulatory compliance.....	84
Figure 30 - Different boundaries of responsibility	88
Figure 31 - Lines of technical integration	90
Figure 32 - Sample hierarchy of schedules and scheduling activities.	94
Figure 33 - CIM and standard levels.....	100

FOREWORD

This standard is Part 3 of a multi-part set of standards that defines the interfaces between enterprise activities and control activities.

Clause 4 of this standard is informative. The intent is to provide an overview of activities associated with production operations management, maintenance operations management, inventory operations management, and quality operations management.

Clause 5 is normative. It defines a standard template that can be applied to different categories of manufacturing operations management and defines the standard terminology to apply to the equipment hierarchy model.

Clause 6 is normative. It defines the standard terminology to apply to information and activities associated with production operations management.

Clause 7 is normative. It defines the standard terminology to apply to information and activities associated with maintenance operations management.

Clause 8 is normative. It defines the standard terminology to apply to information and activities associated with quality operations management.

Clause 9 is normative. It defines the standard terminology to apply to information and activities associated with inventory operations management.

Clause 10 is informative. The intent is to describe other activities in manufacturing operations management, not defined in previous clauses, and to list relevant standards in those areas.

Clause 11 is normative. It defines the criteria for completeness, compliance and conformance in applying the standard.

Annex A is informative. It illustrates how the rules for determining the manufacturing operations management responsibility and technology boundaries can be applied to different manufacturing enterprises.

Annex B is informative. It illustrates an example of the hierarchy of scheduling within an enterprise.

Annex C is informative. It lists standards associated with the other activities in manufacturing operations management listed in Clause 10.

Annex D is informative. It answers a list of frequently asked questions about this standard.

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 (published 2000)
- Part 2: Object model attributes (published 2001)
- Part 3: Activity models of manufacturing operations management (published 2005)
- 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 (in development at the time of publication of this standard)
- Part 6: Manufacturing operations transactions (in development at the time of publication of this standard)

This page intentionally left blank.

INTRODUCTION

This Part 3 standard shows activity models and data flows for manufacturing information that enables enterprise-control system integration. The modeled activities operate between Level 4 logistics and planning functions and Level 2 manual and automated process control functions. The models are consistent with the ANSI/ISA-95.00.01-2000 (hereinafter referred to as "Part 1") object models and the Level 3 (Manufacturing Operations and Control) definitions.

The goal of the ANSI/ISA-95 series of standards is to reduce the risk, cost, and errors associated with implementing enterprise systems and manufacturing operations systems in such a way that they interoperate and easily integrate. The standards may also be used to reduce the effort associated with implementing new product offerings.

This Part 3 standard provides models and terminology for defining the activities of manufacturing operations management. The models and terminology defined in this standard:

- Emphasize good practices of manufacturing operations.
- Can be used to improve existing manufacturing operations systems.
- Can be applied regardless of the degree of automation.

Some potential benefits produced when applying the standard may include:

- Reducing the time to reach full production levels for new products.
- Enabling vendors to supply appropriate tools for manufacturing operations.
- Enabling more uniform and consistent identification of manufacturing needs.
- Reducing the cost of automating manufacturing processes.
- Optimizing supply chains.
- Improving efficiency in life-cycle engineering efforts.

It is not the intent of this standard to:

- Suggest that there is only one way of implementing manufacturing operations.
- Force users to abandon their current way of handling manufacturing operations.
- Restrict development in the area of manufacturing operations.
- Restrict use only to manufacturing industries.

This page intentionally left blank.

1 Scope

This Part 3 standard defines activity models of manufacturing operations management that enable enterprise system to control system integration. The activities defined in this Part 3 standard are consistent with the Part 1 object models definitions. The modeled activities operate between business planning and logistics functions, defined as the Part 1 Level 4 functions, and the process control functions, defined as the Part 1 Level 2 functions.

The scope of this Part 3 standard is limited to:

- A model of the activities associated with manufacturing operations management, Level 3 functions.
- An identification of some of the data exchanged between Level 3 activities.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid normative documents.

- ANSI/ISA-95.00.01-2000, Enterprise-Control System Integration Part 1: Models and Terminology
- ANSI/ISA-95.00.02-2001, Enterprise-Control System Integration Part 2: Object Model Attributes
- IEC/ISO 62264-1:2003, Enterprise-control system integration - Part 1: Models and terminology
- IEC/ISO 62264-2:2004, Enterprise-control system integration - Part 2: Object model attributes
- ANSI/ISA-88.01-1995, Batch Control Part 1: Models and Terminology
- ANSI/ISA-88.00.02-2001, Batch Control Part 2: Data Structures and Guidelines for Languages
- IEC 61512-1:1997, Batch control - Part 1: Models and terminology
- IEC 61512-2:2001, Batch control - Part 2: Data structures and guidelines for languages

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this standard, the following definitions apply:

3.1.1 detailed production schedule:

organized and structured collection of production work orders and sequencing involved in production of one or more products.

3.1.2 finite capacity scheduling:

a scheduling methodology in which work is scheduled for production resources, such that no production resource capacity requirement exceeds the capacity available to the production resource.

3.1.3 inventory operations management:

activities within Level 3 of a manufacturing facility that coordinate, direct, manage, and track inventory and material movement within manufacturing operations.

3.1.4 Level 0:

the actual physical process.

3.1.5 Level 1:

the functions involved in sensing and manipulating the physical process.

3.1.6 Level 2:

the functions involved in monitoring and controlling the physical process.

3.1.7 Level 3:

the functions involved in managing the work flows to produce the desired end products.

3.1.8 Level 4:

the functions involved in the business-related activities needed to manage a manufacturing organization.

3.1.9 maintenance operations management:

activities within Level 3 of a manufacturing facility that coordinate, direct, and track the functions that maintain the equipment, tools, and related assets to ensure their availability for manufacturing and ensure scheduling for reactive, periodic, preventive, or proactive maintenance.

3.1.10 manufacturing facility:

a site, or area within a site, that includes the resources within the site or area, and includes the activities associated with the use of the resources.

3.1.11 manufacturing operations management:

activities within Level 3 of a manufacturing facility that coordinate the personnel, equipment, and material in manufacturing.

NOTE 1 — This Part 3 standard details manufacturing operations management in terms of four categories (production operations management, maintenance operations management, quality operations management, and inventory operations management) and provides references for other enterprise activities affecting manufacturing operations.

NOTE 2 — In the PERA (see clause 3.2) model the concept of manufacturing defines the physical resources used in production. The manufacturing operations management activities defined in this standard pertain to the information-handling functions of the PERA model.

3.1.12 production dispatch list:

a set of specific production work orders to be performed on or by a particular set of resources, at a given location, and the time or event to start or stop the activity.

NOTE 1 — This may take the form of setup instructions for machines, operating conditions for continuous processes, material movement instructions, or batches to be started in a batch system.

NOTE 2 — Dispatch lists are applicable to other operations management areas, such as maintenance dispatch lists, quality test dispatch lists, and inventory dispatch lists.

3.1.13 production operations management:

activities within Level 3 of a manufacturing facility that coordinate, direct, manage, and track the functions that use raw materials, energy, equipment, personnel, and information to produce products, with the required costs, qualities, quantities, safety, and timeliness.

3.1.14 production work order:

unit of scheduled work that may be dispatched to a work center and that consists of lower-level elements.

3.1.15 quality operations management:

activities within Level 3 of a manufacturing facility that coordinate, direct, and track the functions that measure and report on quality.

3.1.16 storage unit:

subordinate entity within a storage zone that consists of equipment and information required to contain, move, condition, and handle material.

NOTE — A storage unit is an element of the equipment hierarchy.

3.1.17 storage zone:

logical grouping of resources that defines a span of logistical control and includes the equipment and information required for containing, moving, conditioning, and handling of one or more material items.

NOTE — A storage zone is an element of the equipment hierarchy.

3.1.18 tracing:

activity that provides an organized record of resource and product use from any point, forward or backward, using tracking information.

3.1.19 tracking:

activity of recording attributes of resources and products through all steps of instantiation, use, change, and disposition.

3.1.20 work center:

process cell, production unit, production line, storage zone, or any other equivalent-level equipment element defined as an extension to the equipment hierarchy model.

3.2 Abbreviations

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

AGV	Automated Guided Vehicles
AMS	Asset Management System
ASRS	Automated Storage and Retrieval System
CAPE	Computer Aided Process Engineering
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CASE	Computer Aided Software Engineering
CIM	Computer Integrated Manufacturing
CNC	Computerized Numerical Control
DCS	Distributed Control System
ERP	Enterprise Resource Planning
EWI	Electronic Work Instructions
HR	Human Resources
KPI	Key Performance Indicator
LIMS	Laboratory Information Management System
MES	Manufacturing Execution System
MPS	Master Production Schedule
MRP	Material Resource Planning
OEE	Overall Equipment Effectiveness



PAT	Process Analytical Technology
PERA	Purdue Enterprise Reference Architecture
PDM	Product Data Management
PLC	Programmable Logic Controller
PLM	Product Lifecycle Management
PRM	Purdue Reference Model for computer integrated manufacturing
QA	Quality Assurance
R&D	Research and Development
RFQ	Request For Quote
ROA	Return On Assets
SCADA	Supervisory Control and Data Acquisition
SOC	Standard Operating Conditions
SOP	Standard Operating Procedure
SQC	Statistical Quality Control
SPC	Statistical Process Control
WIP	Work In Process
WMS	Warehouse Management System

4 Manufacturing operations management overview

4.1 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 includes 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.

The manufacturing operations management activities correspond to the activity set defined in the Part 1 standard. These are the activities contained within the heavy dotted line shown in Figure 1. The heavy dotted line is equivalent to the Level 3/Level 4 interface defined in Part 1. Manufacturing operations management is subdivided into four categories: production operations management, maintenance operations management, quality operations management, and inventory operations management, as shown in shaded areas in Figure 1. There are also other activities of a manufacturing facility, not shown in Figure 1, but described in Clause 4.8 and Clause 10.

The model structure does not reflect a business organizational structure within a company, but is a model of activities. Different companies assign responsibilities for activities or subactivities to different business organizational groups.

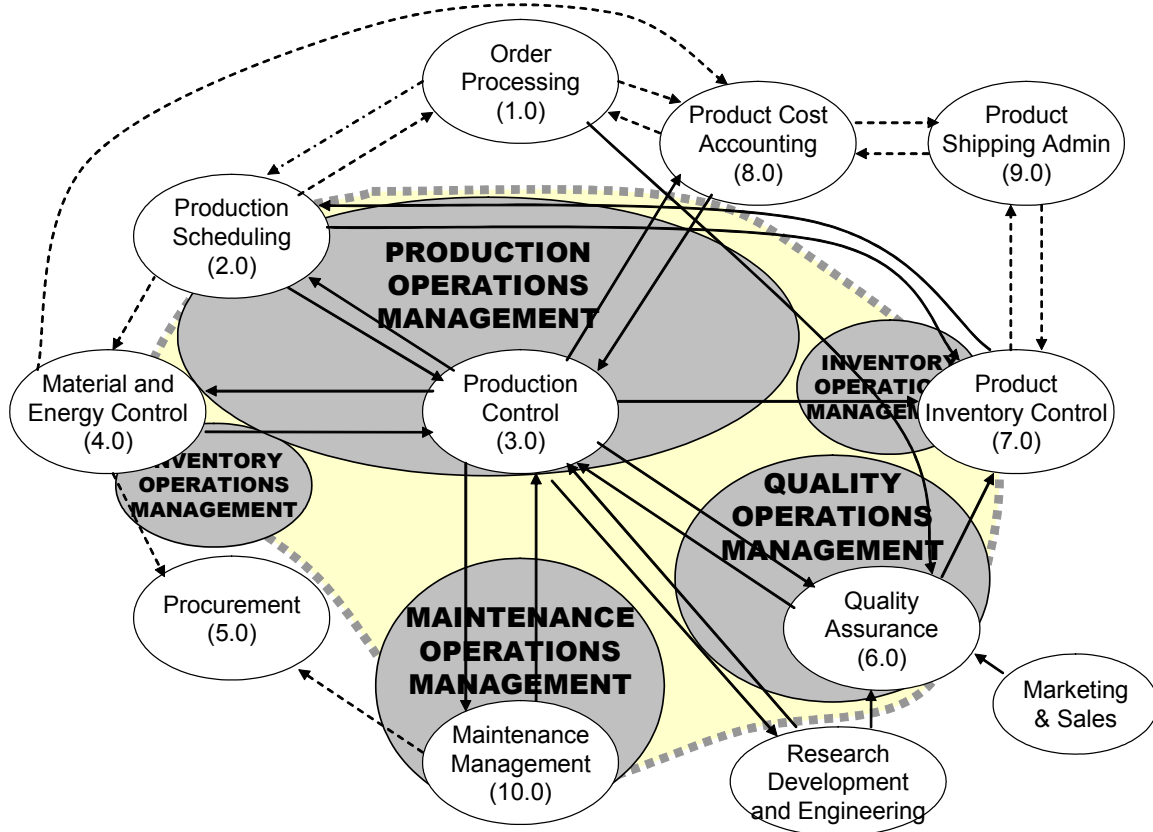


Figure 1 – Manufacturing operations management model

4.2 Functional hierarchy

The Part 1 standard defines a functional hierarchy model. Each level provides specialized functions and has characteristic response times, as shown in Figure 2.

- 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 subseconds.
- Level 3 defines the activities of 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 — There are other business-related activities that may be in Level 4 or higher levels, but these are not defined in this standard.

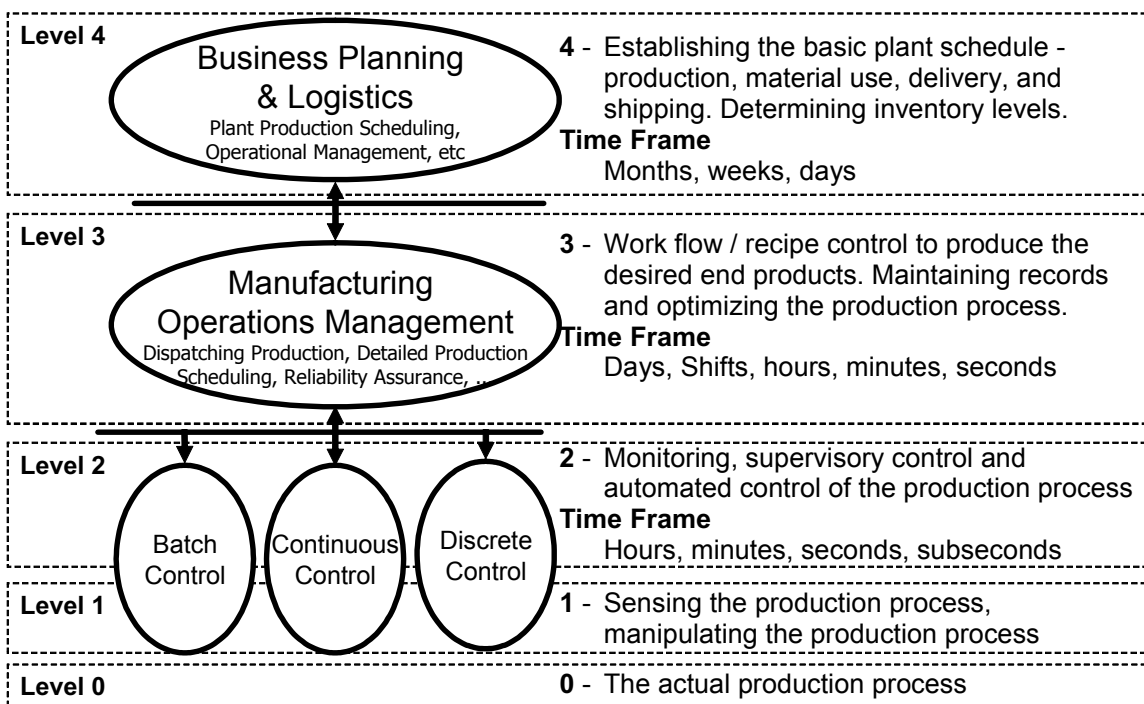


Figure 2 - Multi-level functional hierarchy of activities

4.3 Manufacturing operations management elements

The shaded areas in Figure 1 represent the manufacturing operations management activities modeled in this Part 3 standard. Manufacturing operations management is the collection of production operations management, maintenance operations management, quality operations management, inventory operations management, and other activities of a manufacturing facility.

Four formal models are defined: production operations management, maintenance operations management, quality operations management, and inventory operations management.

- The production operations management model includes the activities of production control (3.0) that operate as Level 3 functions and the subset of the production scheduling (2.0) that operate as Level 3 functions and as shown in Figure 1.
- The maintenance operations management model includes the activities of maintenance management (10.0) that operate as Level 3 functions.
- The quality operations management model includes the activities of quality assurance (6.0) that operate as Level 3 functions.
- The inventory operations management model includes the activities of management of inventory and material including product inventory control (7.0) and material & energy control activities (4.0) defined as operating as Level 3 functions and as shown in Figure 1.

Other categories of operation management may exist depending on company policy or organization. They are not formally modeled in this Part 3 standard, but they can make use of the generic standard model.

4.4 Criteria for defining activities below Level 4

In this Part 3 standard an activity is included as a Level 3, 2, or 1 activity if the activity is directly involved in manufacturing, includes information about personnel, equipment, or material, and meets any of the following conditions:

- The activity is critical to plant safety.

- b) The activity is critical to plant reliability.
- c) The activity is critical to plant efficiency.
- d) The activity is critical to product quality.
- e) The activity is critical to maintaining regulatory compliance.

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

EXAMPLE:

Maintaining regional, government, and other agency compliance.

NOTE 1 — This list is a clarification of the criteria for inclusion of an activity in Level 3, 2, or 1 domain defined in the Part 1 standard. This list supersedes the criteria defined in Part 1.

NOTE 2 — 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 3 — 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.

NOTE 4 — 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.

4.5 Activity relationships

Figure 3 illustrates the activity models of this Part 3 standard in relationship to Parts 1 and 2. The activities in this Part 3 exchange information with Level 4 and Level 2 activities. The gray circles indicate the activities detailed in this Part 3 standard. The information flows between the Part 3 activities, indicated as heavy dashed lines, are described in general in this Part 3 standard. In addition, the information flows between the Part 3 activities and dependent Level 2 activities are identified.

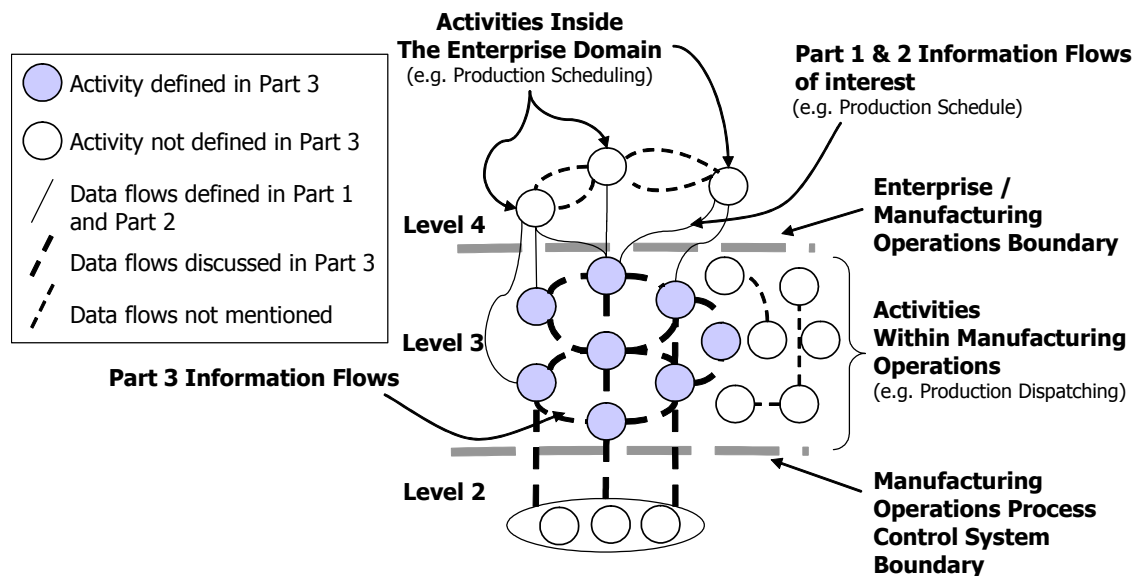


Figure 3 - Activity relationships

4.6 Expanded categories of information

The Part 1 standard defines the models and terminology to be used for enterprise-control system integration. Part 1 contains a definition of three general categories of information that should be exchanged between the business planning system (Level 4) and the manufacturing operations system (Level 3). The result of Part 1 includes object models for the three categories. This is expanded to four

categories in this Part 3 by splitting production information into the separate schedule and performance components of production schedule information and production performance information. See Figure 4.

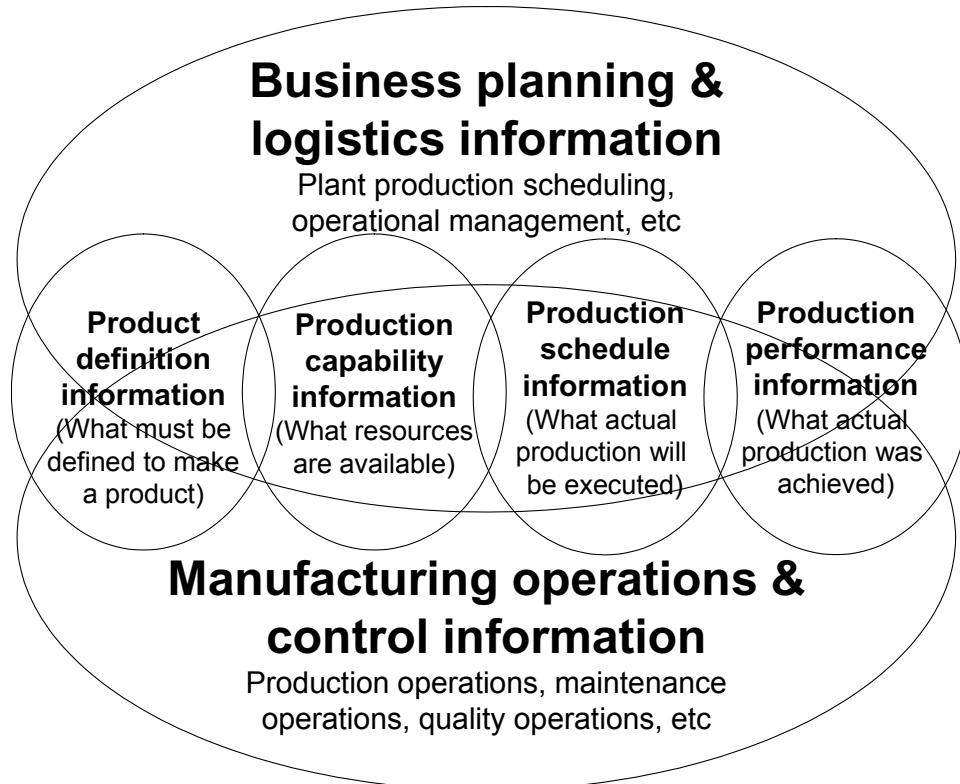


Figure 4 – Categories of information exchange

4.7 Manufacturing operations information

The structure of the production information defined in Part 1 and depicted in Figure 4 can also be applied to maintenance information, quality test information, and inventory transfer information as depicted in Figure 5. The production schedule, production performance, product definition management, production capability, maintenance request, and maintenance response, shown in Figure 5 as bold and underlined text, are defined in the Part 1 standard. There are equivalent information structures for maintenance, quality test, and inventory management that are of importance for manufacturing operations that are also discussed in this Part 3 standard.

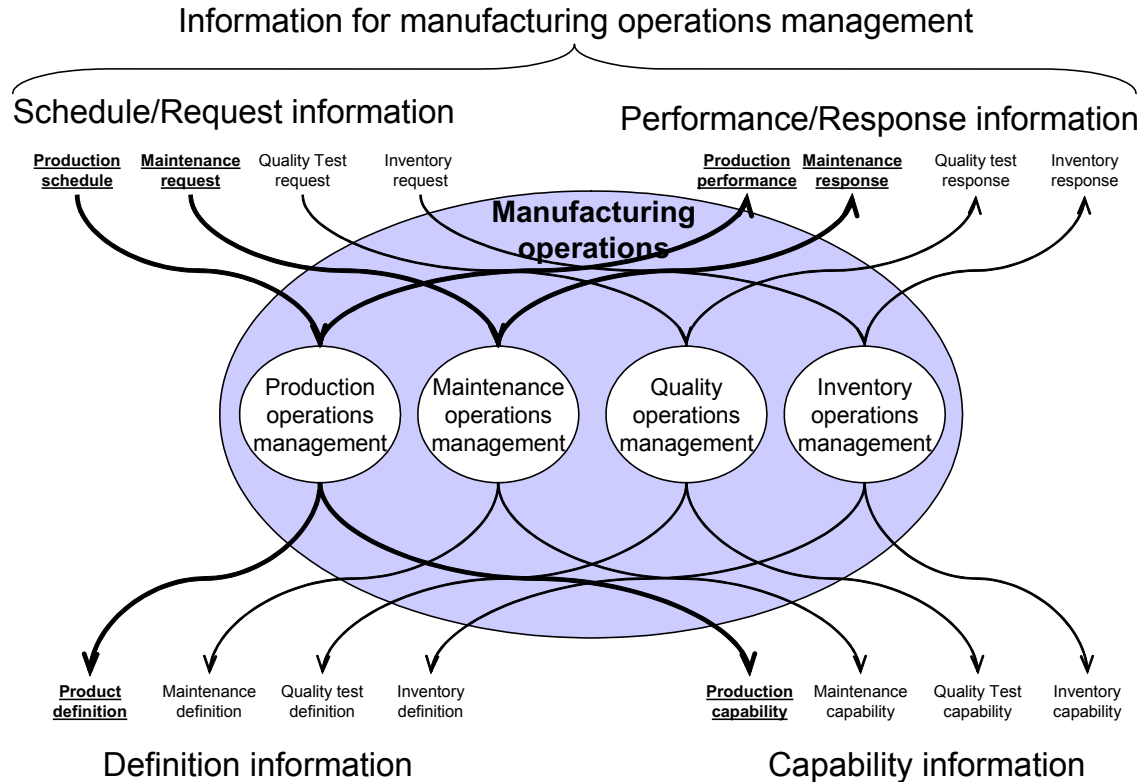


Figure 5 - Manufacturing operations information

4.8 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:

- Management of security within manufacturing operations.
- Management of information within manufacturing operations.
- Management of configurations within manufacturing operations.
- Management of documents within manufacturing operations.
- Management of regulatory compliance within manufacturing operations.
- Management of incidents and deviations.

The definition of the supporting activities is not within the scope of this standard, because those activities often are enterprise wide; however, requirements for the activities as they relate to manufacturing operations are described briefly in Clause 10.

5 Structuring models

5.1 Generic template for categories of manufacturing operations management

5.1.1 Template for management of operations

A generic model for management of operations is used as a template to define the production operations management, maintenance operations management, quality operations management, and inventory operations management models. This model is shown in Figure 6. This generic model is extended for each specific area in later clauses.

NOTE — The fine details of the generic model are different for each of the manufacturing operations management areas.

5.1.2 Use of the generic model

The generic model is instantiated for the four categories listed in Clause 5.1.1. However, this same template could be instantiated for other possible manufacturing operations categories, or for other operations areas within the enterprise.

EXAMPLE:

A company could apply the model to receiving operations management and shipping operations management where these are separately managed.

EXAMPLE:

A company could apply the model to cleaning and sterilization operations management, where these are separately managed.

EXAMPLE:

A company could apply the model to independent logistics operations management categories for inbound logistics, outbound logistics, internal transfer, and inventory control.

NOTE — This clause is normative so that companies that apply the generic model to areas other than the four detailed in this standard can determine and document their degree of conformance to the model.

When the generic model is instantiated for a new category, the activities within a category shall include the definitions of resource management, definition management, dispatching, tracking, data collection, analysis, detailed scheduling, and execution management.

5.1.3 Generic activity model

There is a hierarchy used in this standard that starts at a category of operations management. Each category is composed of a collection of activities, and each activity is composed of a set of tasks. The generic model applies to the sets of activities.

The generic activity model defines a general request-response cycle that starts with requests or schedules, converts them into a detailed schedule, dispatches work according to the detailed schedule, manages the execution of work, collects data, and converts the collected data back into responses. This request-response cycle is supported with:

- Analysis of the work performed for improvements or corrections.
- Management of the resources used in execution of the performed work.
- Management of the definitions of the performed work.

The generic activity model and the detailed models are not intended to represent an actual implementation of a manufacturing information system. However, they do provide a consistent framework for such systems. Actual systems may use different structures supporting other task arrangements. The purpose of these models is to identify possible data flows within manufacturing operations. The ovals in the model indicate collections of tasks, identified as the main activities. Lines with arrowheads indicate a set of important information flows between the activities.

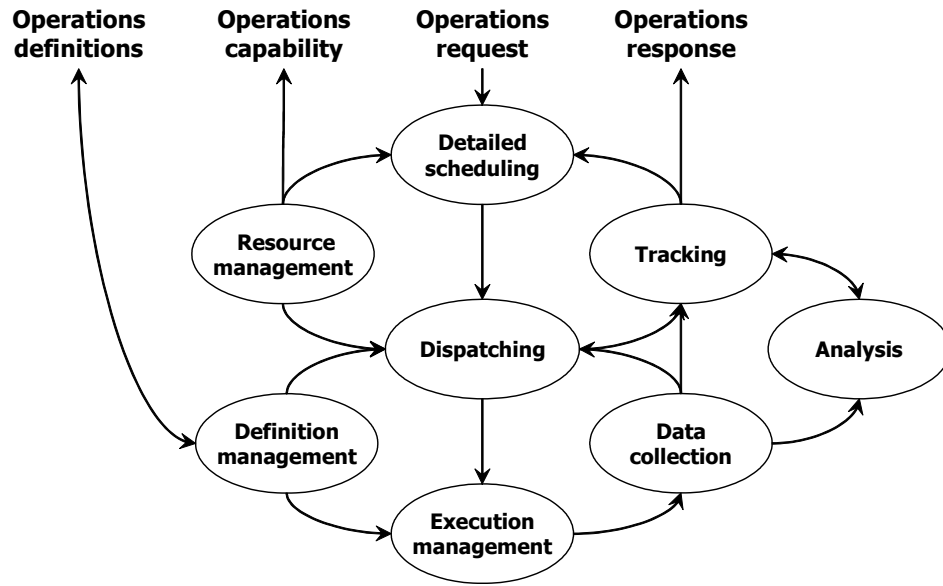


Figure 6 - Generic activity model of manufacturing operations management

Not all information flows are depicted in Figure 6. In any specific implementation, information from any activity may be required by any other activity. Where the model is expanded for specific activities, the lines indicating information flows are not intended to be exclusive lists of information exchanged.

5.2 Interaction among generic activity models

5.2.1 Information flows between generic activity models

In addition to the information flows within the activities of specific operations categories, there are also information flows between the different categories. Some of this information is defined in following clauses, but not all information flows are explicitly defined in this standard.

NOTE — Specific implementations of activity models may give prominence to one specific activity model over others.

EXAMPLE 1:

In pharmaceutical industries, quality operations may provide the direction for other operations.

EXAMPLE 2:

In distribution centers, inventory operations may provide the direction for other operations.

EXAMPLE 3:

In consumer packaged goods, production operations may provide the direction for other operations.

EXAMPLE 4:

In refining, inventory operations may provide the direction for production operations.

5.2.2 Handling Resources within the Generic Activity Models

Information about resources (materials, personnel, and equipment) can be handled within any one of the four activity models of manufacturing operations (production, quality, maintenance, and inventory) presented in this standard.

Although data for different resources may be found in different models, there are primary reporting paths through which information should be obtained:

- a) Personnel information specific to each activity model may be obtained from the specific activity model.
- b) Equipment information specific to each activity model may be obtained from the specific activity model.
- c) Material information specific to each activity model may be obtained from the specific activity model. However, material inventory information, including finished goods, and raw materials may be obtained from the inventory activity model. Material movement operations may be managed by activities in the production, quality, maintenance, or inventory activity models. A specific material movement instance only exists within one activity model at any given point in time.

5.3 Expanded equipment hierarchy model

5.3.1 Equipment hierarchy model

The equipment hierarchy model, defined in Part 1, is extended in this Part 3 standard to the model shown in Figure 7. Additional items are included for inventory operations management and management of material. Lower-level groupings are combined to form higher levels in the hierarchy. In some cases, a grouping within one level may be incorporated into another grouping at that same level as a recursive structure. The models may be collapsed or expanded as required for specific applications.

NOTE — 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:

Collapsing — Elements in the models may be omitted as long as the models remain consistent, and the functions of the element removed are taken into account.

Expanding — Elements may be added to the models. When they are added between related elements, the integrity of the original relationship should be maintained.

There is at least one site within the enterprise, at least one work center in an area (or site if the area is collapsed out) and at least one work unit within a work center.

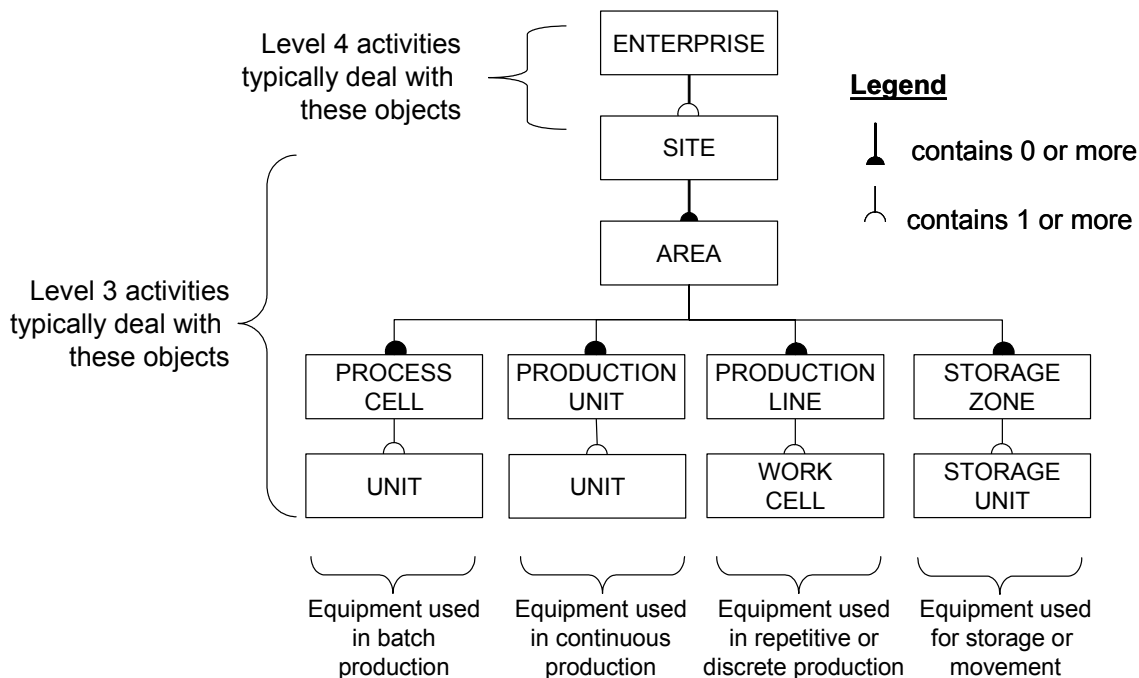


Figure 7 – Typical expanded equipment hierarchy

Storage zones and storage units have been added as elements under an area. These are the lower-level elements used in material storage.

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.

5.3.2 Storage zone

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.

5.3.3 Storage unit

Storage units are typically of interest to business systems only when business functions maintain inventory to 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.

...

5.3.4 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
Silo Farm	Silo, Pipe Section
Ship Terminal	Ship, Ship's Hold, Container, Barrel, Tank
Rail Yard	Railcar
Holding Area	Pallet, Barrel

NOTE — Some storage zones and storage units could also be identified as equipment used in a transport request.

5.3.5 Work center

A work center may be defined as any element of the equipment hierarchy under an area. Work centers may be used when the specific type of the equipment element is not significant for the purpose of the discussion. A work center may be a process cell, production unit, production line, storage zone, or any other equipment element subordinate to an area that may be defined by the user in an extension to the equipment hierarchy model. See Figure 8.

5.3.6 Work unit

A work unit may be defined as any element of the equipment hierarchy under a work center. Work units are typically the most elemental schedulable item by Level 3 functions. See Figure 8.



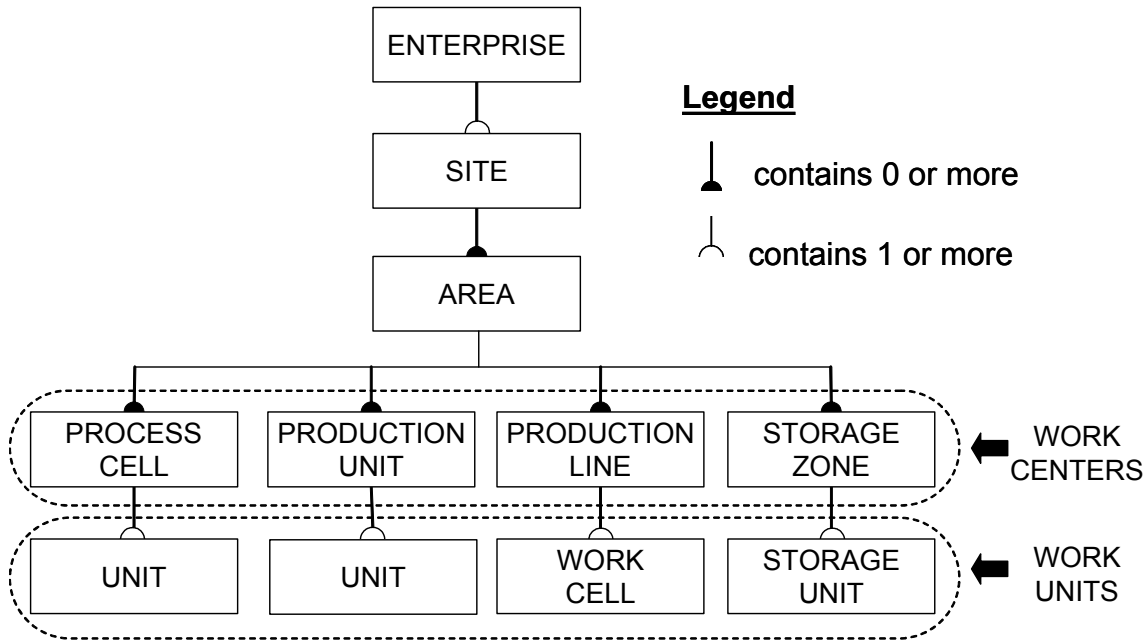


Figure 8 - Work centers and work units

Work centers are typically the grouping of equipment scheduled by the Level 4 or Level 3 functions for continuous, batch, and discrete manufacturing. 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.

6 Production operations management

6.1 General activities in production operations management

Production operations management shall be defined as the collection of activities that coordinate, direct, manage and track the functions that use raw materials, energy, equipment, personnel, and information to produce products, with the required costs, qualities, quantities, safety, and timeliness. The general activities in production operations management are listed in the Part 1 standard and include:

- Reporting on production including variable manufacturing costs.
- Collecting and maintaining data on production, inventory, manpower, raw materials, spare parts, and energy usage.
- Performing data collection and off-line analysis as required by engineering functions. This may include statistical quality analysis and related control functions.
- 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.
- Establishing the immediate detailed production schedule for its own area accounting for maintenance, transportation, and other production-related requests.
- Locally optimizing the costs for individual production areas while carrying out the production schedule established by the Level 4 functions.
- Modifying production schedules to compensate for plant production interruptions that may occur in its area of responsibility.

6.2 Production operations management activity model

The production operations management model illustrated by the shaded area in Figure 1 is expanded to a more detailed activity model of production operations, shown in Figure 9. The four elements of information (product definition, production capability, production schedule, and production performance) correspond to the exchanged information defined in Part 1, and illustrated in Figure 4 of this standard. The oval labeled Production Level 1-2 functions represent the Level 1 and 2 sensing and control functions. The other ovals (with solid outlines) represent the activities of production operations.

The activities defined here are not intended to imply an organizational structure of systems, software, or personnel. The model is provided to help in the identification of activities that may be performed and in the identification of roles associated with the activities. It defines what is done, not how it should be organized. Different organizations may have a different arrangement of roles and assignment of roles to personnel or systems.

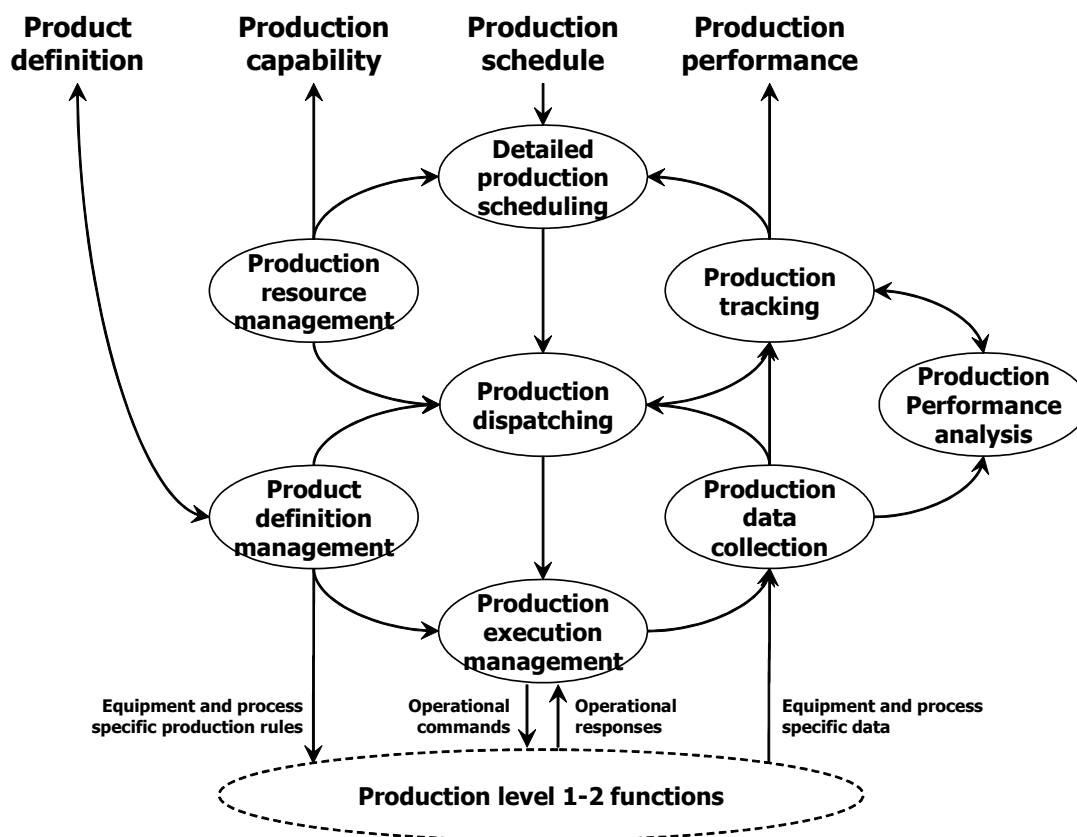


Figure 9 - Activity model of production operations management

Not all production requests and production responses cross the boundary to business systems. While production operations may be driven by production schedules there can be production requests and production responses used internally within manufacturing operations management to handle situations such as rework, local intermediates, or consumable production.

Not all information flows within production operations management are depicted in Figure 9. In any specific implementation, information from any activity may be required by any other activity. Where activities in the production operations management model are defined in detail in this clause, some additional information flows are identified. Not all data sources and data sinks are identified in the detailed models.

6.3 Information exchange in production operations management

6.3.1 Equipment and process specific production rules

Equipment and process specific production rules shall be defined as the specific instructions sent to Level 2 based on the specific assigned tasks.

EXAMPLE:

Programs for CNC machines for a specific product type, PLC programs that change based on the process under control, or unit recipes where these are executed in Level 2 or Level 1 equipment.

NOTE — See IEC 61131-3, "Programmable controllers - Part 3: Programming languages," for examples of this type of data.

6.3.2 Operational commands

Operational commands shall be defined as the request information sent to Level 2. These are typically commands to start or complete elements of a work order. This information may also be SOPs displayed or given to operators, such as procedures for setting up machines or cleaning of machines.

NOTE — This information exchange corresponds to the recipe-equipment interface defined in IEC 61512-1 (see Clause 2).

6.3.3 Operational responses

Operational responses shall be defined as information received from Level 2 in response to commands. These typically correspond to the completion or status of elements of work orders.

NOTE — This information exchange corresponds to the recipe-equipment interface defined in IEC 61512-1 (see Clause 2).

6.3.4 Equipment and process specific data

Equipment and process specific data shall be defined as information received as a result of monitoring Level 2. This is typically information about the process being performed and the resources involved.

6.4 Product definition management

6.4.1 Activity definition

Product definition management shall be defined as the collection of activities that manage all of the Level 3 information about the product required for manufacturing, including the product production rules.

Product definition information is shared between product production rules, bill of material, and bill of resources. The product production rules contain the information used to instruct a manufacturing operation how to produce a product. This may be called a general, site, or master recipe (IEC 61512-1 and ANSI/ISA-88.01-1995 definition), standard operating procedure (SOP), standard operating conditions (SOC), routing, or assembly steps based on the production strategy used. The product definition information is made available to other Level 3 functions and to Level 2 functions as required.

Product definition management includes management of the distribution of product production rules. Some of the product production rules may exist in Level 2 and Level 1 equipment. When that is the case, downloads of this information shall be coordinated with other manufacturing operations management functions to avoid affecting production. This information may be included as part of operational commands when the download is part of a production execution management activity.

6.4.2 Activity model

Figure 10 illustrates some of the interfaces to product definition management.

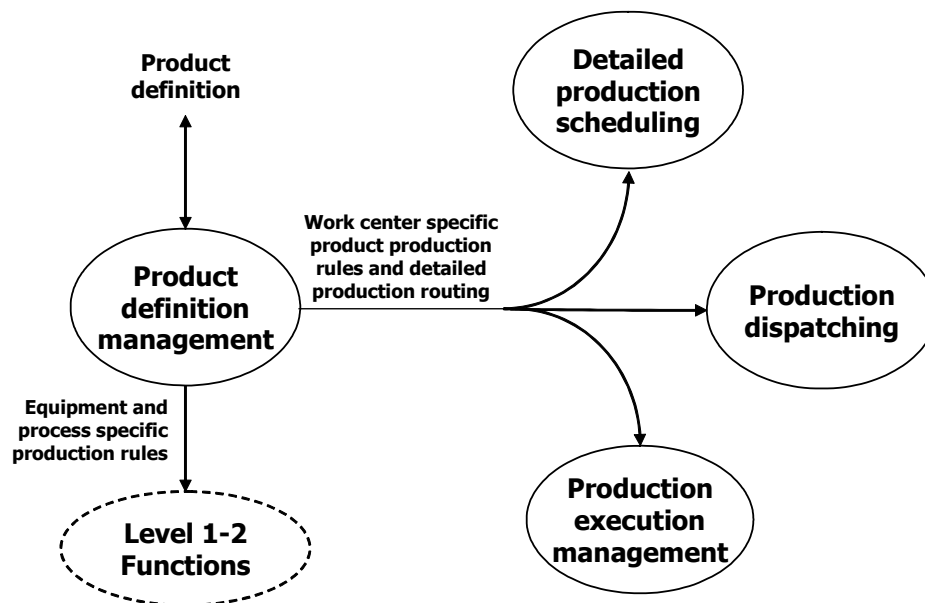


Figure 10 - Product definition management activity model interfaces

6.4.3 Tasks in product definition management

Product definition management tasks may include:

- a) Managing documents such as manufacturing instructions, recipes, product structure diagrams, manufacturing bills, and product variant definitions.
- b) Managing new product definitions.
- c) Managing changes to product definitions. This may include the ability to route designs and manufacturing bill changes through an appropriate approval process, management of versions, tracking of modifications, and security control of the information.
- d) Providing product production rules to personnel or other activities.

EXAMPLE:

These may take the form of manufacturing steps, master recipes, machine setup rules, and process flowsheets.

- e) Maintaining the feasible detailed production routings for products.
- f) Providing the product segment route to manufacturing operations in the level of detail required by manufacturing operations.
- g) Managing the exchange of product definition information with Level 4 functions at the level of detail required by the business operations.
- h) Optimizing product production rules based on process analysis and production performance analysis.
- i) Generating and maintaining local production rule sets indirectly related to products, such as for cleaning, startup, and shutdown.
- j) Managing the Key Performance Indicator (KPI) definitions associated with products and production.

NOTE — There are a number of tools to assist in the product definition management activity, including mechanical and electronic computer-aided design (CAD), Computer-Aided Engineering (CAE), and Computer-Aided Software Engineering (CASE), recipe management systems, Computer-Aided Process Engineering (CAPE), and Electronic Work Instructions (EWIs).