INTERNATIONAL STANDARD

ISO 22400-2

First edition
2014-01-15

Automation systems and integration — Key performance indicators (KPIs) for manufacturing operations management —

Part 2:
Definitions and descriptions

iTeh STANDARD PREVIEW

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Systèmes d'automatisation et intégration — Indicateurs de la performance clé pour le management des opérations de fabrication —

Partie 2: Définitions et descriptions

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 5, *Interoperability, integration and architectures of automation systems and applications*.

ISO 22400 consists of the following parts, under the general title *Automation systems and integration — Key performance indicators (KPIs) for manufacturing operations management*

— *Part 1: Overview, concepts and terminology*

— *Part 2: Definitions and descriptions*

The following parts are under preparation:

— *Part 3: Exchange and use*

— *Part 4: Relationships and dependencies*

Introduction

This part of ISO 22400 focuses on key performance indicators (KPIs) for manufacturing operations management.

KPIs are defined as quantifiable and strategic measurements that reflect an enterprise's critical success factors. KPIs are very important for understanding and improving manufacturing performance, both from the lean manufacturing perspective of eliminating waste and from the corporate perspective of achieving strategic goals.

Manufacturing operations management (MOM) is a term used in IEC 62264 to specify a portion of the functional hierarchy model of a manufacturing enterprise. Figure 1 depicts the different levels of the functional hierarchy model: business planning and logistics (Level 4), manufacturing operations and control (Level 3), and batch, continuous, or discrete control (Level 1-2). The levels provide different functions and work in different timeframes.
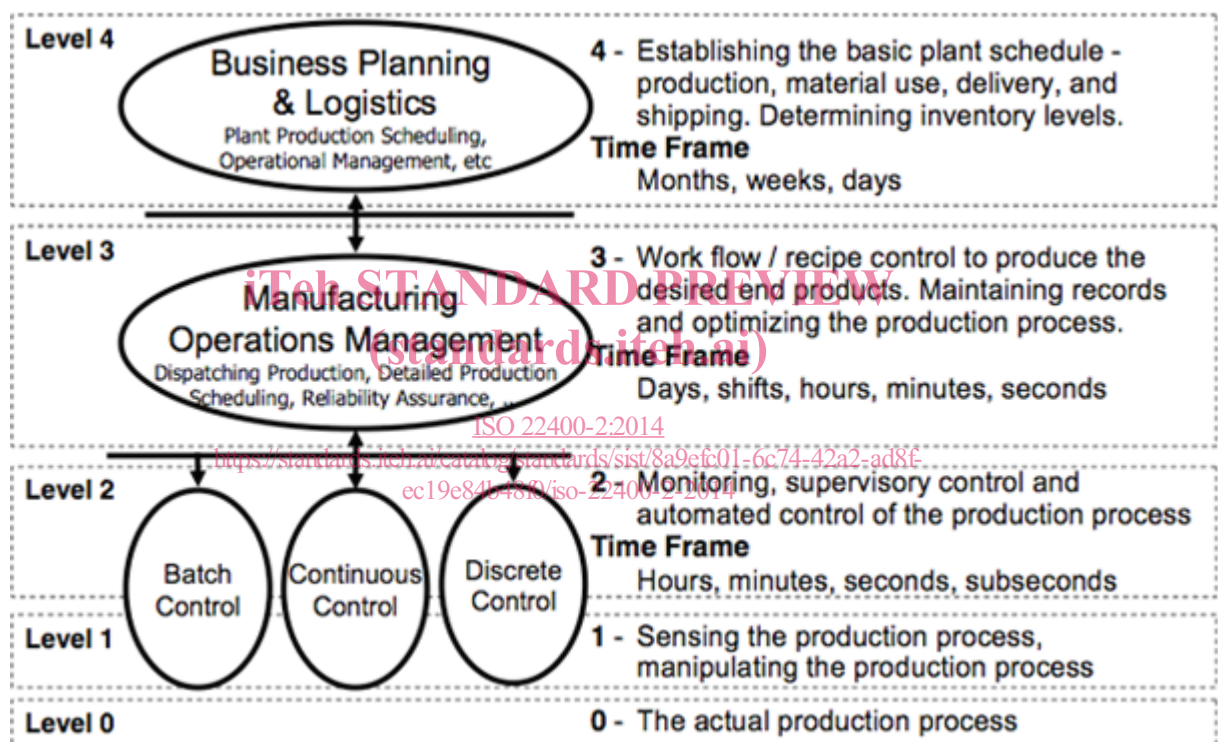
NOTE   Adapted from IEC 62264-3.

Figure 1 — Functional hierarchy

IEC 62264 also specifies a hierarchical structure for the physical equipment (see Figure 2). Enterprise, site and areas are generic terms, whereas there are specific terms for work centres and work units that apply to batch production, continuous production, discrete or repetitive production, and for storage and movement of materials and equipment.
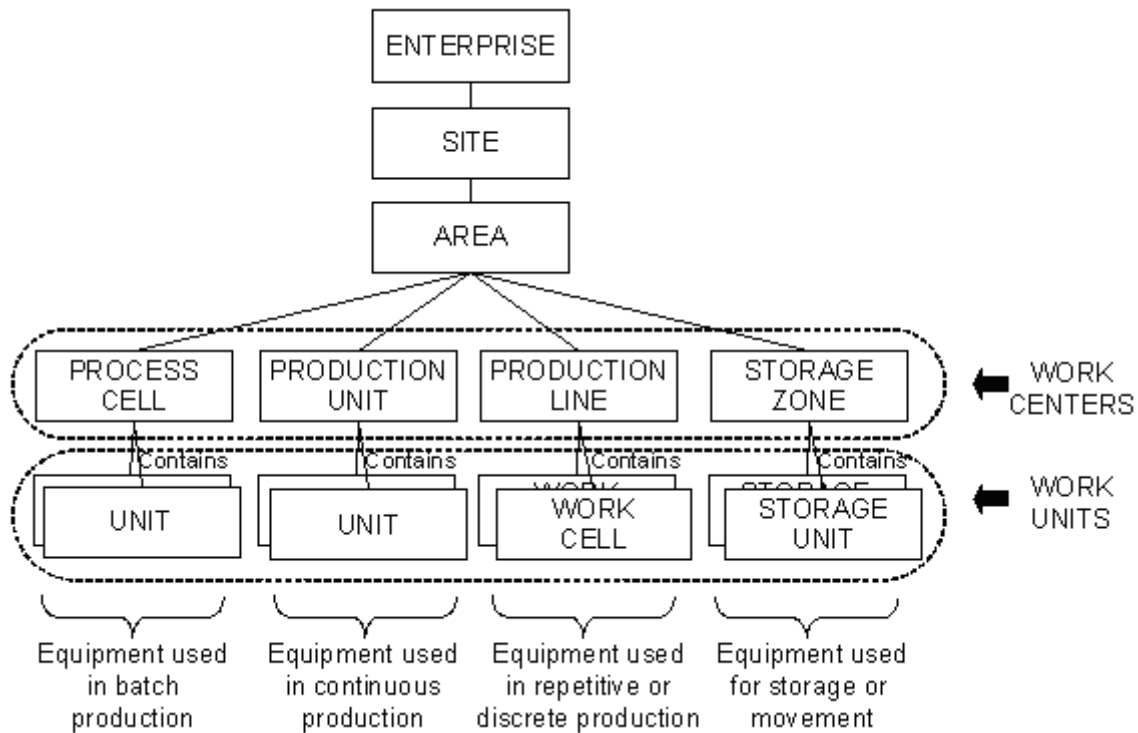
NOTE   Adapted from IEC 62264-3.

Figure 2 — Role based equipment hierarchy

This part of ISO 22400 specifies the KPIs "residing" at Level 3, i.e. related to MOM. These KPIs are generated/calculated within Level 3. Some of these KPIs are forwarded to Level 4 for further usage. In order to generate these KPIs, parameters from Levels 2 and 1 might be needed.

The KPIs in this part of ISO 22400 use the most generic terms possible (e.g. work centres and work units), instead of industry specific terms.

MOM, sometimes referred to as manufacturing execution systems (MES), models four major categories of operations management:

— production operations management;

— maintenance operations management;

— quality operations management;

— inventory operations management.

An activity model further details each category. Each activity model includes eight activities:

— detailed scheduling;

— dispatching;

— execution management;

— resource management;

— definition management;

— tracking;

— data collection;

— analysis.

These activities apply to production operations, quality operations, inventory operations and maintenance operations.

Analysis is the performance of calculating KPIs using information from other activities. Workflows can be used to illustrate the important events and steps needed in the calculation process for KPIs.

KPIs alone are not sufficient factors to perform the necessary management and execution operations for an enterprise. For many of the indicators, a company specific threshold is defined. When the value of the indicator exceeds or falls below the threshold, actions are initiated (e.g. to improve efficiency or quality). Often it is necessary to define warning and action limits. Warning limits help to detect the trends in process and equipment changes before company-specific thresholds are violated.

To improve the productivity of the manufacturing resources, information provided by industrial automation systems and control devices about process, equipment, operator, and material can be useful for providing critical feedback through KPIs.

A standardized schema for the expression of these KPIs is intended to:

a) facilitate the specification and procurement of integrated systems, in particular, the interoperability requirements among MES applications;

b) provide a means to categorize productivity tools that can be used across applications.

ISO 22400 provides an overview of the concepts, the terminology and the methods to describe and to exchange KPIs for the purpose of managing manufacturing operations. The audience is factory managers responsible for production performance, software suppliers developing KPIs for factory management, engineers engaged in process planning of products, planners and designers of manufacturing systems, and equipment and device suppliers.

KPIs also reside at Level 4, i.e. KPIs related to business planning and logistics, which are outside the scope of this part of ISO 22400. Level 4 KPIs are often related to economic, business, logistic and financial factors. These KPIs are used to assess the progress or extent of compliance with regard to important objectives or critical success factors within a company. Economic KPIs serve as a basis for decisions (problem identification, presentation, information extraction), for economic control (target/actual comparison), for financial documentation and for coordination (behaviour management) of important facts and relationships within the company.

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Automation systems and integration — Key performance indicators (KPIs) for manufacturing operations management —

Part 2:
Definitions and descriptions

1   Scope

ISO 22400 specifies key performance indicators (KPIs) used in manufacturing operations management (MOM).

This part of ISO 22400 specifies a selected number of KPIs in current practice. The KPIs are presented by means of their formula and corresponding elements, their time behaviour, their unit/dimension and other characteristics. This part of ISO 22400 also indicates the user group where the KPIs are used, and the production methodology to which they correspond.

With reference to equipment, the KPIs in this part of ISO 22400 relate to work units, as specified in IEC 62264.

2   Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1
reference time
base timeline used for time models, corresponding to the planned maximum time interval available for production and maintenance tasks

EXAMPLE   A calendar day with 24 hours; a week.

2.2
planned time
planned duration of a specific time period

EXAMPLE   The intended duration of an operation or a resource state according to the planning.

2.3
actual time
realized duration of a specific time period

EXAMPLE   The actual duration of an operation or a resource state.

Note 1 to entry: Actual time may be less than, equal to, or greater than corresponding planned time.

2.4
time model
partition of the reference time

3   Symbols and abbreviated terms

ADET   actual unit delay time

ADOT	actual unit downtime
AOET	actual order execution time
APAT	actual personnel attendance time
APT	actual production time
APWT	actual personnel work time
AQT	actual queuing time
AUST	actual unit setup time
ATT	actual transport time
AUBT	actual unit busy time
AUPT	actual unit processing time
CI	consumables inventory
C_m	machine capability index
CM	consumed material
C_{mk}	critical machine capability index
CMT	corrective maintenance time
C_p	process capability index
C_{pk}	critical process capability index
EPC	equipment production capacity
FE	failure event
FGI	finished goods inventory
GP	good part
GQ	good quantity
IGQ	integrated good quantity
IP	inspected part
LSL	lower specification limit
LT	loading time
MOM	manufacturing operations management
NEE	net overall equipment effectiveness index
NOT	net operating time
OC	operation cluster
OEE	overall equipment effectiveness
OL	other loss

OPT	operating time
PBT	planned busy time
PL	production loss
PMT	preventive maintenance time
PO	production order
POET	planned order execution time
POQ	planned order quantity
POS	production order sequence
POT	planned operation time
PQ	produced quantity
PRI	planned run time per item
PSQ	planned scrap quantity
PUST	planned unit setup time
RMI	raw material inventory
RQ	rework quantity
σ	standard deviation
SQ	scrap quantity
STL	storage and transportation loss
TBF	operating time between failure
TTF	time to failure
TTR	time to repair
USL	upper specification limit
WG	working group
WIP	work in process inventory
WOP	work process
WP	work place
$\bar{x}$	arithmetic average
$\bar{\bar{x}}$	average of average values
$\hat{\sigma}$	estimated deviation
σ^2	variance

4   Structure of KPI description

KPI specifications are expressed using the structure in Table 1 and are in accordance with ISO 22400-1. The structure in Table 1 identifies KPI descriptive elements in the left column and gives a description of each element in the right column.

Table 1 — Structure of KPI description

KPI description	
Content:	
Name	Name of the KPI
ID	A user defined unique identification of the KPI in the user environment
Description	A brief description of the KPI
Scope	Identification of the element that the KPI is relevant for, which can be a work unit, work centre or production order, product or personnel
Formula	The mathematical formula of the KPI specified in terms of elements
Unit of measure	The basic unit or dimension in which the KPI is expressed
Range	Specifies the upper and lower logical limits of the KPI
Trend	Is the information about the improvement direction, higher is better or lower is better
Context:	
Timing	A KPI can be calculated either in • real-time - after each new data acquisition event • on demand - after a specific data selection request • periodically - done at a certain interval, e.g. once per day
Audience	Audience is the user group typically using this KPI. The user groups used in this part of ISO 22400 are • Operators – personnel responsible for the direct operation of the equipment • Supervisors – personnel responsible for directing the activities of the operators • Management – personnel responsible for the overall execution of production
Production methodology	Specifies the production methodology that the KPI is generally applicable for • Discrete • Batch • Continuous
Effect model diagram	The effect model diagram is a graphical representation of the dependencies of the KPI elements that can be used to drill down and understand the source of the element values. NOTE This is a quick analysis which supports rapid efficiency improvement by corrective actions, and thus reduces errors
Notes	Can contain additional information related to the KPI. Typical examples are • Constraints • Usage • Other information

5   Elements used in KPI description

5.1   Time elements

5.1.1   Notations

In the time model of this part of ISO 22400, in order to process and complete a production order, one or more tasks are performed using a set of production resources, e.g. production personnel, equipment and materials.

NOTE 1   Since many continuous operations (e.g. refineries and other petrochemical facilities) define "throughput" using an arbitrary time period (e.g. a day or a shift), rather than a production order based time interval, KPIs derived using this production order time model need to be adjusted for those industries.

NOTE 2   The identifying element name abbreviations indicated in round brackets in this clause are used in KPI calculations in Clause 6.

NOTE 3   Definitions of maintenance elements have been taken from IEC 60050-191.

NOTE 4   The term "time" in the element specifications refers to a duration of time.

5.1.2   Planned times

5.1.2.1   Planned order execution time (POET)

The planned order execution time shall be the planned time for executing an order.

NOTE   It is often calculated from the planned run time per item multiplied by the order quantity plus the planned setup time.

5.1.2.2   Planned operation time (POT)

The planned operation time shall be the planned time in which a work unit can be used. The operation time is a scheduled time.

5.1.2.3   Planned unit setup time (PUST)

The planned unit setup time shall be the planned time for the setup of a work unit for an order.

5.1.2.4   Planned busy time (PBT)

The planned busy time shall be the planned operation time minus the planned downtime.

NOTE   The planned down time can be used for planned maintenance work. The planned busy period is available for the detailed planning of the work unit for expected production orders.

5.1.2.5   Planned run time per item (PRI)

The planned run time per item shall be the planned time for producing one quantity unit.

5.1.3   Actual times

5.1.3.1   Actual personnel work time (APWT)

The actual personnel work time shall be the time that a worker needs for the execution of a production order.

5.1.3.2   Actual unit processing time (AUPT)

The actual unit processing time shall be the time needed for setup and for the production.

5.1.3.3   Actual unit busy time (AUBT)

The actual unit busy time shall be the actual time that a work unit is used for the execution of a production order.

5.1.3.4   Actual order execution time (AOET)

The actual order execution time shall be the time difference between start time and end time of a production order. It includes the actual busy time, the actual transport and the actual queuing time.

5.1.3.5   Actual personnel attendance time (APAT)

The actual personnel attendance time shall be the actual time that a worker is available to work on production orders. It does not include actual time for company authorized break periods (e.g. lunch). It shall be the difference between login and logout excluding breaks.

5.1.3.6   Actual production time (APT)

The actual production time shall be the actual time during which a work unit is producing. It includes only the value-adding functions.

5.1.3.7   Actual queuing time (AQT)

The actual queuing time shall be the actual time in which the material is either in transport or progressing through a manufacturing process, i.e. the material is waiting for the process to begin.

5.1.3.8   Actual unit down time (ADOT)

The actual unit down time shall be the actual time when the work unit is not executing order production although it is available.

5.1.3.9   Actual unit delay time (ADET)

The actual unit delay time shall be the actual time associated with malfunction-caused interruptions, minor stoppages, and other unplanned time intervals that occur while tasks are being completed that lead to unwanted extension of the order processing time.

5.1.3.10   Actual unit setup time (AUST)

The actual unit setup time shall be the time consumed for the preparation of an order at a work unit.

5.1.3.11   Actual transport time (ATT)

The actual transport time shall be the actual time required for transport between work units.

5.1.3.12   Actual unit processing time (AUPT)

The actual unit processing time shall be the actual production time plus the actual unit setup time.

5.1.3.13   Actual unit busy time (AUBT)

The actual unit busy time shall be the actual unit processing time plus the actual unit delay time.

5.1.3.14 Actual order execution time (AOET)

The actual order execution time shall be the time from the start of the order until the time of the completion of the order.

5.1.4 Maintenance times

5.1.4.1 Time between failures (TBF)

The time between failures shall be the actual unit busy time (AUBT) between two consecutive failures of a work unit including setup time, production time and repair time related to the orders being processed and without delay times.

5.1.4.2 Time to repair (TTR)

The time to repair shall be the actual time during which a work unit is unavailable due to a failure.

5.1.4.3 Time to failure (TTF)

The time to failure shall be the time between failures minus the time to repair.

5.1.4.4 Failure event count (FE)

The failure event count shall be the count over a specified time interval of the terminations of the ability for a work unit to perform a required operation.

5.1.4.5 Corrective maintenance time (CMT)

The corrective maintenance time shall be that part of the maintenance time during which corrective maintenance is performed on a work unit, including technical delays and logistic delays inherent in corrective maintenance (see IEC 60050-191).

5.1.4.6 Preventive maintenance time (PMT)

The preventive maintenance time shall be that part of the maintenance time during which preventive maintenance is performed on a work unit, including technical delays and logistic delays inherent in preventive maintenance (see IEC 60050-191).

5.2 Time model for work units

This time model applies to time considerations for the use of work units. Figure 3 shows the relationship between specific periods. In Figure 3, the difference between time elements constitutes a loss of operation time.