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

Part 1:

**Overview, concepts and terminology**

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

ISO 22400-1:2014

*Partie 1: Aperçu, concepts et terminologie*

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# Contents

	Page
<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Terms and definitions</b> .....	<b>1</b>
<b>3 Abbreviated terms</b> .....	<b>3</b>
<b>4 Concept of KPIs</b> .....	<b>3</b>
4.1 General.....	3
4.2 Criteria for KPIs.....	3
4.3 Characterization of KPIs.....	4
4.4 Types of KPIs by unit of measure.....	6
4.5 Categories of KPIs by purpose.....	6
4.6 Generating KPIs from measurements.....	6
4.7 Identification and selection of KPIs.....	7
4.8 Structure of KPI.....	7
4.9 Presentation of KPI.....	7
<b>5 Definitions and descriptions</b> .....	<b>7</b>
5.1 General model.....	7
5.2 Table structure.....	8
5.3 Elements.....	8
5.4 Time models.....	8
5.5 Effect model diagrams.....	8
<b>6 Exchange and use</b> .....	<b>9</b>
6.1 General.....	9
6.2 Abstract structure for exchange purposes.....	9
<b>7 Relationships and dependencies</b> .....	<b>11</b>
7.1 General.....	11
7.2 Model of relationships and dependencies.....	12
7.3 Effectiveness of KPIs.....	12
7.4 Maturity model.....	13
<b>Annex A (informative) KPIs in the context of MOM</b> .....	<b>15</b>
<b>Bibliography</b> .....	<b>19</b>

## 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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

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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 planned:

- *Part 3: Exchange and use*
- *Part 4: Relationships and dependencies*

## Introduction

Using key performance indicators (KPIs) for manufacturing operations management (MOM) is motivated by the possibility to use them to improve the value creation processes of an enterprise.

Measuring performance enables an enterprise to quantify aspects of all its activities. ISO 22400 focuses on performance measures found to be particularly meaningful for the realization of operational performance improvement. These performance measures can be achieved through combining various measurements from operations and forming what are called KPIs. The monitoring of performance is specific to identified objectives of the enterprise, and KPIs are most useful when their values can be used to identify trends relative to certain operational objectives.

Within an enterprise, the various operational areas, such as sales, manufacturing, engineering, marketing, and other business support functions, have different sets of performance indicators. These various performance indicators are used together to monitor the realization of enterprise business objectives.

An International Standard for KPIs is beneficial for comparing enterprise operations over extended periods of time and for comparing similar operations of enterprises within an industry.

The management of manufacturing operations is normally associated with an intermediate level within the functional hierarchy of a manufacturing enterprise. In IEC 62264-1, the MOM domain is the intermediate domain between the enterprise domain (Level 4) and the control domain (Levels 1 and 2).

The KPIs defined in this part of ISO 22400 are intended to be calculated using data from the control domain, and to provide both the enterprise domain and the MOM domain with decision support information to manage the enterprise.

This part of ISO 22400 presents an overview, concepts and terminology for KPIs. ISO 22400-2 covers guidelines for computing and for measuring the components of a KPI. Future parts of ISO 22400 will cover definitions for the content and context of the exchange and the use of KPIs, and specifications of relationships, dependencies among KPIs, and the maturity of the collection and use of KPIs.

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

## Part 1: Overview, concepts and terminology

### 1 Scope

ISO 22400 specifies an industry-neutral framework for defining, composing, exchanging, and using key performance indicators (KPIs) for manufacturing operations management (MOM), as defined in IEC 62264-1, for batch, continuous and discrete industries.

This part of ISO 22400

- provides an overview of a KPI;
- presents concepts of relevance for working with KPIs, including criteria for constructing KPIs;
- specifies terminology related to KPIs;
- describes how a KPI can be used.

### 2 Terms and definitions

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

#### 2.1.1

##### **capability**

ability to perform actions

Note 1 to entry: The definition includes attributes on qualifications and measures of the ability, as in the definition of capacity.

[SOURCE: IEC 62264-1:2013, 3.1.6, modified]

#### 2.1.2

##### **element**

relevant measurements for use in the formula of a *key performance indicator* (2.1.5)

#### 2.1.3

##### **integration**

state or condition wherein two or more entities are able to form, or be observed as, a single entity exhibiting a structure, a behaviour, and a boundary that are determined by the *interoperability* (2.1.4) properties of the forming entities, as needed to perform a common task

[SOURCE: ISO 18435-1:2009, 3.9, modified]

## ISO 22400-1:2014(E)

### 2.1.4

#### **interoperability**

*capability* (2.1.1) of two or more entities to exchange items in accordance with a set of rules and mechanisms implemented by an interface in each entity, in order to perform their respective tasks

Note 1 to entry: Examples of entities include devices, equipment, machines, people, *processes* (2.1.8), applications, software units, systems and enterprises.

Note 2 to entry: Examples of items include information, material, energy, control, assets and ideas.

[SOURCE: ISO 18435-1:2009, 3.12]

### 2.1.5

#### **key performance indicator**

##### **KPI**

quantifiable level of achieving a critical objective

Note 1 to entry: The KPIs are derived directly from, or through an aggregation function of, physical measurements, data and/or other KPIs.

### 2.1.6

#### **manufacturing operations management**

##### **MOM**

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

[SOURCE: IEC 62264-1: 2013, 3.1.22]

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### 2.1.7

#### **manufacturing resource**

physical or logical entity that enables a manufacturing *process* (2.1.8)

Note 1 to entry: Manufacturing resources include (but are not limited to) manufacturing assets such as equipment, machinery, software, automation units, control devices, instrumentation, tooling, and other resources, e.g. operators, materials, fuels and the physical plant wherein the resources are deployed.

[SOURCE: ISO 18435-1:2009, 3.17]

### 2.1.8

#### **process**

set of activities performed with a set of resources to realize an objective within a specified timeline

### 2.1.9

#### **(role-based) equipment hierarchy**

equipment model defined in terms of the Level 3 and 4 functions and activities that equipment entities can perform

Note 1 to entry: Adapted from IEC 62264-1:2013, 5.3.1, Note 1.



### 3 Abbreviated terms

ID	Identification
KPI	Key Performance Indicator
KPI-E	Key Performance Indicator Effectiveness
MOM	Manufacturing Operations Management
UML	Unified Modeling Language
URL	Uniform Resource Locator
XML	eXtensible Mark-up Language

## 4 Concept of KPIs

### 4.1 General

The motivation for using KPIs in the MOM domain starts with a description of the value creation processes (see [Clause A.2](#)). An enterprise is described by three hierarchical models:

- physical asset;
- functional;
- equipment.

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The functional and the equipment hierarchy models are of importance in ISO 22400. The KPIs in ISO 22400 are limited to the MOM domain (see [Clause A.4](#)). Selection of KPIs depends on the production methodology that is used by the enterprise (see [Clause A.5](#)). KPIs in the MOM domain identify and achieve improvement targets based on actionable information (see [Clauses A.6](#) and [A.7](#)).

### 4.2 Criteria for KPIs

A good KPI has certain criteria which ensure its usefulness in achieving various goals in the manufacturing operation. The criteria are listed below, along with the process for performing each individual measurement.

- a) Aligned: the KPI is aligned to the degree to which the KPI affects change in relevant higher-level KPIs, where alignment implies a high ratio of the percent improvement (assuming positive impact) in important higher-level metrics to the percent improvement in a KPI (or KPI set), given no other changes in the system.
- b) Balanced: the extent to which a KPI is balanced within its chosen set of KPIs.
- c) Standardized: the KPI is standardized to the extent to which a standard for the KPI exists and that standard is correct, complete, and unambiguous; the standard can be plant-wide, corporate-wide, or industry-wide.
- d) Valid: the KPI is valid to the extent of the syntactic (i.e. grammar) and semantic (i.e. meaning) compliance between the operational definition of the KPI and the standard definition. If no standard exists, then validity is zero.
- e) Quantifiable: the KPI is quantifiable to the extent to which the value of the KPI can be numerically specified; there is no penalty for the presence of uncertainty, as long as the uncertainty can also be quantified.

## ISO 22400-1:2014(E)

- f) Accurate: the KPI is accurate to the extent to which the measured value of the KPI is close to the true value, where a departure from the true value can be affected by poor data quality, poor accessibility to the measurement location, or the presence of substandard measurement devices and methods.
- g) Timely: the KPI is timely to the extent it is computed and accessible in real-time, where real-time depends on the operational context.
- h) Predictive: the KPI is predictive to extent to which a KPI is able to predict non-steady-state operations.
- i) Actionable: the KPI is actionable to the extent to which a team responsible for the KPI has the knowledge, ability, and authority to improve the actual value of the KPI within their own process.
- j) Trackable: the KPI is trackable to the extent to which the appropriate steps to take to fix a problem are known, documented, and accessible, where the particular problem is indicated by particular values or temporal trends of the KPI.
- k) Relevant: the KPI is relevant to the extent to which the KPI enables performance improvement in the target operation, demonstrates real-time performance, allows the accurate prediction of future events, and reveals a record of the past performance valuable for analysis and feedback control.
- l) Correct: the KPI is correct to the extent that, compared to the standard definition (if one exists), the calculation required to compute the value of the KPI compared to the standard definition (if one exists) has no errors with respect to the standard definition.
- m) Complete: the KPI is complete to the extent that, compared to the standard definition (if one exists), the definition of the KPI, and the calculation required to compute the value of the KPI, covers all parts, and no more, of the standard definition.
- n) Unambiguous: the KPI is unambiguous to the extent that the syntax (i.e. grammar) and semantics (i.e. meaning) in the definition of the KPI lacks ambiguity or uncertainty.
- o) Automated: the KPI is automated to the extent that KPI collection, transfer, computation, implementation, and reporting are automated.
- p) Buy-in: the KPI has buy-in to the extent that the team responsible for the target operation, as well as teams responsible for both upper and lower level KPIs, are willing to support the use of the KPI and perform the tasks necessary to achieve target values for the KPI; includes difficulty of obtaining official approval by management for the KPI.
- q) Documented: the KPI is documented to the extent that the documented instructions for implementation of a KPI are up-to-date, correct, complete, and unambiguous, including instructions on how to compute the KPI, what measurements are necessary for its computation, and what actions to take for different KPI values.
- r) Comparable: the KPI is comparable to the extent that means are defined to reference supporting measurements over a period of time, and a normalizing factor to express the indicator in absolute terms with appropriate units of measure.
- s) Understandable: the KPI is understandable to the extent that the meaning of the KPI is comprehended by team members, management, and customers, particularly with respect to corporate goals.
- t) Inexpensive: the KPI is inexpensive to the extent that the cost of measuring, computing, and reporting the KPI is low.

### 4.3 Characterization of KPIs

#### 4.3.1 General

A KPI is characterized by information regarding its content and context:

- a) content information: a quantifiable element with a specific unit of measure;

- b) context information: a verifiable list of conditions that are met.

The factors that determine the value of a KPI are assumed to be accessible to change using a particular action plan. The action plan describes the activities that will lead to achieving the objective of the operation, the resources and actors required for performing the activities, and the timeframe for completing these activities.

#### 4.3.2 Content information

When a definition of a KPI is given, it should contain information about its content:

- a) name: name of KPI, e.g. availability, worker effectiveness;
- b) ID: a user-defined unique identification of the KPI in the user's environment;
- c) description: a description of the KPI;
- d) scope: identification of the element for which the KPI is relevant, e.g. a work unit, work centre, work order, product, or personnel (see IEC 62264-3);
- e) formula: the mathematical formula of the KPI defined in terms of elements;
- f) unit of measure: the basic unit or dimension in which the KPI is expressed;
- g) range: the upper and lower logical limits of the KPI;
- h) trend: information about the improvement direction, i.e. higher-is-better or lower-is-better.

#### 4.3.3 Context information (standards.iteh.ai)

The specification of a KPI should contain information about its context, including timing, audience, production methodology, effect model diagram, and notes.

- a) The timing context information should specify the frequency of KPI calculation as following:
  - 1) real-time (as the process is occurring): after each new data acquisition event,
  - 2) periodically: done at a certain interval, e.g. one time per day, or
  - 3) on-demand: after a specific data selection request.
- b) Constraints: information about possible constraints on how the KPI can be used.
- c) Usage: information about how to use the KPI.
- d) The audience context information should specify the user group typically utilizing the KPI. The user-groups in ISO 22400 may include:
  - 1) operators: personnel responsible of direct operation of the equipment,
  - 2) supervisors: personnel responsible for directing the activities of the operators, and
  - 3) management: personnel responsible for the overall execution of production.
- e) The production methodology should identify the method of production for which the KPI is generally applicable: batch, continuous, and/or discrete.
- f) The effect model diagram information should specify the location of the diagram depicting the composition of the KPI from measurement sources. An effect model diagram is a graphical representation of the dependencies of the KPI elements that is useful for understanding the impact of the source values.