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

Part 1: Overview, concepts and terminology

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

Partie 1: Aperçu, concepts et terminologie

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Foreword

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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.

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]

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]

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.

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.

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

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.

g) The notes should specify additional information related to the KPI calculation or use. This information may include:

1) Constraints that apply to the KPI in certain situations that make the KPI valid or invalid,

2) Usage situations where the KPI is particularly useful for understanding performance improvement opportunities or needs, and

3) Other info that can be of relevance for the usage of the KPI, e.g. physical structure necessary, related operational categories, and improvement methods.

EXAMPLE 1 KPI constraints can be that a certain KPI only holds for production with a single path structure (see A.5.3), or a certain KPI is useful only if the personnel are permanent to a working unit (see Clause A.3).

EXAMPLE 2 Physical structure can be single path, multiple path, or network-based with single or multiple products (see A.5.3).

EXAMPLE 3 Related categories can be production operations, maintenance operations, inventory operations, or quality operations (see A.4.1).

EXAMPLE 4 Improvement methods can be lean, total quality management, world class manufacturing, Six Sigma, etc. (see Clause A.6).

4.4 Types of KPIs by unit of measure

The value of a KPI may be one of several types:

— ratio: a functional relation between two elements of the same unit-of-measure;

— utilization: a ratio with time as the unit of measure;

— efficiency: ratio of the effort expended to the effort available;

— effectiveness: ratio of a planned or expected value to an observed value;

— rate: functional relation between two elements of different unit of measures where the unit of measure of the denominator is time;

— capability index: measure of the fit of the capability (the characteristic of a resource) to the task assigned.

4.5 Categories of KPIs by purpose

The KPIs may be grouped in different ways, depending upon their purpose of use, as follows:

— cost, time, quality, flexibility and sustainability;

— lead and lag;

— quantitative and qualitative;

— maintenance, production, inventory and quality;

— resources (i.e. personnel, material or equipment);

— process, product and production.

4.6 Generating KPIs from measurements

4.6.1 Elements

The relevant measurements for a KPI shall be referred to as elements of the KPI formula.

4.6.2 Weighting

The elements occurring in the KPI formula may be weighted so that certain elements have a greater impact on the value of the KPI.

4.7 Identification and selection of KPIs

To identify KPIs, the following aspects of the target operation are assumed to be known:

— well-defined component processes of the target operation;

— required conditions to conduct the component processes;

— quantitative and qualitative measures of the outcomes and of the objectives;

— available courses of action for adjusting the processes and resources to achieve the operation's objectives.

KPIs are selected to focus on users' needs and expectations regarding the outcomes of the manufacturing operations, without restricting the means of meeting those needs and expectations. The intent of ISO 22400 is to allow the broadest possible use of the KPI definitions across a variety of industry sectors and regional markets.

The selection and use of KPIs within a manufacturing enterprise are illustrated by the following steps:

a) operations and elements of operations to be evaluated are identified;

b) objectives to be realized with use of performance indicators are determined;

c) operational actions when using performance indicators to realize expectations are described;

d) defining assessment criteria and associated measurements for performance indicators;

e) selecting KPIs;

f) assessing performance versus objectives with the KPIs obtained;

g) performing associated actions to meet objectives.

In some manufacturing enterprises, the KPIs have an owner, i.e. a person or a team responsible for achieving the desired result.

4.8 Structure of KPI

The structure of a KPI should represent the description and definition of a KPI. It could be given in a table format, exchange format, graphical format, etc.

4.9 Presentation of KPI

The presentation of a KPI (i.e. the value of the KPI and not the definition of it) can be made in various ways (e.g. a pie-chart).

5 Definitions and descriptions

5.1 General model

A KPI may be represented by its definition (i.e. composed of content and context information as described in 4.3.1, 4.3.2 and 4.3.3) and its description (further information is provided in ISO 22400-2). The definition part is compact (compare what may be found in a dictionary), whereas the description is an explanation of its meaning, structure and usage.

5.2 Table structure

The description of a KPI definition should be expressed using the table structure in Table 1.

Table 1 — Table structure of a KPI

KPI description	
Content:	
Name	
ID	
Description	
Scope	
Formula	
Unit of measure	
Range	
Trend	
Context:	
Timing	
Audience	
Production methodology	
Effect model diagram	
Notes	(including information on constraints, usage, etc.)

5.3 Elements

The relevant measurements for a KPI shall be referred to as elements of the KPI formula.

5.4 Time models

The elements and their relationship to each other and to other elements may be visualized in a graphic time model.

5.5 Effect model diagrams

Each definition and description of a may include an effect model. The effect model is a kind of root-cause diagram. The effect model is a depiction that highlights the relationship between the KPI value and its source measurements or elements. The depiction also may highlight the relationship between KPI's elements with other KPIs and other KPI elements.

The KPI can also be defined and described by an effect model. The effect model can be seen as a root-cause diagram. The effect model is a picture that highlights the relationship between the KPI and its elements. The effect models also highlight the relationship between these elements and other KPI elements.

The KPIs and the elements are visualized as rectangles. The relationships are shown as arrows. The arrows can be of different types, as shown in Table 2.

Table 2 — Effect model diagram key

Arrow	Definition
	results, through use of a formula, in a KPI
	includes (a 1:1 relationship)
	has (i.e. is booked or entered)
	consists of (a 1:*n* relationship)

6 Exchange and use

6.1 General

A KPI may be exchanged from one MOM application to another, i.e. exchange within Level 3 or from a MOM application to other enterprise applications in the enterprise domain, i.e. exchange between Level 3 and Level 4.

NOTE 1 The KPI transfer syntax is assumed to conform to the formal KPI templates and will be specified in ISO 22400-3[1)]. To realize the interoperability of applications, those applications need to have access to the formal KPI template.

NOTE 2 Detailed scenarios regarding exchanges of KPIs among applications residing in various domains will be described in in ISO 22400-3[2)].

6.2 Abstract structure for exchange purposes

For the purpose of exchanging KPIs, the KPI definition and description should be given in an abstract structure. In addition to the KPI definition and description, the KPI instance and KPI value could be given in abstract structures. The abstract structure could be in UML.

— KPI definition: This is the definition of a KPI, i.e. the table structure and its content. This should be used if the formula and correlated information should be exchanged between two applications.

— KPI instance: The KPI definition may be used for several instances, like work-units, persons, and several orders.

— KPI value: A KPI instance has one value which may vary over time. There can be many KPI values associated to one KPI instance, one for each point in time.

The KPI model is presented in Figure 1.

1) Under preparation.

2) Under preparation.

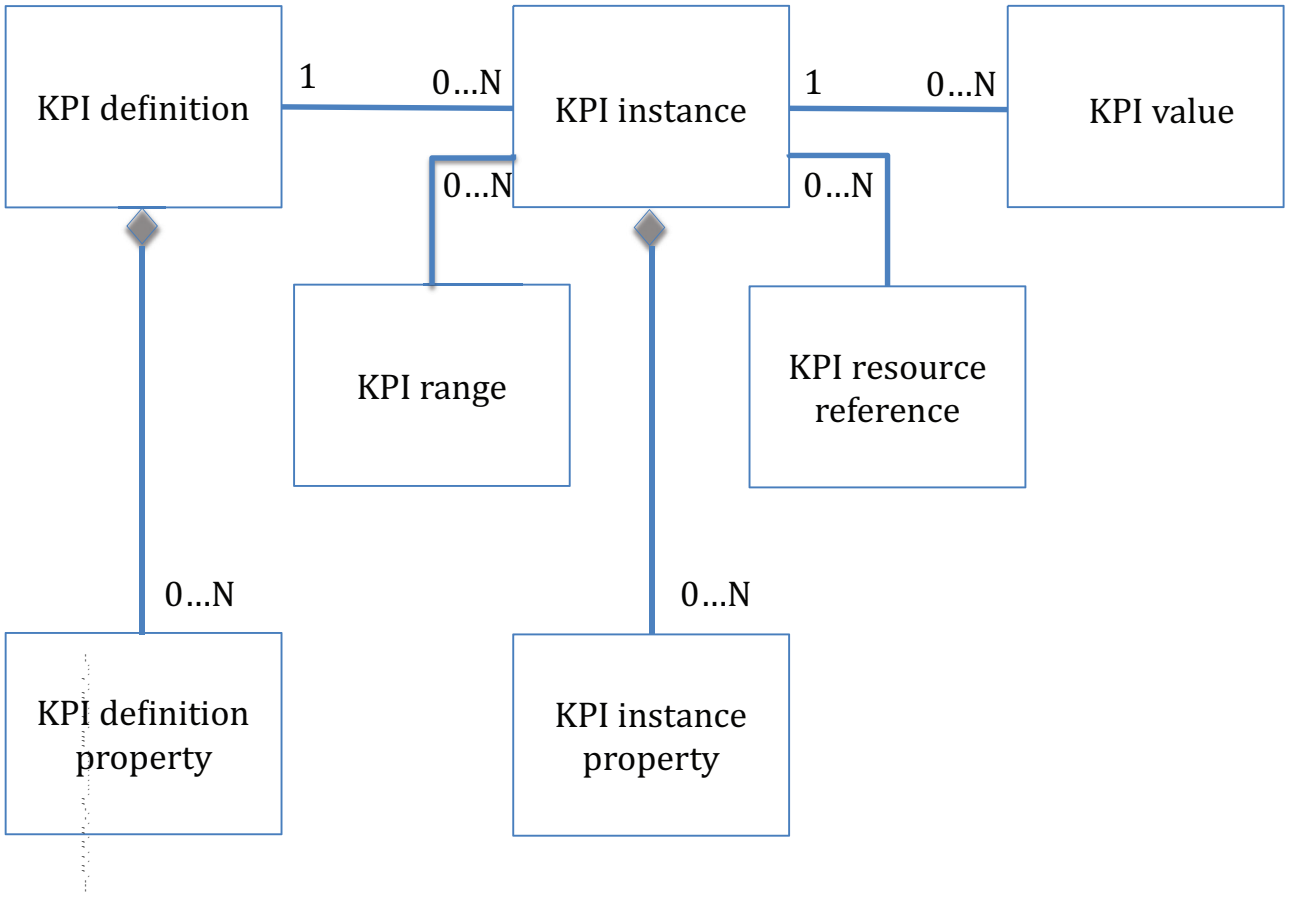

Figure 1 — KPI model (UML notation)

Each object in the KPI model has a set of associated attributes. The KPI definition property and the KPI instance property correspond to user-defined attributes. Each property has a set of associated attributes.

a) KPI definition attributes:

- name;
- ID;
- description;
- scope;
- formula;
- unit of measure;
- range;
- trend;
- timing;
- audience;
- production methodology;
- effect model;
- notes;

b) KPI definition property attributes:

- name;
- ID;
- value;
- description;
- unit of measure;

c) KPI instance attributes:

- name;
- ID;
- hierarchy scope;

d) KPI instance property attributes:

- name;
- ID;
- value;
- description;
- unit of measure;

e) range attributes:

- name;
- description;
- upper;
- lower;

f) KPI resource reference:

- ID;
- reference;

g) KPI value attributes:

- ID;
- time;
- value;
- unit of measure.

7 Relationships and dependencies

7.1 General

When performing the manufacturing operations, the evaluation of the results and the comparison of these results with the objectives of the business can be expressed in either technical or economic terms.

These evaluations are based on measurements about the products, processes, services and resources as they relate to the performance of the operations. The comparisons with business objectives depend on the measures and metrics being chosen alignment with the objectives and on those measures being used to identify actions at the MOM domain to meet the business objectives. To a certain extent, the alignment of the measures and metrics from the MOM domain with the business objectives reflects the quality of the enterprise integration.

— Relationships result from a change in one KPI affecting other KPIs.

— Dependencies result from a KPI used in the calculation of other KPIs.

NOTE ISO 22400-4[3)] will detail relationships and dependencies.

7.2 Model of relationships and dependencies

Models may be used to express the relationships and dependencies of a KPI, see Figure 2.

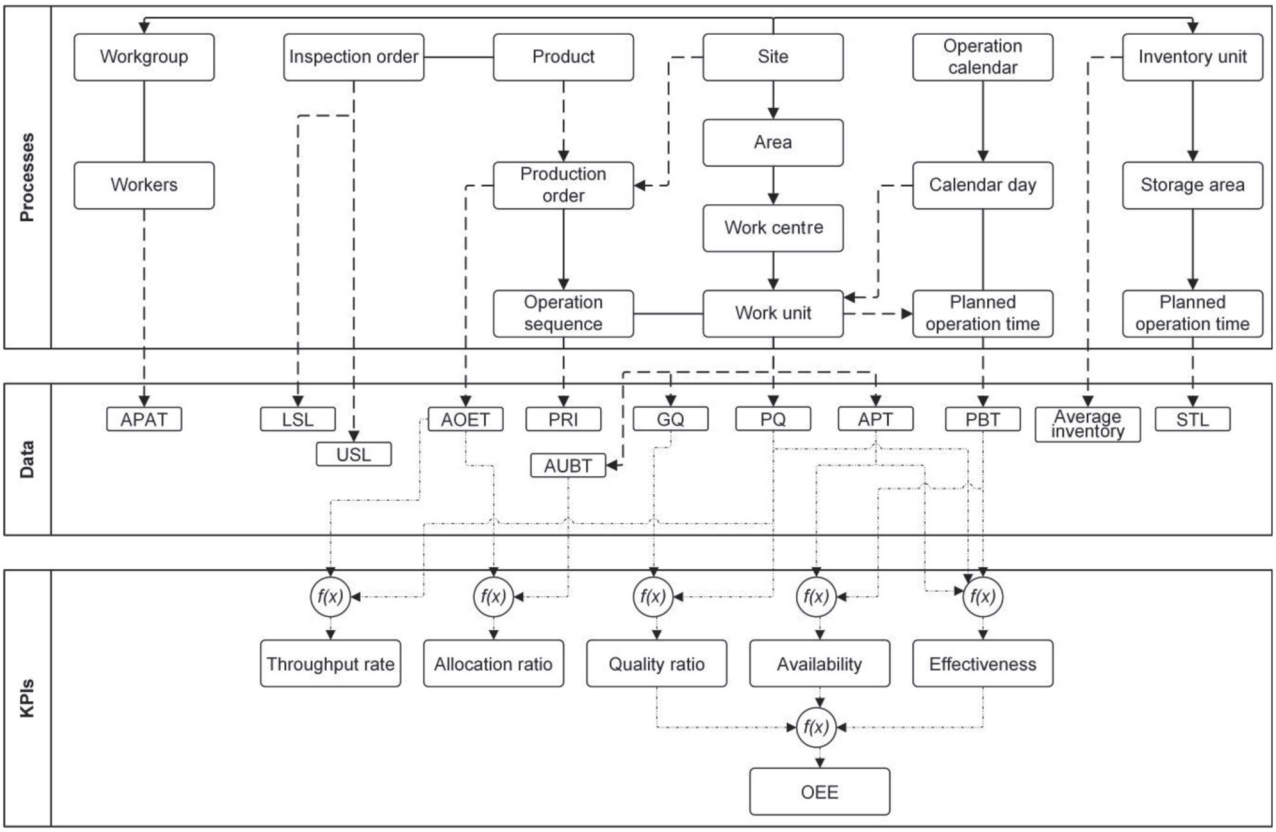

Figure 2 — Model presenting the relationship and dependencies of a KPI

NOTE 1 The abbreviations used in Figure 2 are defined in ISO 22400-2.

NOTE 2 ISO 22400-4[4)] will detail the model of relationships and dependencies for KPIs.

7.3 Effectiveness of KPIs

Effectiveness of KPIs means how well the KPI helps to create value.

3) Under preparation.

4) Under preparation.

At MOM domain, manufacturers are faced with choosing only a few KPIs from the many available. The few chosen should be the most effective possible in order to maximize efficient and effective production, as well as to achieve business objectives. Therefore, it is essential that manufacturers understand well the usefulness of the different KPIs. In order to compare the relative usefulness of individual KPIs, it is necessary to understand the effectiveness of each KPI. This understanding is currently accomplished implicitly by operators, supervisors, and managers in collaboration. However, what is described here is a formula to compute KPI effectiveness (KPI-E).

KPI-E is a measure of the usefulness of a single KPI for a particular operation. KPI-E can be computed by a normalized weighted average of the individual effectiveness scores, using the criteria listed in 4.2. KPI-E is calculated according to Formula (1):

$$\frac{\sum_{j=1}^{M} w_j E_{ij}}{\sum_{j=1}^{M} w_j} \tag{1}$$

where

E_{ij} is the i^{th} KPI's score in terms of the j^{th} criterion: the weights are expected to vary based on the particular KPI under consideration;

w_j is the relative importance (weight) of the j^{th} criterion to the operation;

M is the total number of criteria.

NOTE ISO 22400-4[5)] will detail KPI effectiveness.

7.4 Maturity model

The use of KPIs has become increasingly important for the success of manufacturers. Manufacturers are seeking guidance to improve their performance management. The aim is to assess effectiveness of their current performance measurement practices, to visualize the path to increased performance, and to benefit from benchmarking in their industry. An understanding of their current performance management maturity level will help to achieve this aim.

The maturity model can be used to realize these aims. The maturity model defines five levels of increasing maturity:

— innocence;

— awareness;

— understanding;

— competence;

— excellence.

The maturity model recognizes categories of MOM operations relevant to metrics maturity, such as production, inventory, quality, and maintenance. KPI relevant maturity characteristics for each category of MOM operations are then defined for each maturity level.

In order to achieve performance management success, the underlying performance management processes also have to be identified, implemented, and continuously improved. These performance management processes are KPI definition, KPI relevant data collection, KPI computation, KPI analysis, and KPI use. The management processes are viewed from the perspective of people, data collection

5) Under preparation.

and aggregation processes, and technology. KPI relevant maturity characteristics for underlying performance management processes are defined for each maturity level.

NOTE ISO 22400-4[6] will detail the maturity model.

6) Under preparation.

Annex A
(informative)

KPIs in the context of MOM

A.1 General

The motivation for using KPIs in the MOM context starts with a description of the value creation processes.

A.2 Value creation processes

The goal of a production-oriented enterprise is to give values (financial, social, ethical, environmental, etc.) to the stakeholders by satisfying some market demands, conducted in a smart, safe and sustainable manner. Managing a value creation processes implies completing the processes as planned and continuously improving the processes. An appropriate set of performance indicators is used to determine if the processes were completed as planned and the goals are realized as expected. Those performance measures found to be the most useful in monitoring and evaluating improvement or degradation of performance are called KPIs. Generally speaking, it is estimated that KPIs constitute approximately 20% of all performance measures that account for 80% of impacts from changes in operations.

A.3 Functional and equipment hierarchies

The functionalities of an enterprise are hierarchically structured in a functional model. The different levels in the functional hierarchy model are:

— business planning and logistics (Level 4);

— MOM (Level 3);

— batch, continuous or discrete control (Levels 1 and 2).

The levels provide different types of functionality and work in different timeframes. The functional hierarchy is further explained in IEC 62264. This part of ISO 22400 focuses on the MOM level.

The equipment used in the enterprise can be structured in a hierarchical structure (as defined in IEC 62264-1). The different levels are enterprise, site area, work cell, work unit and lower equipment used in production.

A.4 MOM

A.4.1 Categories of operations

The domain of manufacturing operations is composed of the following sub-domain categories of operations (as described in IEC 62264-1):

a) production operations;

b) inventory handling operations;

c) quality assurance testing operations;

d) maintenance operations;

e) remaining operations categories.

Each category is further detailed by an activity model. Production operation is the main type of operation whereas maintenance, inventory and quality could be thought of as complimentary type of operations. KPIs are associated with each major manufacturing operation category of IEC 62264.

A.4.2 Activity model

The 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.

The activity model is defined in IEC 62264-3. The performance analysis activity takes care of the activities related to performance indicators, i.e. definitions, calculations, presentations and exchange of KPIs.

A.4.3 Resources

A resource is an entity that provides some or all of the capabilities required by the execution of the enterprise activities and/or business processes. The resources involved in MOM are personnel, material, equipment and process segments (as described in IEC 62264-1).

Equipment also incorporates asset management.

Material also incorporates consumable materials like energy and additives/utility.

A.5 Concepts of production operations

A.5.1 Production methodology

There are many ways of classifying an enterprise. One way is according to the industry sector within which the enterprise is active. Another way is according to the type of production process that the enterprise has. Three main types of production processes exist:

— continuous;

— discrete;

— batch.

There are enterprises that include all three types of production processes and there are others that operate only one of them. It is common to refer to a production process according to the dominant type of process.

A.5.2 Production execution through work orders

The enterprise receives customer orders that are transformed into production orders and further refined and regrouped (merged and/or split) into executable work orders:

a) customer order: a combination of production orders;

b) production order: a fixed quantity of a single product;

c) work orders: a fixed quantity of a product or sub-product /intermediate.

NOTE Customer orders and production orders are outside the scope of this part of ISO 22400.

The concept of orders is very clear in discrete and batch production, whereas it is more subtle in continuous production processes.

A.5.3 Physical structure

The order of equipment actually used or expected to be used in the execution of a work order is called the path. A work centre is classified as single path, multiple paths, or network based on its physical structure. Regardless of which structure is used, several work orders may be in progress at the same time, multiple input materials may be used, multiple finished materials may be generated, and production units may be shared with input material sources and production storage.

A.5.4 Single product/multiple products

A work centre may be of single product type or of multiple product type. The hardest plants to operate and evaluate are network-structured plants with multiple products.

A.6 Concepts of improvement methods

An improvement method requires an understanding of the objective through which a set of KPIs has to be managed. This set of KPIs depends on selection criteria that will enable the objective to be realized.

These KPIs may be associated with different manufacturing operations categories in which the measures are further derived from concurrent processes and resources at level 2 and below (see Clause A.3 and IEC 62264).

The use of KPIs is only one of the potential support tools for continuous improvement (see ISO 13053-1). There are many other methods with a focus on continuous improvements.

A.7 Concepts of targets-and-measures and drivers-and-enablers

KPIs can be related to each other, such that the value of one KPI is based on the value of another KPI. This relationship can be structured in a network structure that is roughly hierarchical, as illustrated in Figure A.1.

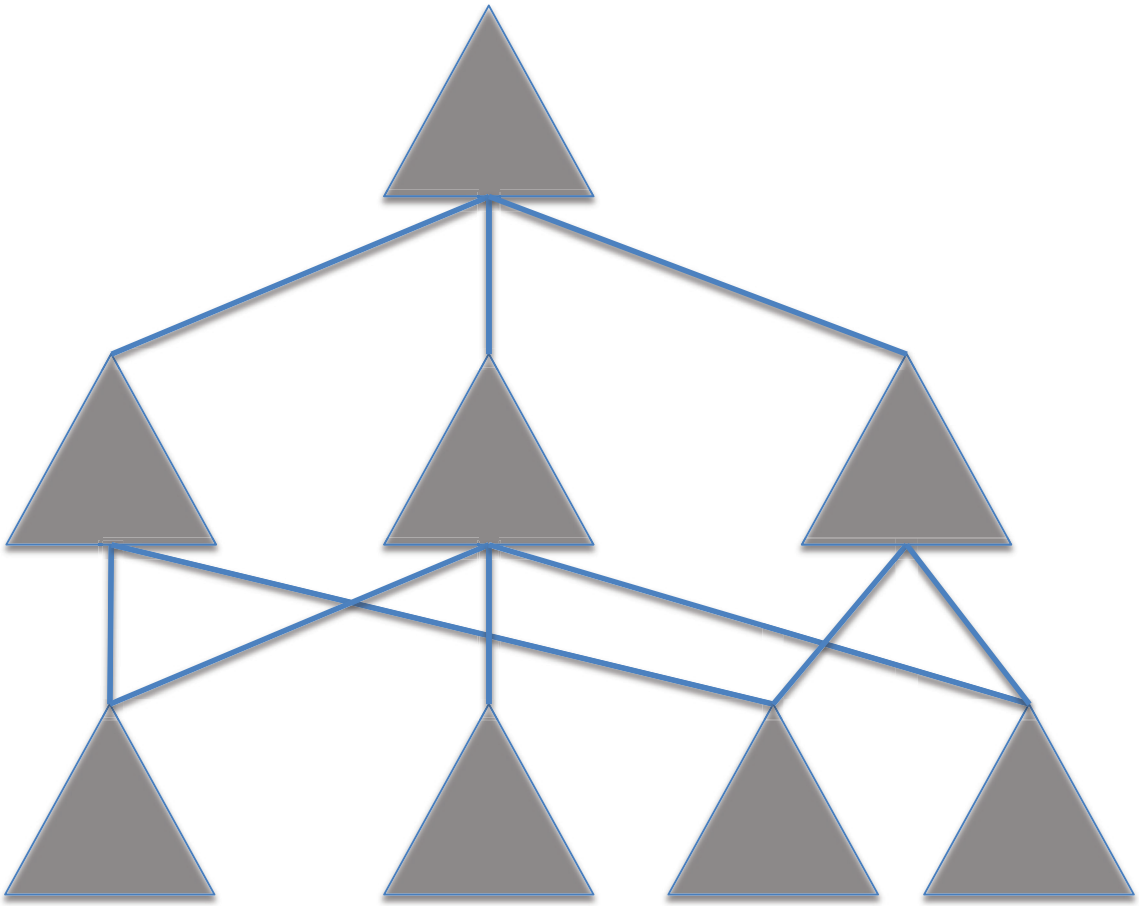

Figure A.1 — KPI network structure

The KPIs at the lowest level are derived from measurements of the processes. KPIs at higher levels are based on the KPI values from the lower level KPIs. KPIs at higher levels are derived KPIs.

— Bottom-up: There are ways to collect the measures. There are ways to aggregate measures and form KPIs. There are ways to combine KPIs to form higher level KPIs. There are ways to visualize the KPI also in real time. The shorter time delay, the easier the process is to control. A long time delay makes the process more difficult to control.

— Top-down: The strategic decisions should help formalize the objectives and the priority among the objectives. The objectives are converted/mapped into a set of KPIs. The set of KPIs should be used as target values for selecting the plant floor measures.

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