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AMENDMENT 1
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Automation systems and integration — Key performance indicators (KPIs) for manufacturing operations management —

Part 2: **Definitions and descriptions**

AMENDMENT 1: Key performance indicators for energy management

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

Partie 2: Définitions et descriptions

AMENDEMENT 1: Indicateurs de la performance clé pour le management de l'énergie

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This document was prepared by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 5, *Interoperability, integration, and architectures for enterprise systems and automation applications*.

A list of all parts in the ISO 22400 series can be found on the ISO website.

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

Part 2: **Definitions and descriptions**

AMENDMENT 1: Key performance indicators for energy management

Introduction

Add the following paragraph and new Figure 3 at the end of the Introduction. Renumber Figures 3 to 5 as Figures 4 to 6.

KPIs for energy management within MOM are in accordance with ISO 50001 and ISO 20140, and they complement MOM indicators regarding energy consumption. KPIs for energy management support the evaluation of direct energy consumption per work unit or per order, and per manufactured product item. Figure 3 illustrates the approach and the focus in the determination of energy consumption.

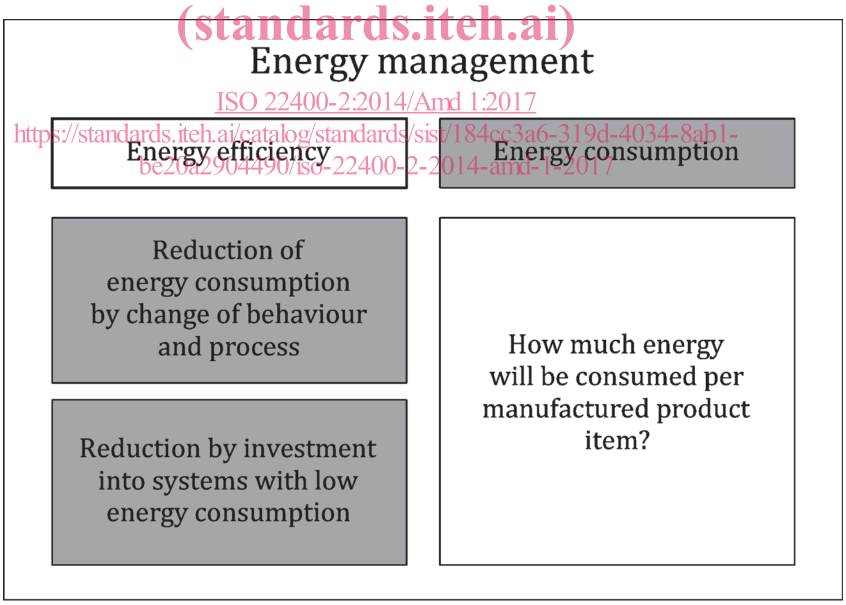

Figure 3 — Approach and focus in the determination of energy consumption

Clause 2, Terms and definitions

Add the following term and definition:

2.5
direct energy consumption
energy consumed by the work unit during the actual unit busy time

Note 1 to entry The concept of "direct energy consumption" in ISO 20140-1 represents the energy consumed by a work unit for a direct operation (as defined in ISO 20140-1:2013, 3.4). ISO 20140 enables an energy efficiency evaluation quantified by KPIs with a granularity that itemizes the energy consumption per equipment part of the work unit. The granularity of this part of ISO 22400 does not itemize the work unit energy consumption per equipment part of the work unit. The difference in the granularity of the KPI and scope between ISO 22400 and ISO 20140 leads to different, though not contradictory, definitions of the term "direct energy consumption" in the two standards.

Note 2 to entry If a work centre fulfils the same requirements as a work unit, it can be considered as a work unit.

Note 3 to entry The attribute direct is used for the purpose of consistency with the concept direct cost.

Clause 3, Symbols and abbreviated terms

Add the following abbreviated terms:

ADEC actual direct energy consumption

PDEI planned direct energy consumption per item

Clause 5

Add the following subclauses, including new Figure 7, immediately after 5.7.5:

5.8 Energy elements

5.8.1 Actual direct energy consumption (ADEC)

The actual direct energy consumption is the measured direct energy consumption per work unit and during actual unit busy time.

5.8.2 Planned direct energy consumption per item (PDEI)

The planned direct energy consumption shall be the planned energy consumption in average for producing one product item.

NOTE This factor is analogous to the planned run time per item.

5.8.3 Time period

A time period is the time during which a work unit is in a specific state. With each change of state a new time period always begins.

5.8.4 Fundamentals of energy types

5.8.4.1 Conversion to a unified energy unit

Energy measurements are commonly made in various units of energy and shall be converted to the industry standard, namely, kWh, as illustrated in Figure 7. This conversion is necessary to obtain a valid summation of the different expressions of energy usage for computing the direct energy consumption. For this purpose, conversion factors depending on the type of energy need to be determined.

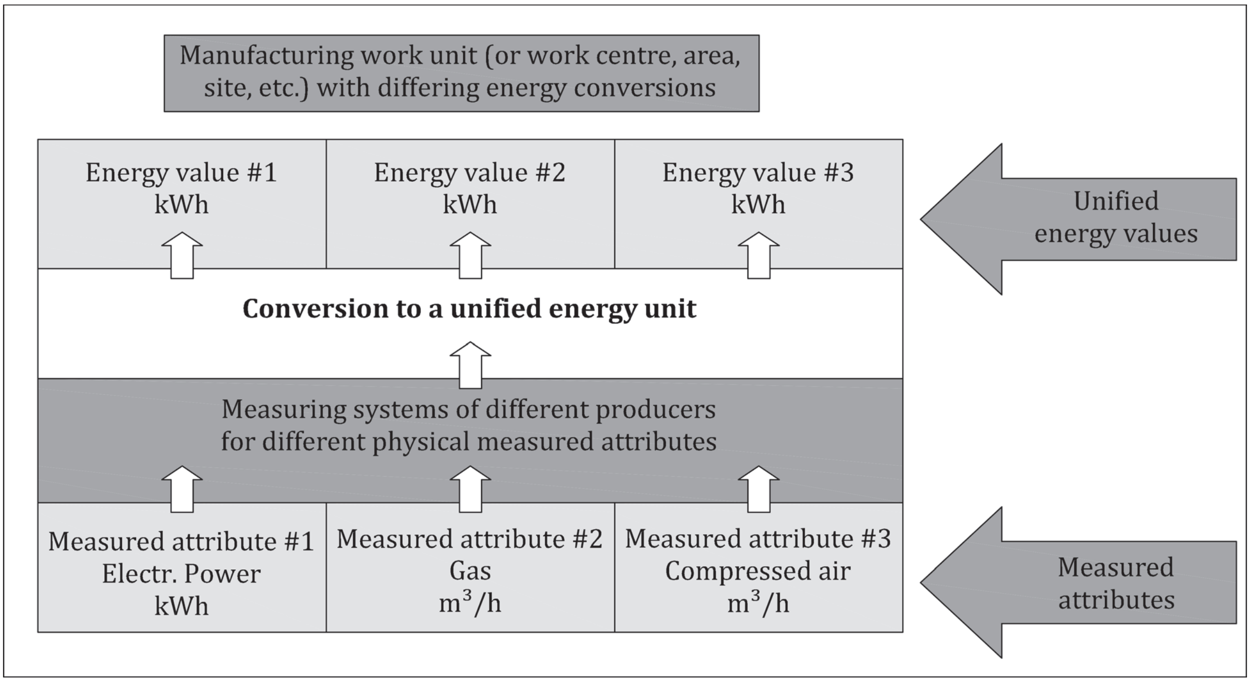

Figure 7 — Conversion to energy unit of measure from measured attributes

5.8.4.2 Conversion factors

5.8.4.2.1 Conversion factors provided by energy suppliers

Conversion factors for energy types are usually obtained directly from an energy supplier. These conversions introduce measurement uncertainties from a number of different sources, which should be understood and incorporated in calculations.

EXAMPLE

Natural gas	10 kWh/m^3	12,66 kWh/kg
Gas oil	9,93 kWh/l	11,68 kWh/kg
Bunker oil	10,27 kWh/l	11,17 kWh/kg
Hard coal		approx. 8,14 kWh/kg
Lignite		approx. 5,35 kWh/kg

5.8.4.2.2 Conversion factors requiring calculation

Some conversion factors may not be constants that can be found in property tables, but may need to be calculated individually. For example, the conversion factors need to be calculated individually for compressed air, steam, and water.

EXAMPLE 1

The measured energy consumption for compressed air generation need to be allocated to actually measured compressed air consumption at the involved work units. The calculated conversion factor is used for the conversion of the measured energy type on the respective work unit to the collective energy unit kWh.

The conversion factor is calculated via the relation:

Σ (energy consumed [kWh] for compressed air generation) / Σ (compressed air [m^3] generated)

The conversion factor in this case is the unit “kWh/m^3”.

EXAMPLE 2

Calculation:

A compressor with 37 kW power generates at 600 kPa up to 7 m^3/min compressed air. A direct air consumption of 6 m^3/min will be measured as consumed by the work units.

The conversion factor would be at a total consumption of measured 6 m^3/min and 37 kW power as follows:

Conversion factor = 37 kW/360 m^3/h = 0,102 8 kWh/m^3

Clause 6

Replace the first sentence with the following sentence:

Tables 2 to 39 describe the KPIs for MOM.

Add the following tables immediately after Table 35:

Table 36 — Direct energy consumption effectiveness

KPI description	
Content	
Name	Direct energy consumption effectiveness
ID	
Description	The direct energy consumption effectiveness represents the relation of the planned direct energy consumption per item (PDEI) multiplied by the produced quantity (PQ) to the actual direct energy consumption (ADEC). Using this KPI, the produced quantity of an order during the measurement period is considered. The ratio gives information how effective is the planning of the energy consumption for manufacturing the produced quantity (PQ).
Scope	Work unit, product, production order
Formula	Direct energy consumption effectiveness = PDEI * PQ / ADEC * 100
Unit of measure	%
Range	Min: 0 % Max: 100 % The 100 % may be exceeded if the planned energy consumption is higher than the actual energy consumption.
Trend	The higher, the better (but not exceeding 100 %)
Context	
Timing	On demand, periodically, online
Audience	Supervisor, management
Production methodology	Discrete, batch, continuous
Effect model diagram	See Figure A.33
Notes	This indicator shows whether the planned direct energy consumption coincides with the measured values. With this indicator, unknown energy losses can be identified at the production unit (e.g. Example compressed air leakage). The planned energy consumption per product unit need to be planned before start of production.