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Automation systems and integration — Evaluating energy efficiency and other factors of manufacturing systems that influence the environment —

Part 5: Environmental performance evaluation data

Systèmes d'automatisation et intégration — Évaluation de l'efficacité énergétique et autres facteurs de fabrication des systèmes qui influencent l'environnement —

Partie 5: Données d'évaluation de la performance environnementale

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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).

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).

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For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared jointly by Technical Committee ISO/TC 184, *Automation systems and integration*, Subcommittee SC 5, *Interoperability, integration, and architectures for enterprise systems and automation applications*, and Technical Committee IEC/TC 65, *Industrial-process measurement, control and automation*. The draft was circulated for voting to the national bodies of both ISO and IEC.

A list of all parts in the ISO 20140 series can be found on the ISO website.

Introduction

ISO 20140 specifies an environmental performance evaluation (EPE) method for evaluating the energy efficiency and other factors of manufacturing systems that influence the environment (e.g. energy consumption, waste and release). The EPE method includes guidelines for analysing the usage of energy by the manufacturing system and the effects of the manufacturing system on the environment. The method described in ISO 20140 is used to perform systematically an EPE by analysing the manufacturing activities and the manufacturing system.

ISO 20140 is intended for discrete products/parts manufacturing systems used in manufacturing processes such as forming, machining, painting, assembling, testing for the production of products such as aircraft, automobile, electric appliances, machine tools and their components.

ISO 20140 focuses on applying the EPE method on a manufacturing system having a hierarchical structure comprised of work units, work centres and areas. The EPE method can be applied for quantifying the improvements in production management and individual manufacturing equipment operations in various manufacturing system configurations.

The EPE method and underlying concept of ISO 20140 can also be used as the foundation for EPE for continuous processes and batch processes.

ISO 20140 can be used for:

— benchmarking of environmental performance for a generic manufacturing system;

— performing studies of environmental performance for improving a current manufacturing process, reconfiguring a current manufacturing system/equipment and designing a new manufacturing system;

— comparing the environmental performance of different manufacturing systems producing the same product;

— setting the top level target of environmental improvement and the breakdown to constituent systems, work units and individual manufacturing equipment;

— improving the shop floor operations by visualizing the actual status of environmental performance.

Expected users of ISO 20140 are:

— managers for environmental conditions in a factory, site and enterprise;

— engineers for process planning of products;

— planners and designers for manufacturing systems;

— engineers and foremen that produce products by operating a manufacturing system.

ISO 20140-1 provides an overview and general principles of a method for evaluating the environmental performance of manufacturing systems.

Automation systems and integration — Evaluating energy efficiency and other factors of manufacturing systems that influence the environment —

Part 5: Environmental performance evaluation data

1 Scope

This document specifies the types of environmental performance evaluation (EPE) data, including their attributes, which can be used for evaluating the environmental performance of manufacturing systems based on the general principles described in ISO 20140-1. It also provides recommendations for mapping the EPE data on to information models specified by IEC 62264.

This document applies to discrete, batch and continuous manufacturing.

This document is applicable to entire manufacturing facilities and to parts of a manufacturing facility.

This document specifically excludes from its scope the syntax of the data and information models, the protocols to exchange data models, the functions that can be enabled by data models, and the activities in Level 1 and Level 2.

The scope of this document also includes indicating the differences among various data and information models and the differences among various representations of environmental performance by actual data.

This document refers to the semantics of the structured data and information models used by communication protocols. The semantics explain the meaning of the attributes and of the context information.

The following are outside the scope of this document:

— product life cycle assessment;

— EPE data that are specific to a particular industry sector, manufacturer or machinery;

— acquisition of data;

— the activity of data communication.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 20140-1:2013, *Automation systems and integration — Evaluating energy efficiency and other factors of manufacturing systems that influence the environment — Part 1: Overview and general principles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20140-1 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
actual data
data (3.2) measured or counted from the *manufacturing system* (3.16) during the *manufacturing process* (3.15)

3.2
data
collection of values of measured or derived characteristics of objects, such as facts, processes, or events, before it is interpreted as an *information* (3.5) in a formalized manner suitable for communication, processing and interpretation

3.3
enterprise domain
domain that includes all the activities in *Level 4* (3.12) and *information* (3.5) that flows to and from *Level 3* (3.11)

[SOURCE: IEC 62264-1:2013, 3.1.11]

3.4
external data
data (3.2) that come from outside of the manufacturing enterprise

3.5
information
combination of *data* (3.2) concerning objects, such as facts, processes or events, in a meaningful form that enables interpretation with a particular meaning within a certain context

Note 1 to entry: Both data and information are collections of items. In the context of this document, data become information when the data structure, model, or object contains also reference elements (see 3.17 and Clause 4).

Note 2 to entry: For the purpose of simplifying the text, unless explicitly specified, this document uses the word "information" with the meaning of the term "information for environmental performance evaluation".

3.6
environmental performance evaluation data
EPE data
data (3.2) that can used for environmental performance evaluation

3.7
key performance indicator
KPI
performance measurement of some critical aspect of the system or component

Note 1 to entry: KPIs are chosen by an organization based on a specific criterion determined by its mission, operating plans and continual improvement procedures.

3.8
Level 0
actual physical process

Note 1 to entry: This term is used in the context of functional hierarchy of enterprise-control systems.

[SOURCE: IEC 62264-1:2013, 3.1.19, modified — Note 1 to entry has been added.]

3.9
Level 1
functions involved in sensing and manipulating the physical process

Note 1 to entry: This term is used in the context of functional hierarchy of enterprise-control systems.

[SOURCE: IEC 62264-1:2013, 3.1.18, modified — Note 1 to entry has been added.]

3.10
Level 2
functions involved in monitoring and controlling of the physical process

Note 1 to entry: This term is used in the context of functional hierarchy of enterprise-control systems.

[SOURCE: IEC 62264-1:2013, 3.1.17, modified — Note 1 to entry has been added.]

3.11
Level 3
functions involved in managing the work flows to produce the desired end-products

Note 1 to entry: This term is used in the context of functional hierarchy of enterprise-control systems.

[SOURCE: IEC 62264-1:2013, 3.1.17, modified — Note 1 to entry has been added.]

3.12
Level 4
functions involved in the business-related activities needed to manage a manufacturing organization

Note 1 to entry: This term is used in the context of functional hierarchy of enterprise-control systems.

[SOURCE: IEC 62264-1:2013, 3.1.16, modified — Note 1 to entry has been added.]

3.13
manufacturing operations and control domain
MO&C domain
domain that includes all the activities and *information* (3.5) that flows in *Level 3* (3.11), *Level 2* (3.10) and *Level 1* (3.9) and information flows to and from *Level 4* (3.12)

Note 1 to entry: Traditional use of the terminology “control domain” included the activities defined here as the terminology “manufacturing operations and control domain”.

[SOURCE: IEC 62264-1:2013, 3.1.21]

3.14
manufacturing operations management domain
MOM domain
domain that includes all the activities in *Level 3* (3.11) and *information* (3.5) that flows to and from *Level 1* (3.9), *Level 2* (3.10) and *Level 4* (3.12)

Note 1 to entry: The manufacturing operations management domain is a subset of the *manufacturing operations and control domain* (3.13).

Note 2 to entry: For the purposes of this document, the word “information” in this definition also means *data* (3.2).

[SOURCE: IEC 62264-1:2013, 3.1.23, modified – Note 2 to entry has been added.]

3.15
manufacturing process
set of processes in manufacturing involving a flow and/or transformation of material, *information* (3.5), energy, control, or any other element in a manufacturing area

[SOURCE: ISO 18435-1:2009, 3.16]

3.16
manufacturing system
system comprised of a hierarchical structure of individual manufacturing equipment, coordinated by a particular *information* (3.5) model to support the execution and control of *manufacturing processes* (3.15) involving the flow of information, material and energy in a manufacturing plant

[SOURCE: ISO 16100-1:2009, 3.19, modified — The words "comprised of a hierarchical structure of individual manufacturing equipment" have been added.]

3.17
reference data
data (3.2) concerning aspects of *manufacturing system* (3.16) and *manufacturing process* (3.15), data that are generated or managed by the manufacturing system, other than *actual data* (3.1)

3.18
upstream data
data (3.2) associated with resources incoming through the unit process boundary

4 Classification of EPE data

4.1 EPE data context information

Values of EPE data (actual data obtained by measurements performed in Level 1) are rarely available in the form of a single numerical value (e.g. the instantaneous beer mash temperature in fermenting tank, the instantaneous pump energy consumption). The value of the actual data gets commonly associated with equipment and operation context information by means of structured data models (see Reference [36]). The actual data and context information contained in data models are thereafter processed and aggregated into structured information models (see IEC 62264-1:2013) containing also production control, manufacturing system and process plan context information.

Subclause 5.2 indicates that a same actual data value can be contained in multiple data and information models located in either of the functional Levels 2, 3 and 4 of the manufacturing system.

NOTE An actual data value can be included in a variety of data and information models based on the purpose for which that model is configured: energy management, operation control, etc.

An aspect common to the structured data and the information models is that they can be exchanged among various activities located in different levels of the functional hierarchy while the context information gets successively added by those activities in the model structure.

An EPE data model can contain one or more attributes. Attributes can represent context information, including:

— when the data have been obtained;

— by what method the data have been obtained;

— how the data have been processed;

— the purpose of the data (as a response to information request, for control, for reporting, for EPE, for KPI evaluation, etc.).

4.2 Classification by source and time

The EPE data shall be classified based on source and time, as follows:

— actual data;

— external data;

— reference data.

Figure 1 illustrates that the actual data are being generated in the manufacturing enterprise during the manufacturing process. The reference data are generated also within the manufacturing enterprise but at another timing than during the execution of the manufacturing process.

A distinct category of EPE data is represented by the external data that consists of data that comes from outside of the manufacturing enterprise.

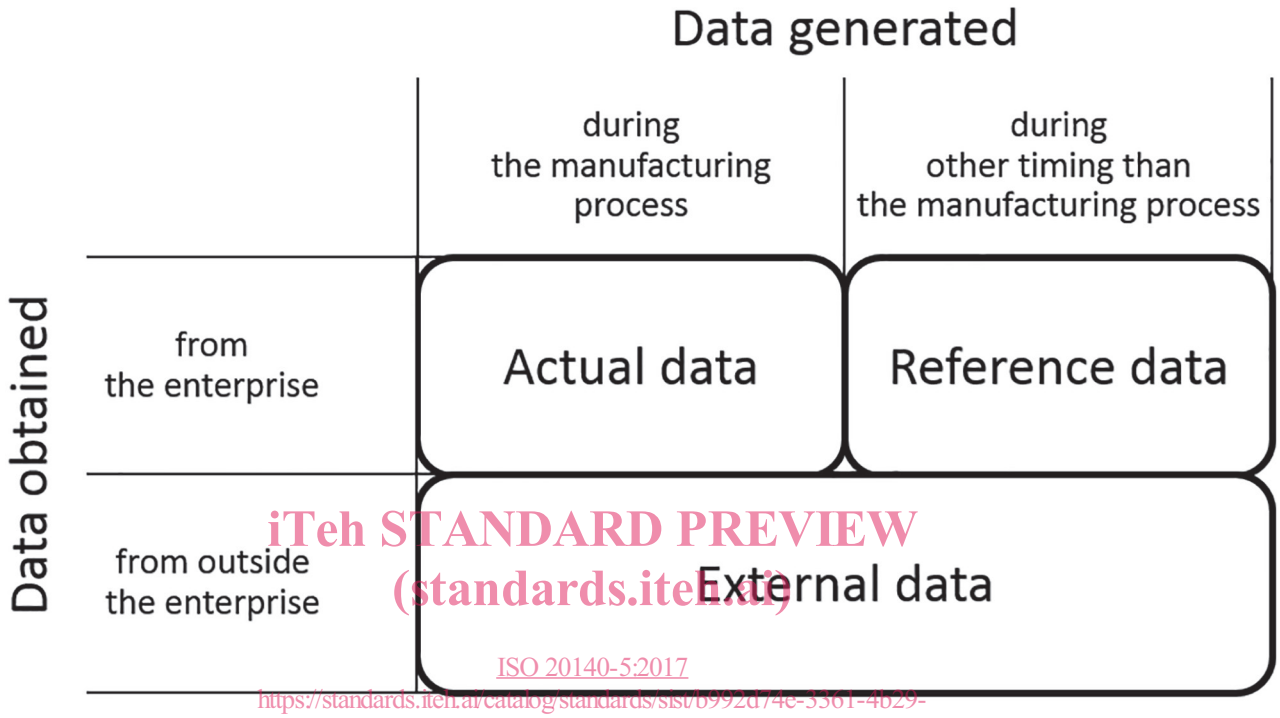

Figure 1 — Classification of EPE data by source and time

The categories of actual, external and reference data are complementary and, as illustrated in Figure 1, the three data categories contain together the entire amount of data needed for EPE.

The high level classification of data by source and time indicates the requirement for every data to have the following two attributes describing the data:

a) an attribute indicating the data sourcing;

b) an attribute indicating the data timing (the time when data are created with respect to the execution of the manufacturing process).

The two data attributes unequivocally identify whether the EPE data is actual, external or reference data.

4.3 Further classification of data

Figure 2 describes a refinement of the data classification illustrated in Figure 1. The actual, external and reference data classes contain data types as shown in the following not all-inclusive list:

— actual data:

  — actual data in operation step;

  — actual data in the construction, reconfiguration and retirement (CRR) step;

  - other;
- external data:
  - upstream data;
  - environmental characteristic data;
  - residual CRR data;
  - other;
- reference data:
  - process control data;
  - manufacturing system data;
  - process plan data;
  - other.

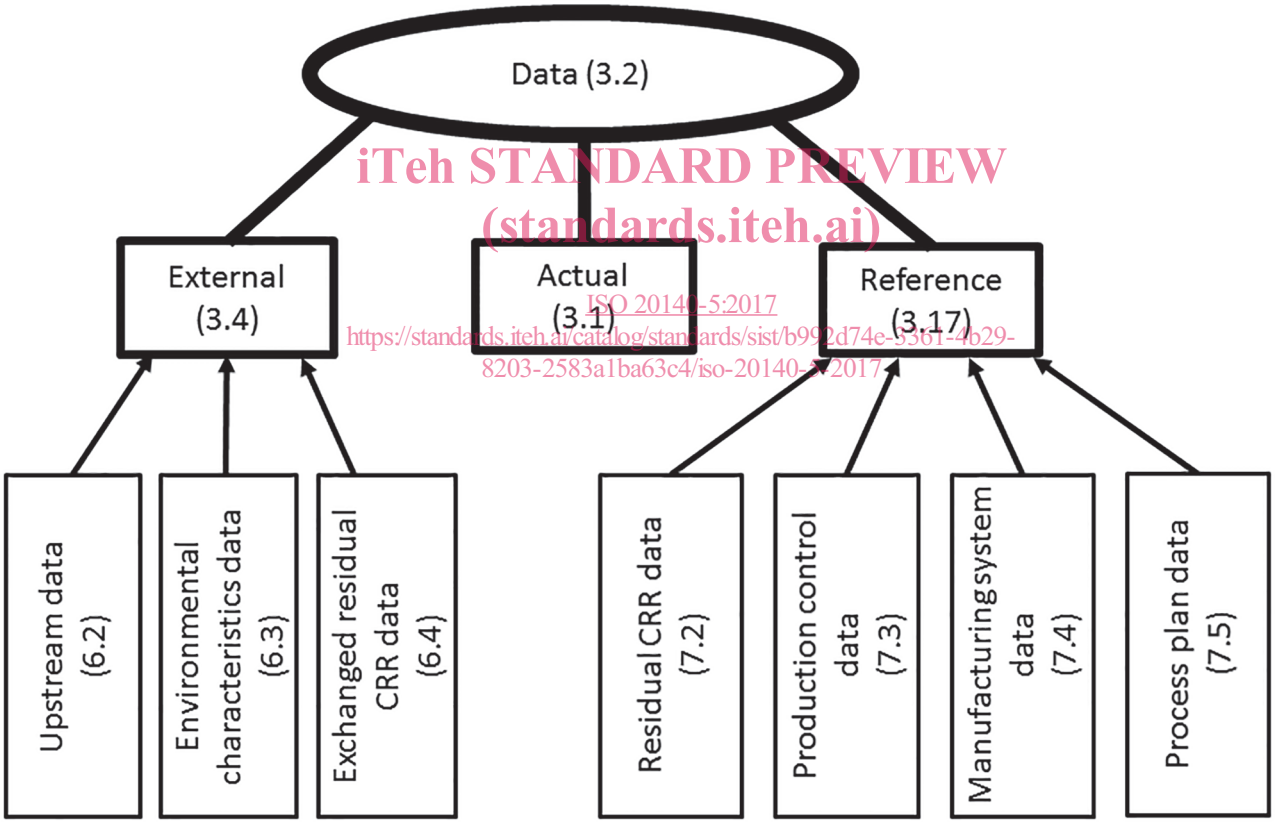

Figure 2 — Refined classification of EPE data

5 Actual data

5.1 Overview

Physical and chemical systems have measureable properties whose values describe a state of the system. Examples of physical and chemical systems properties include temperature, distance, voltage, flow and level. The measurements are commonly performed by transducers located in Level 1.

Level 1 actual data are rarely available to Levels 3 and 4 in a single value format as measured by a transducer (e.g. an instantaneous temperature or voltage value). An automation system could associate and aggregate actual data with equipment and operation context information into data and information structures. Accordingly, the term “actual data” in this document refers commonly to a data structure that contains an actual data value.

5.2 Sources of actual data

5.2.1 Overview

Figure 3 illustrates that the same value of an actual data value can be contained in data and information models that can have various context information and can be found in multiple levels.

The MO&C domain and the MOM domain include only activities and information flows and do not include actual data. This document specifies the data for EPE and does not describe either the activities that generate actual data (e.g. data acquisition) or how the information is transferred among activities and levels. The shapes illustrating information flows and activities in Figure 3 are marked up with grey for the purpose of emphasizing that those specific topics are out of the scope of this document.

5.2.2 Actual data located in Level 2

Level 2 receives and contains actual data from Level 1 (the transfer of actual data from Level 1 to Level 2 is not depicted in Figure 3 because the data transfer activity is not in the scope of this document).

The MO&C executes the transfer of actual data and context information among levels. The MO&C can, for example, transfer actual data from Level 2 to Level 3 for storage purposes.

Actual data from Level 1 located in Level 2 can be selected for processing and transfer by the MO&C without further processing in Level 2. Alternatively, context information can be added within Level 2 to the actual data from Level 1, either in the same data or information model as received from Level 1 or in a new data or information model.

Level 2 contains also actual data generated by activities prescribed by the MO&C in Level 2. MO&C activities can process one or multiple actual data from Levels 1, 2 and 3 (e.g. calculating power consumption by multiplying the current consumed measured in Level 1 with the value of the line voltage measured at an earlier time in Level 1 and stored for later use in Level 3).

5.2.3 Actual data located in Level 3

Level 2 actual data might be required for processing by activities that are included in Level 3.

NOTE It is common for a manufacturing system to have only a limited number of power meters for measuring the energy consumption of individual pieces of equipment. Consequently, it is common to derive the energy consumption of a piece of equipment from the power line energy consumption (whose value is stored in Level 3) and the measured energy consumption (actual data located in Level 2) of the other pieces of equipment that use same power line as the energy source.

The MO&C activities store selected actual data from Level 2 in Level 3 (e.g. in a historian database). The data stored in Level 3 can be used on a later date for performing an EPE of the manufacturing system.

The Level 3 associates actual data from Level 2 with various context information originated in Levels 0, 1, 2, 3 and 4 in structured documents generated by MO&C activities (e.g. production report, test reports). Those documents, in printed or electronic format, constitute possible sources of actual data available in Level 3.

The historian database and the reports located in Level 3 contain also context information that can be included in Level 2 and Level 4 data and information models.

KPIs reported to Level 3 or calculated in Level 3 can also contain actual data in their model structure (see Annex C).

5.2.4 Actual data located in Level 4

Actual data available for processing in Level 4 are contained in structured information models commonly used by enterprise resource planning (ERP) or manufacturing resource planning (MRP) (e.g. IEC 62264 information models). KPIs reported to Level 4 or calculated in Level 4 can also contain actual data in their model structure (see Annex C).

5.2.5 Selecting the source of actual data

Figure 3 illustrates the multiple choices available for selecting the source of actual data. A measured data value can be available and accessible in multiple levels and in various data and information models. Moreover, a specific data model containing the same actual data can be located also in multiple levels while having different amount of context information added in the model.

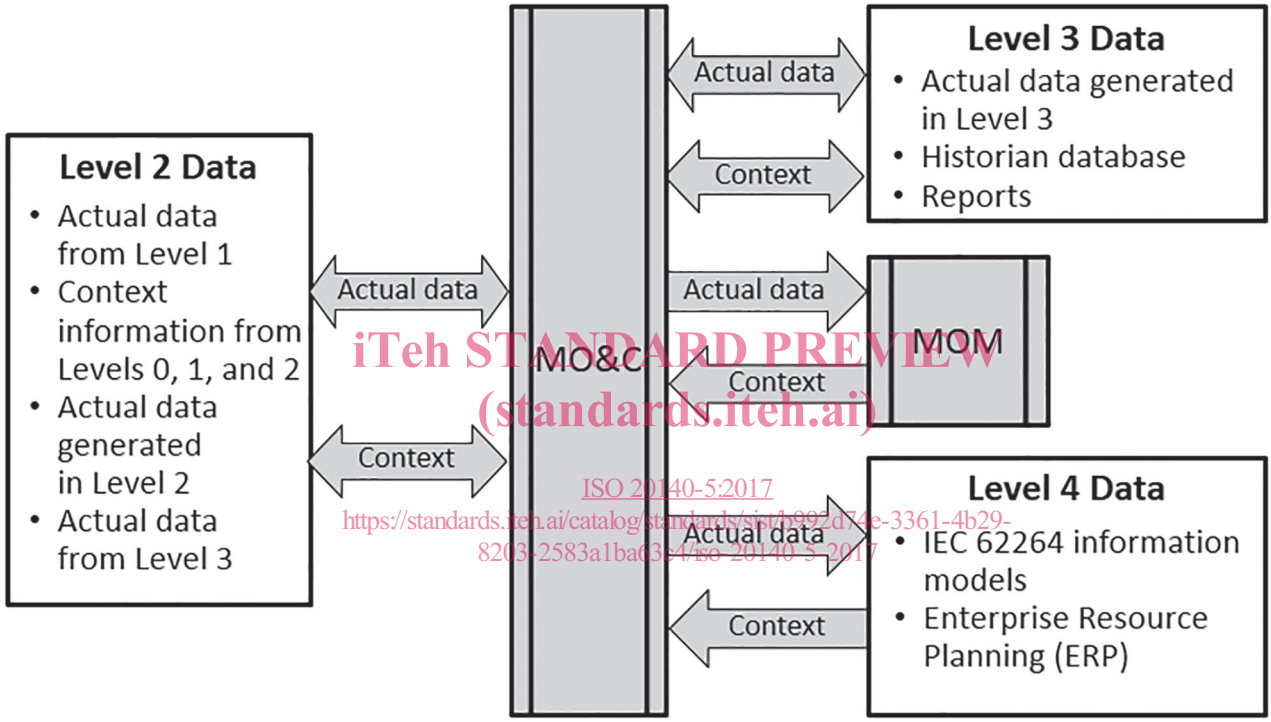

Figure 3 — Locations with actual data

Selection of the source for actual data may depend on:

— the availability of the data (the degree of automation);

— the availability of standardized data and energy models in the manufacturing system;

— the accuracy required by the EPE;

— the granularity required by the EPE;

— the scope of the EPE (e.g. evaluating the energy performance improvement by using the energy use state modes (see Annex G);

— the duration and the frequency of the EPE;

— the cost of storing actual data;

— the availability of actual data.

The actual data in Level 2 have the highest degree of granularity and resolution among the types of available actual data. The actual data contained in the Level 3 historian database have a high content of operation context information over a longer period of time than the actual data in Level 2. The actual data located in Level 4 (e.g. actual data contained in IEC 62264-2 information models) contain information relevant for management and decision making at the enterprise level (e.g. specifying the energy policy).

Data models are generated and configured as prescribed by standards addressing the resource management and communication protocols. It is relevant for the EPE to make use of those data and information models that exist in the manufacturing system.

5.3 Actual data in operation step

5.3.1 Overview

The actual data can be further sorted in four categories as follows:

— Energy actual data: This type of data requires frequent measurements and intense post-processing.

NOTE 1 Energy data can trigger Level 2 and Level 3 operation control commands and can be used to capture unscheduled operation changes occurring in Level 0. Data models (see Clause A.1) are means to increase the granularity of energy data at high resolution. Information models (see Clause A.2) are means to increase the granularity of energy data at medium resolution.

NOTE 2 Energy data are described in 5.3.5.

— Material actual data: This type of data are generated by measurement and counting and are mainly used in conjunction with upstream and reference data (e.g. the number of purchased components is counted and thereafter multiplied with the mass of each component as recorded in upstream data). This type of data requires less post-processing and the material usage balance can be easily verified.

NOTE 3 Material actual data are further described in 5.3.6.

— Manufacturing operations and process actual data.

NOTE 4 Manufacturing operations actual data and process actual data include context information such as status description (e.g. stand-by, sleep) and the description of perturbations in the process schedule induced by control commands operation alerts;

NOTE 5 Manufacturing operations actual data and process actual data are further described in 5.3.7.

— Environmental actual data: This type of data includes states and changes in the surrounding environment parameters that might not be controllable by the manufacturing system.

NOTE 6 Real time measurement of environmental actual data can be critical when the manufacturing process includes thermal or chemical processes. Demand response data exchanged with the smart grid are also a type of environmental actual data.

NOTE 7 Weather can be considered as an environmental data, unless the manufacturing system boundaries are factored into a controlled environment, such as an air conditioned manufacturing facility.

NOTE 8 Environmental data are further described in 5.3.8.

The four categories of environmental data listed above can be used by inter-related optimization functions that can have, at times, objectives conflicting with the objective of minimizing the energy consumption. Variances in the manufacturing process or demand response transactions may negatively affect the planned energy efficiency.

A relevant difference among the four categories of actual data consists in the quantity of measured data needed for the EPE. The energy data requires the largest amount of measurements among these four categories of actual data. The energy data is described in more details in 5.3.3.