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

Part 3: Environmental performance evaluation data aggregation process

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

Partie 3: Processus d'agrégation des données d'évaluation de la performance environnementale

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Foreword

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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 of 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 www.iso.org/iso/foreword.html.

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

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

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

ISO 20140 specifies a method for evaluating the energy efficiency and other factors of a manufacturing system that influence the environment, such as energy consumption, waste and release.

ISO 20140 is applicable to manufacturing systems for discrete, batch, and continuous manufacturing.

ISO 20140 focuses on manufacturing systems that have a hierarchical structure.

ISO 20140 can be used for:

— benchmarking the environmental performance against a generic reference manufacturing system or comparing between different manufacturing systems;

— alternative studies for improving environmental performance;

— setting targets for improving environmental performance;

— visualizing the environmental performance of a manufacturing system under operation.

Expected users of ISO 20140 are:

a) managers who are responsible for the environmental conditions of a manufacturing system;

b) engineers who design manufacturing processes for products;

c) engineers who design a manufacturing system;

d) engineers and foremen who are responsible for manufacturing products.

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

Part 3: Environmental performance evaluation data aggregation process

1 Scope

This document specifies an aggregation process that provides aggregated environmental performance evaluation data in accordance with a given environmental performance evaluation specification conforming to ISO 20140-2, by using a set of environmental performance evaluation data conforming to ISO 20140-5.

This document does not specify any aggregation processes specific to particular implementations of manufacturing systems.

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, *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 https://www.iso.org/obp

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

3.1
aggregated environmental performance evaluation data
aggregated EPE data
numerical representation of *environmental influence* (3.4) caused by a *manufacturing process* (3.8) in a given type of environmental influence and in a given mode

Note 1 to entry: Aggregated EPE data is the total value of a set of *converted EPE data* (3.3) associated with every *constituent activity* (3.2) involved in the given manufacturing process.

[SOURCE: ISO 20140-2:2018, 3.1, modified — Note 1 to entry has been added.]

3.2
constituent activity
part of a given *manufacturing process* (3.8) identified by a piece of equipment used and a specific period of time

3.3
converted EPE data
numerical representation of *environmental influence* (3.4) of a specified type caused by a specified *constituent activity* (3.2) in a specified mode

3.4
environmental influence
result of *manufacturing process* (3.8) that can cause environmental impacts and that is considered throughout the lifecycle of the manufacturing system associated with the process

Note 1 to entry: Environmental influence, such as energy consumed and CO_2 emitted, can cause environmental impacts, such as global warming and sea level rise.

EXAMPLE Amount of electric energy consumed; amount of CO_2 emitted; amount of hazardous substance discharged.

[SOURCE: ISO 20140-2:2018, 3.3]

3.5
environmental KPI
key performance indicator that represents *environmental performance* (3.6)

[SOURCE: ISO 20140-2:2018, 3.4]

3.6
environmental performance
measurable results related to environmental aspects

[SOURCE: ISO 14045:2012, 3.5]

3.7
environmental performance evaluation data
EPE data
data that are used to evaluate the *environmental performance* (3.6)

[SOURCE: ISO 20140-5:2017, 3.6, modified — The words "that can be used for environmental performance evaluation" have been replaced with "that are used to evaluate the environmental performance".]

3.8
manufacturing process
structured set of activities involving a flow and/or transformation of material, information, energy, or any other element

[SOURCE: ISO 18435-1:2009, 3.16, modified — The words "set of processes in manufacturing" have been replaced with "structured set of activities" and the word "control" has been deleted.]

4 Mathematical formulae

$\beta < \gamma 1, \gamma 2, \ldots >$ represents a variable β that is identified by attributes $\gamma 1, \gamma 2, \ldots$ in the angle brackets.

$f(\varepsilon 1, \varepsilon 2, \ldots) \rightarrow \delta$ δ represents the result of an operation specified by a function f and its arguments (i.e. $\varepsilon 1, \varepsilon 2, \ldots$).

5 Overview

This clause describes the roles of an EPE data aggregation process in relation to other parts of ISO 20140.

Figure 1 describes relationships among the following process and sub-processes, and data exchange between them:

a) the sub-process of developing specification of environmental performance evaluation,

b) the EPE data aggregation process,

c) the sub-process of calculating environmental KPIs.

The EPE data aggregation process provides the aggregated EPE data to the sub-process of calculating environmental KPIs. The calculation of environmental KPIs is specified according to the specification of environmental performance evaluation.

NOTE 1 The EPE data aggregation process is specified by this document.

NOTE 2 The classification of EPE data is specified by ISO 20140-5.

NOTE 3 The sub-process of developing specification of environmental performance evaluation and the sub-process of calculating environmental KPIs are specified by ISO 20140-2.

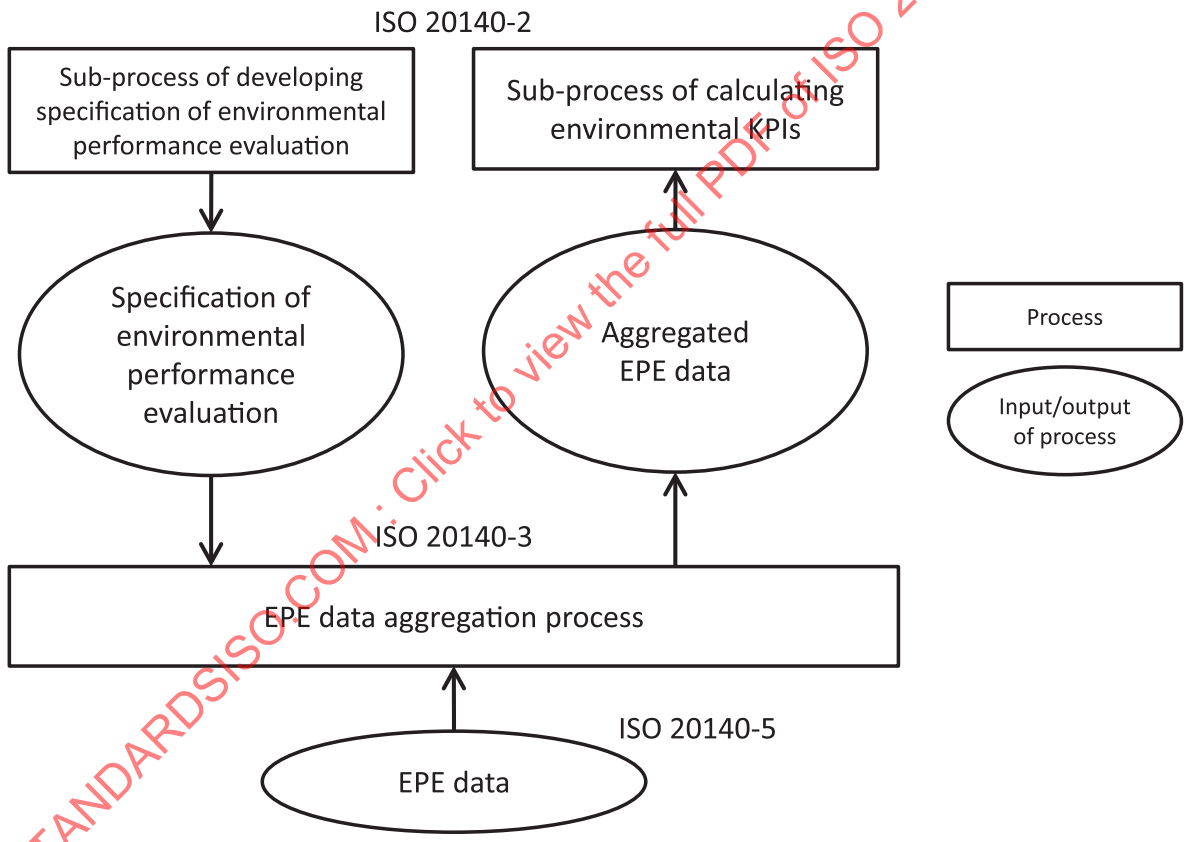

Figure 1 — Roles of EPE data aggregation process

6 Input to the EPE data aggregation process

The EPE data aggregation process assumes a specification of environmental performance evaluation as the input. The specification of environmental performance evaluation includes the following items:

a) description of the manufacturing process to be evaluated;

b) a mode of the manufacturing process;

EXAMPLE 1 Depending on application cases, many different kinds of modes are possible, such as actual production, waiting, sleeping, off, or maintenance. A mode can represent distinct ambient conditions of a manufacturing system used for a manufacturing process, such as ambient temperature.

c) a type of environmental influence to be evaluated;

EXAMPLE 2 Types of environmental influence include energy consumption, consumption of natural resources, emission of hazardous substance, and emission of greenhouse gas.

NOTE 1 Although types of environmental influence to be evaluated are included in the specification, one particular type is provided for every single request of an aggregation process of multiple requests initiated for an evaluation.

d) qualitative requirements for the evaluation.

EXAMPLE 3 Qualitative requirements include resolution, precision, repeatability and stability.

In addition to the specification of environmental performance evaluation, the following item can be added as input to the EPE data aggregation process:

e) structure of the manufacturing system used for the manufacturing process, including specifications of every piece of equipment of the manufacturing system.

The detail level of the structure differs depending on the structure of the manufacturing system and the quality level of the aggregated EPE data requested by the specification of environmental performance evaluation. This item should be provided separately from the specification of environmental performance evaluation, so that the specification can be applied to different implementations for the purpose of comparing.

7 Structure and functions of sub-processes

An EPE data aggregation process shall include the following sub-processes, as shown in Figure 2:

a) decomposition sub-process;

b) conversion sub-process;

c) summation sub-process;

d) allocation/charge sub-process.

NOTE The allocation/charge sub-process is outlined, but not specified, in this document.

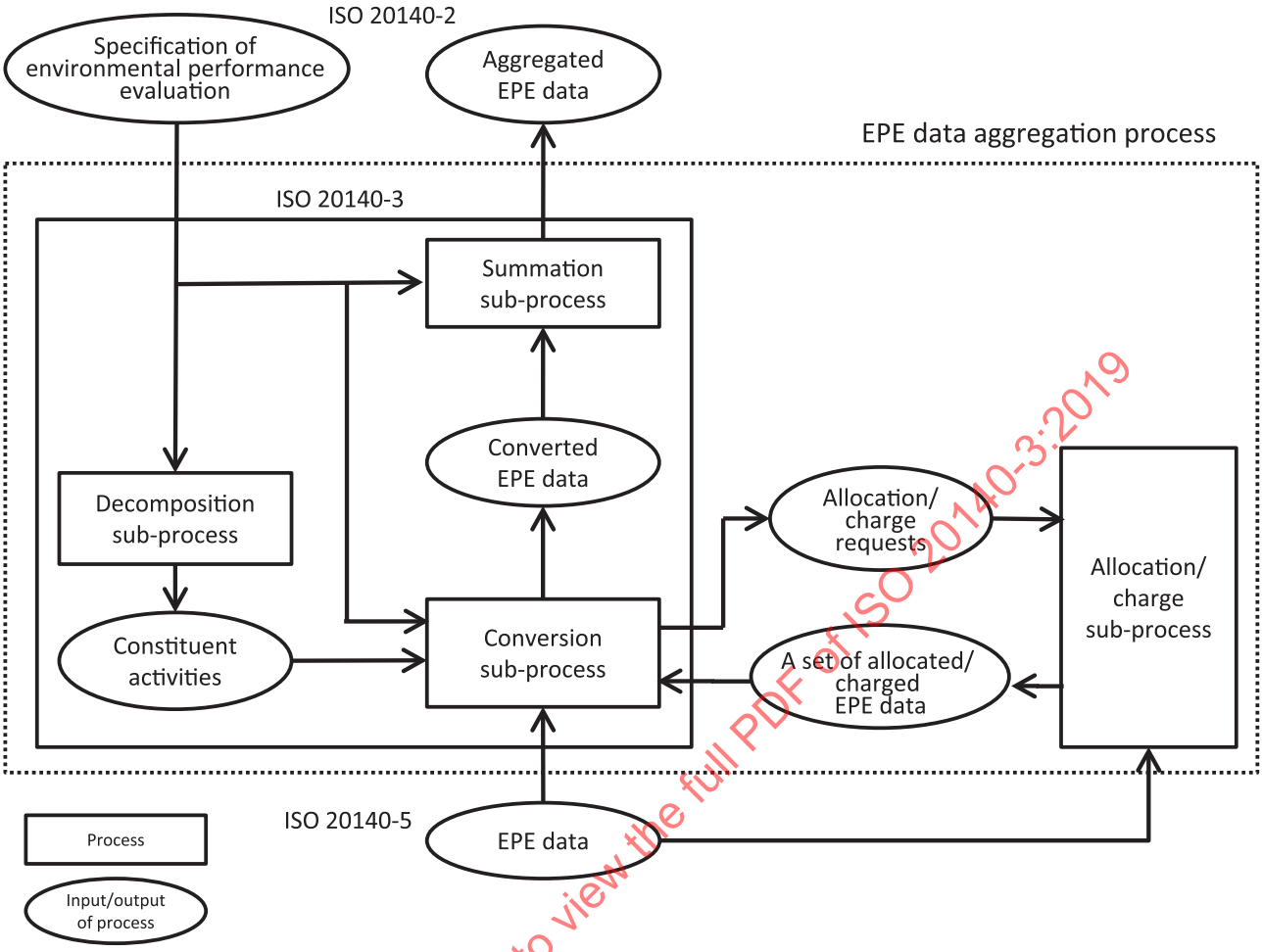

Figure 2 — EPE data aggregation process

Figure 3 shows an example of decomposing a manufacturing process. The decomposition sub-process decomposes the manufacturing process into some constituent activities.

The appropriate granularity for a constituent activity occurs when, for a particular piece of equipment used for a quantified period of time, EPE data are available or obtainable.

EXAMPLE As shown in Figure 3, according to the specification of environmental performance evaluation, the constituent activity corresponding to Equipment A occurs with respect to the timing T3, T4 and T5, whereas the constituent activity with Equipment C occurs with respect to the timing T2 and T3. In this way, blocks specified by combinations of (identifiers of) a piece of equipment and a period of time identify the appropriate constituent activities, as shown by A-3 to C-3.

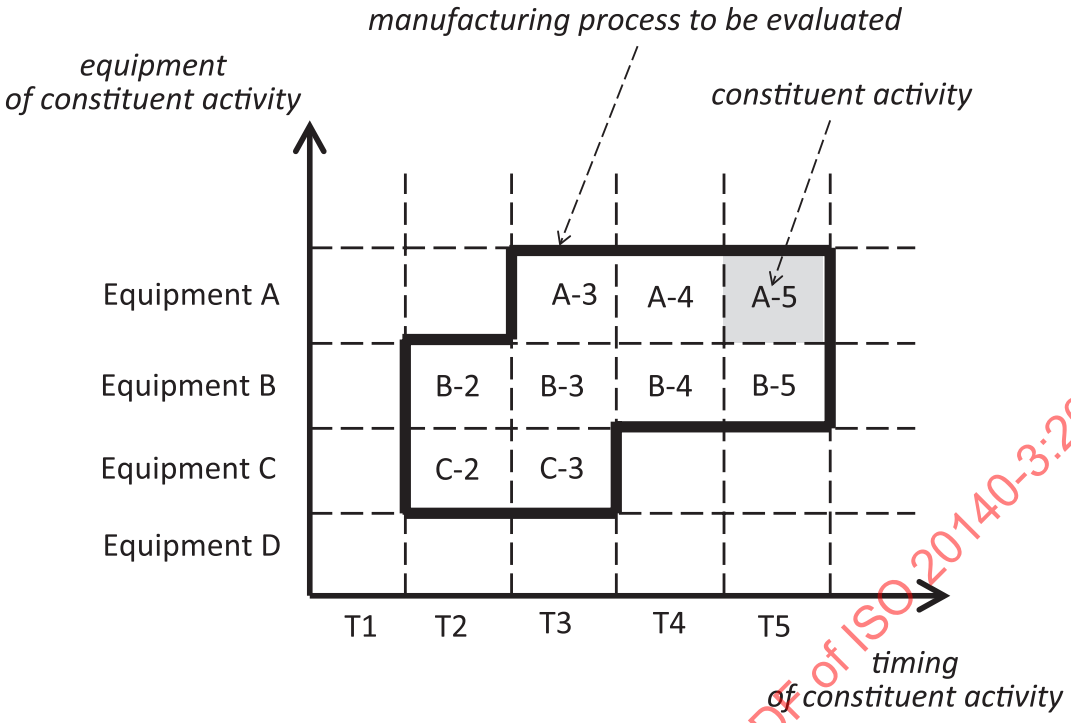

Figure 3 — Decomposition of a manufacturing process into constituent activities

Figure 4 shows an example of EPE data conversion and summation.

The conversion sub-process provides converted EPE data of every constituent activity, which is identified by the decomposition sub-process, by using a set of EPE data associated with the constituent activity.

NOTE 1 In situations where the EPE data are already in a suitable unit of measure for subsequent calculations, the converted EPE data are the same as the EPE data prior to conversion.

The summation sub-process totals all converted EPE data associated with every constituent activity of the manufacturing process to obtain the aggregated EPE data.

NOTE 2 In some situations with complicated decomposition structure, several successive conversions of EPE data can be necessary.

The allocation/charge sub-process is required in cases where some converted EPE data with a constituent activity cannot be obtained directly from a set of EPE data.

NOTE 3 The outline of the interface with the allocation/charge sub-process is explained in 8.4.

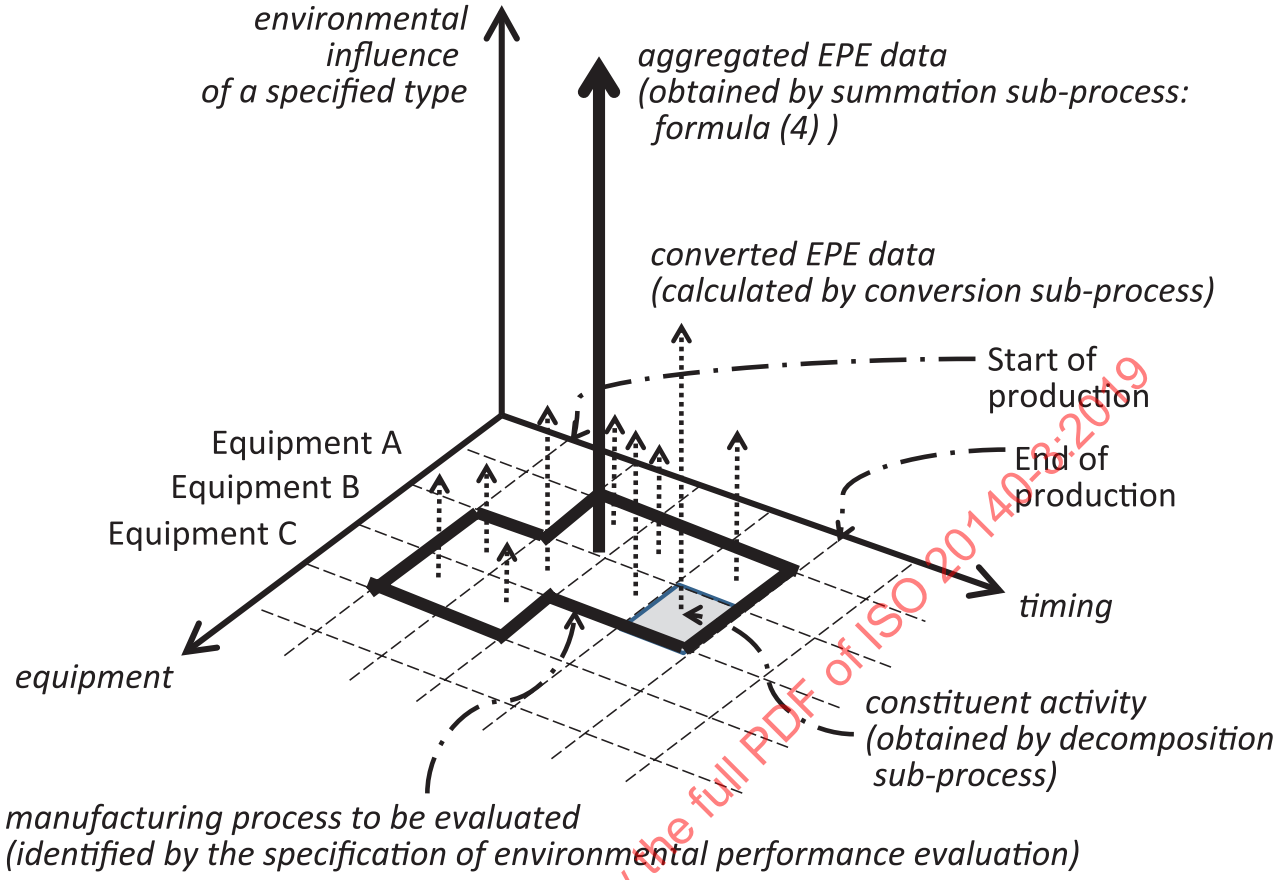

Figure 4 — EPE data conversion and summation

8 Specifications of sub-processes

8.1 Decomposition sub-process

The decomposition sub-process shall decompose a specified manufacturing process in a specified mode into some constituent activities in appropriate granularity taking into consideration a specified type of environmental influence to be evaluated, based on the specification of environmental performance evaluation.

The expression in Formula (1) represents a constituent activity:

$$a< e, t, m_e > \tag{1}$$

where

a represents a constituent activity;

e represents an identifier of a piece of equipment associated with the constituent activity;

EXAMPLE 1 A machine tool, a production machine, material-handling equipment, an auxiliary machine or support facility.

t represents a period of time in which the constituent activity is executed;

NOTE 1 It can be represented by a set of points of time indicating starting and ending of the constituent activity or by a combination of a point of time indicating its starting time and a time duration.

EXAMPLE 2 Time elements in the time model in ISO 22400-2.

m_e is a refinement of a specified mode of a manufacturing process with respect to a piece of equipment associated with the constituent activity.

NOTE 2 According to a structure of a manufacturing system used for a manufacturing process, a specified mode of a manufacturing process is refined to be applied to a piece of equipment associated with the constituent activity.

Formula (2) represents a decomposition sub-process:

$$D(\ p, i, m\ ) \rightarrow (\{a < e, t, m_e >\}, i, m\ ) \tag{2}$$

where

$D(\ )$ represents a decomposition function;

p represents a manufacturing process to be evaluated;

i represents a specified type of environmental influence to be evaluated;

m represents a specified mode of a manufacturing process;

$\{a < e, t, m_e >\}$ represents a set of constituent activities.

8.2 Conversion sub-process

An input to the conversion sub-process is a set of EPE data associated with each constituent activity specified by the decomposition sub-process.

The conversion sub-process shall convert a set of EPE data associated with a specified constituent activity into converted EPE data suitable for use during the summation sub-process. Converted EPE data represents an environmental influence of a specified type, resulting from the constituent activity in a specified mode of the manufacturing process.

EXAMPLE 1 The following are examples of conversion calculations by the conversion sub-process.

— CO_2 emission resulting from combustion of fuel oil for a particular day is calculated by using the following conversion function:

CO_2 emission = (amount of product produced by the day) × (amount of fuel oil consumed to produce a unit of product) × (coefficient related to the characteristics of the fuel oil used)

— Mass flow rate of natural gas (m^3/min) is converted into power value (W).

— Time series data of electric power are integrated over the time period to obtain the electric energy. The associated attribute *t* is used to decide the duration of integration.

— Time series data of heat transfer rate are integrated over the time period to obtain the heat energy. The associated attribute *t* is used to decide the duration of integration.

— Time series data of material flow rate are integrated over the time period to obtain the material volume. The associated attribute *t* is used to decide the duration of integration.

