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Machine tools — Environmental evaluation of machine tools —

Part 3: Principles for testing metal-cutting machine tools with respect to energy efficiency

Machines-outils — Évaluation environnementale des machines-outils —

Partie 3: Principes des essais des machines travaillant par enlèvement de métal à l'égard de l'efficacité énergétique

Reference number
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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).

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Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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 39, *Machine tools*.

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.

A list of all parts in the ISO 14955 series can be found on the ISO website.

Introduction

Machine tools are complex products for industrial use to manufacture parts ready for use or semi-finished products. The performance of a machine tool as key data for investment is multi-dimensional regarding its economic value, its technical specification, and its operating requirements which are influenced by the specific application. Therefore, the same machine tool can show quite different energy supplied to the machine depending on the part which is manufactured and the conditions under which the machine is operated. Therefore, the environmental evaluation of a machine tool cannot be considered in isolation from these considerations.

ISO 14955-1 defines an analysis and evaluation procedure for machine tools based on functional units with the intention of a unified approach. ISO 14955-1 enables simplified and general evaluation methods in order to define and assess the energetic behaviour and the individual energetic and/or efficiency weaknesses of a machine tool.

ISO 14955-2 defines the required parameters and procedures for machine tool and machine tool component measurement, including required parameters which are relevant for the assessment of the energetic machine tool behaviour.

The reference scenario introduced in this part reflects the actual machine process in the field under best knowledge. The definition of the reference scenario and its measurement helps to indicate application-dependent improvement potential and the application of the methodology as defined in ISO 14955-1 and related improvement measures for given industrially driven applications.

The ISO 14955 series takes care of relevant environmental impacts during the use stage. Aside from the design and engineering of machine tools, the intended utilization of machine tools is addressed by this document.

Machine tools — Environmental evaluation of machine tools —

Part 3: Principles for testing metal-cutting machine tools with respect to energy efficiency

1 Scope

This document supports the energy-saving design methodology according to ISO 14955-1 and the methods for measuring energy supplied to machine tools and machine tool components defined in ISO 14955-2. This document addresses the environmental evaluation of machine tools during the use stage based on reference scenarios. It contains an example for metal cutting machine tools.

This document defines a methodological approach to assess relevant machine tool operating states based on an individual reference scenario for the energy assessment of machine tools and the integration of energy-efficiency aspects into machine tool design.

This document explains what needs to be measured in line with ISO 14955-1 and ISO 14955-2. Furthermore, it shows how a reference scenario for the measurement of the machine function "processing", according to ISO 14955-1, is evaluated.

An example of how to use this document is given in Annex A.

The results from applying this document are influenced by the effect of user behaviour and manufacturing strategies during the use phase. This document does not support the comparison of machine tools.

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 14955-1:2017, *Machine tools — Environmental evaluation of machine tools — Part 1: Design methodology for energy-efficient machine tools*

ISO 14955-2:2018, *Machine tools — Environmental evaluation of machine tools — Part 2: Methods for measuring energy supplied to machine tools and machine tool components*

DIN 8580:2003, *Manufacturing processes — Terms and definitions, division*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 14955-1, ISO 14955-2 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
reference part
workpiece with defined specification of geometry, material, size, geometric tolerances, surface quality and defined related manufacturing procedure

Note 1 to entry: The reference part is a determined number of geometric elements in given composition and dimension which are manufactured under defined operating states (see [8]).

3.2
reference scenario
individually defined manufacturing process, containing the definition of part handling and the environmental conditions to achieve an individual *reference part* (3.1)

Note 1 to entry: The reference scenario covers machine based and task-based scenarios according to ISO 14955-2:2018.

3.3
discrete part manufacturing
production process in which its output is individually countable, or identifiable by serial numbers, and is measurable in distinct units rather than by weight or volume

Note 1 to entry: Term used in distinction to process manufacturing, e.g. of substances such as plastics, food, beverages or pharmaceuticals.

3.4
mass production
large-scale production
manufacturing of large quantities of standardized products, frequently utilizing assembly line technology

Note 1 to entry: Mass production refers to the process of creating large numbers of similar products efficiently. Mass production is typically characterized by some type of automation, as with an assembly line, to achieve high volume, the detailed organization of materials flow, careful control of quality standards and division of labour.

3.5
tool
device for imparting a desired shape, form, or finish to a material

Note 1 to entry: The desired shape can be achieved by different means, e.g. by material removal, forming, shaping.

3.6
shop floor production
job shop
fabrication-outfit specializing in small quantities of custom-made parts, produced according to customer specifications

Note 1 to entry: Usually, in shop floor production, there is no workpiece defined between machine tool builder/supplier and machine tool user at the time of machine tool acquisition.

Note 2 to entry: In shop floor production, time shares are strongly related to the specific production being executed. A typical utilization of a machine tool in a shop floor production is 8 h/day for 5 days/week.

3.7
energy performance indicator
EnPI
measure or unit of energy performance, as defined by the organization

Note 1 to entry: EnPI(s) can be expressed by using a simple metric, ratio or a model, depending on the nature of the activities being measured.

Note 2 to entry: See ISO 50006 for additional information on EnPI(s)[4].

Note 3 to entry: Examples for organizations are manufacturer, supplier and user.

[SOURCE: ISO 50001:2018, 3.4.4]

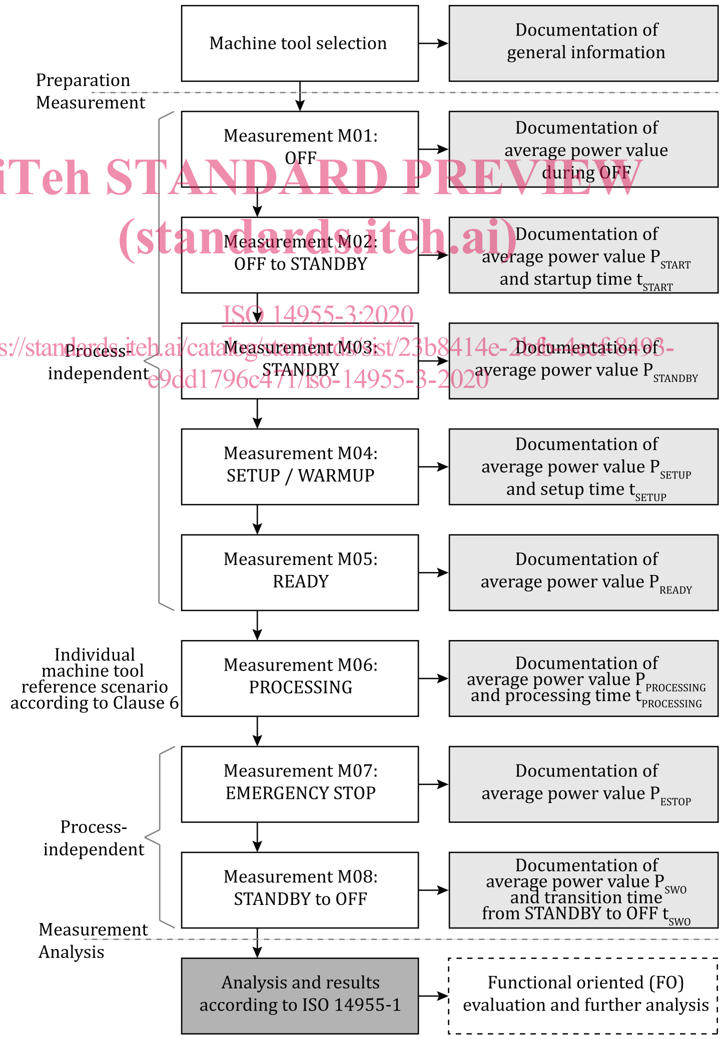
4 General approach for the environmental evaluation of machine tools

4.1 General

This clause describes the procedure for the environmental evaluation of machine tools according to ISO 14955-1. This approach requires the measurement of all possible operating states of the machine tool, including the reference scenario, as defined in Clause 6. Based on this assessment, relevant machine tool operating states can be indicated and assessed and the functional oriented analysis according to ISO 14955-1 can be performed.

Stable conditions are assumed if the difference of the average of the measured value over two measurement periods is not larger than 100 W or ±5 % of the connected load (nominal power).

Figure 1 shows the general approach for the environmental evaluation of machine tools. Detailed information is given in 4.2 to 4.10. Clause 5 shows the results and further assessments based on the performed machine tool measurement.



NOTE STANDBY is a stable state after machine tool is turned ON. This state can include heating on some machine tools.

Figure 1 — General approach for the environmental evaluation of machine tools

In 4.2 to 4.10, each step is explained in detail.

4.2 Step 1 — Documentation of general information

The following table shows the information that shall be given for the intended machine tool assessment.

Table 1 — General information

Information	Description
Company	Company and location where the machine tool is measured
Responsible person	Person in charge of machine tool assessment and measurement service provider (if different from company)
Machine tool manufacturer/ model/serial number	Name and serial number indicating the type and configuration setup of the machine tool
System boundary	According to ISO 14955-2:2018, Clause 6.
Nominal power [kW]	Nominal power [kW] as declared by the machine tool manufacturer
Temperature/humidity during measurement	Indication of conditions during measurement. In order to proof stable conditions the values should be documented at least every 30 min during the measurement
Date and time	Date of performed measurement and duration of the measurement

4.3 Step 2 – Measurement of machine tool state OFF — M01

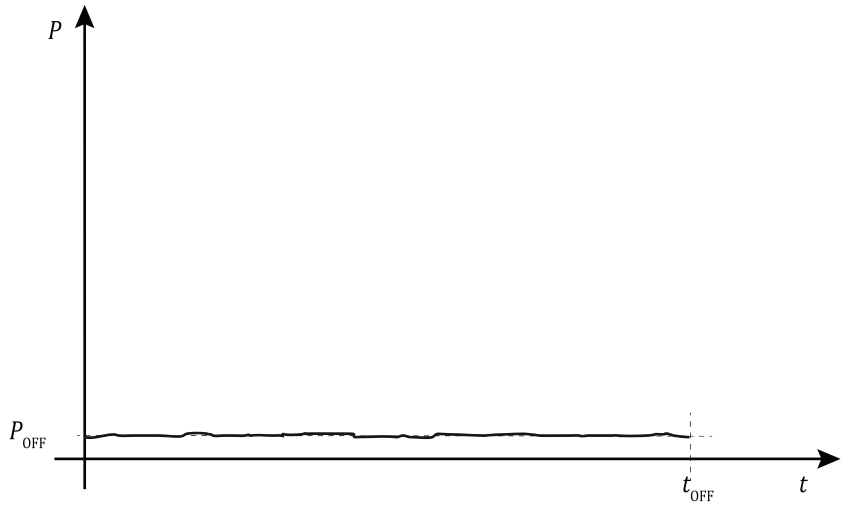
4.3.1 Description

The power, P_{OFF} [kW], including all required external media, e.g. compressed air, according to the system boundary definition of the machine tool are measured during OFF. The main switch is off. The measurement shall be performed when steady-state conditions are reached and should last for at least 300 s (default value). If this condition is not fulfilled, measurements shall last longer.

NOTE This measurement aims to indicate compressed air leakage and/or active components during OFF, e.g. monitoring modules. This machine tool state is independent of the process.

4.3.2 Measurements

Measurement of power during machine tool state OFF, as exemplified in Figure 2.



Key

P power [kW]

t time [s]

P_{OFF} average power [kW] during machine tool state OFF

t_{OFF} measurement time [s] during machine tool state OFF

Figure 2 — Example of measurement of power during machine tool state OFF

4.3.3 Documentation

Table 2 shows the required values for machine tool state OFF.

Table 2 — Required values for machine tool state OFF

Required value	Unit	Description
P_{OFF}	kW	Average power during machine tool state OFF
t_{OFF}	s	Default value is 300 s. It is required to document the duration of the measurement, even if it is equal to the default duration.

4.4 Step 3 — Measurement of transition from machine tool state OFF to STANDBY (START) — M02

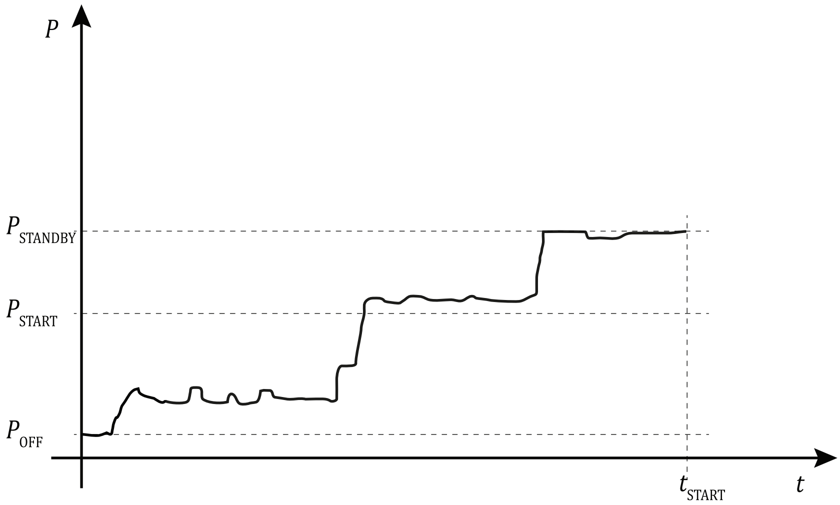
4.4.1 Description

The power, P_{START} [kW], including all required external media, e.g. compressed air, according to the system boundary definition of the machine tool is measured during the transition from OFF to STANDBY. The main switch is turned from OFF to ON. The machine starts up until it reaches a steady state (STANDBY). P_{START} represents the average power value during machine tool start up. This measurement does not contain axis reference or any movement of axis.

NOTE This measurement aims to indicate the required time for machine tool start-up and related component activity. The duration of the start-up depends on the machine tool.

4.4.2 Measurements

Measurement of power during transition from machine tool state OFF to STANDBY, as exemplified in Figure 3.



Key

P	power [kW]
t	time [s]
P_{OFF}	average power [kW] during machine tool state OFF
P_{START}	average power [kW] during transition from machine tool state OFF to machine tool state STANDBY
$P_{STANDBY}$	average power [kW] during machine tool state STANDBY
t_{START}	duration of transition from machine tool state OFF to machine tool state STANDBY

Figure 3 — Example of measurement of power during transition from machine tool state OFF to STANDBY

4.4.3 Documentation

Table 3 shows the required values for transition from machine tool state OFF to STANDBY.

Table 3 — Required values for transition from machine tool state OFF to STANDBY

Required value	Unit	Description
P_{START}	kW	Average power during transition from machine tool state OFF to STANDBY
t_{START}	s	Duration of transition from machine tool state OFF to STANDBY. This duration depends on the machine tool.

4.5 Step 4 — Measurement of machine tool state STANDBY — M03

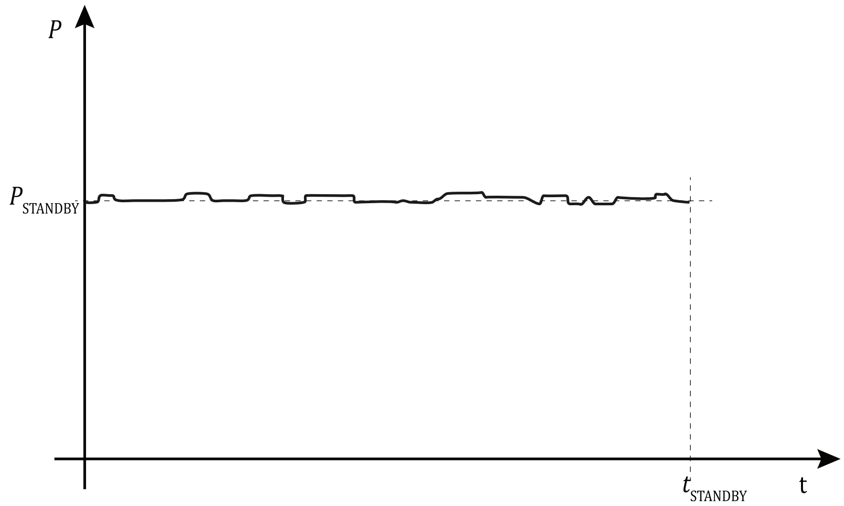
4.5.1 Description

The power, $P_{STANDBY}$ [kW], including all required external media, e.g. compressed air, according to the system boundary definition of the machine tool are measured during STANDBY. The machine tool is in a steady state. The measurement should be performed in stable conditions for a time, $t_{STANDBY}$, of 300 s (default value). Measurement should be performed when stable conditions are reached, for a time, $t_{STANDBY}$, of at least 300 s (default value). If none of these conditions are fulfilled, measurement shall last longer.

NOTE This measurement aims to indicate the required average power during machine tool standby including related component activity. This state is independent of the process.

4.5.2 Measurements

Measurement of power during machine tool state STANDBY, as exemplified in Figure 4.



Key

P power [kW]

t time [s]

$P_{STANDBY}$ average power [kW] during machine tool state STANDBY

$t_{STANDBY}$ measurement time [s] during machine tool state STANDBY

Figure 4 — Example of measurement of power during machine tool state STANDBY

4.5.3 Documentation

Table 4 shows the required values for machine tool state STANDBY.

Table 4 — Required values for machine tool state STANDBY

Required value	Unit	Description
$P_{STANDBY}$	kW	Average power during machine tool state STANDBY
$t_{STANDBY}$	s	Default value is 300 s. It is required to document the duration of the measurement even if it is equal to the default duration.

4.6 Step 5 — Measurement of machine tool state SETUP/WARMUP — M04

4.6.1 Description

The power, P_{SETUP} [kW], including all required external media, e.g. compressed air, according to the system boundary definition of the machine tool is measured during the machine tool process preparation and/or warm up. This measurement includes all required activities for machine tool process preparation. This state can include machine tool-specific warm up times.

NOTE This measurement aims to indicate required activities, e.g. moving of axes, fixing workpiece, cleaning process area and/or warm up time. It shows the required average power during machine tool setup including related component activity. This state depends on the machine tool, in some cases it depends also on the process. Some machine tools do not require the machine tool state SETUP.

4.6.2 Measurements

Measurement of power during machine tool state SETUP, as exemplified in Figure 5.

