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Machine tools — Environmental evaluation of machine tools —

Part 1: Design methodology for energy-efficient machine tools

Machines-outils — Évaluation environnementale des machines-outils —
Partie 1: Méthode de conception pour l'efficacité énergétique des machines-outils

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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 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 by Technical Committee ISO/TC 39, *Machine tools*.

This second edition cancels and replaces the first edition (ISO 14955-1:2014), which has been technically revised with the following changes:

— the former Annexes A and B have been combined into a new Annex A, on energy efficiency improvements, which includes woodworking machine tools.

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

Introduction

As environmental impact is a common challenge for all products and as natural resources become scarce, environmental performance criteria for machine tools need to be defined and the use of these criteria specified.

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 tool depending on the part which is being manufactured and the conditions under which the machine tool is operated. Therefore, the environmental evaluation of a machine tool cannot be considered in isolation from these considerations.

This document proposes to analyse machine tools considering the delivered functions, in order to highlight the commonalities in the huge variety of existing machine tool types. Machine tool components that realize the various functions are objects of specific improvements, keeping in mind the application of the system under evaluation. These improvements are subject for quantification, together with the overall system design to achieve a product with an improved environmental performance. The approach specified in this document is also intended to support environmental improvements on a multi-national level and across different manufacturers/suppliers and users.

Based on a list of positive environmental features which can be built into a machine tool, the performance of the product is intended to be evaluated in order to quantify the environmental improvements achieved over a defined period.

This document provides guidelines for the design and engineering of machine tools with reduced environmental impact, focusing on the energy supplied during the use stage.

Machine tools might have a significant influence on the environmental performance of the manufactured products.

Machine tools — Environmental evaluation of machine tools —

Part 1: Design methodology for energy-efficient machine tools

1 Scope

This document constitutes the application of eco-design standards to machine tools, mainly for automatically operated and/or numerically controlled (NC) machine tools.

This document addresses the energy efficiency of machine tools during the use stage, i.e. the working life of the machine tool. Environmentally relevant stages other than the use stage and relevant impacts other than energy supplied to machine tools are not within the scope and need special treatment (e.g. according to ISO/TR 14062).

Elements of eco-design procedure according to ISO/TR 14062 are applied to machine tools. Reporting of results to users and suppliers and monitoring of results are defined.

Evaluation of energy efficiency implies quantification of the resources used, i.e. energy supplied, and of the result achieved. This document provides guidance for a reproducible quantification of the energy supplied. It does not suggest a methodology for quantifying the result achieved due to the lack of universal criteria. The result achieved in industrial application being machined workpieces, their properties (e.g. material, shape, accuracy, surface quality), the constraints of production (e.g. minimum lot size, flexibility) and other appropriate parameters for the quantification of the result achieved are intended to be determined specifically for each application or for a set of applications.

This document defines methods for setting up a process for integrating energy efficiency aspects into machine tool design. It is not intended for the comparison of machine tools; also, this document does not deal with the effect of different types of user behaviour or different manufacturing strategies during the use phase.

Lists of environmentally relevant improvements and machine tool components, control of machine tool components and combinations of machine tool components are given in Annex A. Annex B provides an example of application of the methodology.

NOTE Certain machining processes and specific machine tools can allow significant changes in the environmental impact of machined workpieces, e.g. material reduction for aluminium cans by application of special press technology, higher performance of compressors by machining on precision form grinders[10][13]. The environmental impact of such processes or machine tools might be less important compared to the environmental impact of the machined workpieces and their application. These changes in the environmental impact of machined workpieces are not subject of this document, but might be important if different machining processes or different machine tools are compared related to environmental impact of products. For instance, the accuracy of a machined workpiece might be a significant parameter for the environmental impact of the workpiece in its use stage, and any attempt to compare machine tools is intended to take this into account necessarily.

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/TR 14062:2002, *Environmental management — Integrating environmental aspects into product design and development*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/TR 14062 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
design and development
set of processes that transforms requirements into specified characteristics or into the specification of a product, process or system

Note 1 to entry: The terms “design” and “development” are sometimes used synonymously and sometimes used to define different stages of the overall process of turning an idea into a product.

Note 2 to entry: Product development is the process of taking a product idea from planning to market launch and review of the product, in which business strategies, marketing considerations, research methods and design aspects are used to take a product to a point of practical use. It includes improvements or modifications to existing products or processes.

Note 3 to entry: The integration of environmental aspects into product design and development may also be termed design for environment (DFE), eco-design, the environmental part of product stewardship, etc.

3.2
environment

surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans and their interrelation

Note 1 to entry: Surroundings in this context extend from within an organization to the global system.

[SOURCE: ISO 14001:2015, 3.2.1]

3.3
environmental aspect
element of an organization's activities or products or services that interact or can interact with the environment

Note 1 to entry: A significant environmental aspect is an environmental aspect that has or can have significant environmental impact.

[SOURCE: ISO 14001:2015, 3.2.2]

3.4
environmental impact
change to the *environment* (3.2), whether adverse or beneficial, wholly or partially resulting from an organization's *environmental aspects* (3.3)

[SOURCE: ISO 14001:2015, 3.2.4]

3.5
life cycle
consecutive and interlinked stages of a product system, from raw material acquisition or generation from natural resources to the final disposal

Note 1 to entry: The stages of a product's life cycle are raw material acquisition, manufacture, distribution, use and disposal (introduction of ISO/TR 14062 based on ISO 14040:2006, 5.2.3).

[SOURCE: ISO 14040:2006, 3.1]

3.6
mode of operation
method of operating and controlling a *machine tool* (3.16), whereby different modes of operation are defined by safety standards for machine tools

Note 1 to entry: Examples for modes of operation are manual mode, automatic mode, setting mode.

Note 2 to entry: Different machine tool activities require certain modes of operation as laid down in safety standards for machine tools.

3.7
operating state
combination of ON, HOLD and OFF etc., settings of mains, peripheral units, machine tool control, machine tool processing unit and machine tool motion units including relevant machine tool activities

Note 1 to entry: Peripheral units are, for example, units for machine tool cooling/heating, process conditioning, workpiece and tool handling, recyclables and waste handling.

Note 2 to entry: Machine tool processing units are, for example, main spindle of a turning machine, tool spindle of a machining centre, generator for electro-discharge machine, slide of a press, draw cushions of a press.

Note 3 to entry: Machine tool motion units are, for example, linear axes of a turning machine, linear and rotary axes of a machining centre, linear axes of a wire electro-discharge machine.

Note 4 to entry: Reference to operating states (e.g. OFF, STANDBY, EXTENDED STANDBY, WARM UP, READY FOR PROCESSING, PROCESSING and CYCLING) requires definition of these states. An example for such a definition for a metal-cutting machine tool is given in Annex C.

Note 5 to entry: Examples for machine tool activities are tool loading, workpiece loading, axes movements, waiting, machine tool operation or cycling, or complete test cycles.

Note 6 to entry: Depending on the operating state and the machine tool activities, a mode of operation is selected as defined by relevant safety standards of machine tools.

3.8
environmental claim
statement, symbol or graphic that indicates an *environmental aspect* (3.3) of a product, a component or packaging

Note 1 to entry: An environmental claim may be made on product or packaging labels, through product literature, technical bulletins, advertising, publicity, telemarketing, as well as through digital or electronic media such as the Internet.

[SOURCE: ISO 14021:2016, 3.1.4]

3.9
environmental claim verification
confirmation of the validity of an *environmental claim* (3.8) using specific predetermined criteria and procedures with assurance of data reliability

[SOURCE: ISO 14021:2016, 3.1.5]

3.10
explanatory statement
explanation which is needed or given so that an *environmental claim* (3.8) can be properly understood by a purchaser, potential purchaser or user of the product

[SOURCE: ISO 14021:2016, 3.1.7]

3.11
functional unit
quantified performance of a product system for use as a reference unit in a *life cycle* (3.5) assessment study

[SOURCE: ISO 14021:2016, 3.1.8]

3.12
machine tool function
machine tool operation (machining process, motion and control), process conditioning, workpiece handling, tool handling or die change, recyclables and waste handling, machine tool cooling/heating

Note 1 to entry: Any machine tool function may be realized by one machine tool component or by a combination of machine tool components. Some machine tool components may realize more than one machine tool function.

Note 2 to entry: Figure 7 shows an example of the relationship between machine tool components and machine tool functions.

Note 3 to entry: Machine tool functions may be used for identifying machine tool components (3.13) relevant for energy supplied to the machine tool.

3.13
machine tool component
mechanical, electrical, hydraulic, or pneumatic device of a *machine tool* (3.16), or a combination thereof

3.14
qualified environmental claim
environmental claim (3.8) which is accompanied by an *explanatory statement* (3.10) that describes the limits of the claim

[SOURCE: ISO 14021:2016, 3.1.15]

3.15
self-declared environmental claim
environmental claim (3.8) that is made, without independent third-party certification, by manufacturers, importers, distributors, retailers or anyone else likely to benefit from such a claim

[SOURCE: ISO 14021:2016, 3.1.16]

3.16
machine tool
mechanical device which is fixed (i.e. not mobile) and powered (typically by electricity and compressed air), typically used to process workpieces by selective removal/addition of material or mechanical deformation

Note 1 to entry: Machine tools operation can be mechanical, controlled by humans or by computers. Machine tools may have a number of peripherals used for machine tool cooling/heating, process conditioning, workpiece and tool handling (workpiece feeding excluded), recyclables and waste handling and other tasks connected to their main activities.

3.17
energy efficiency
relationship between the result achieved and the resources used, where resources are limited to energy

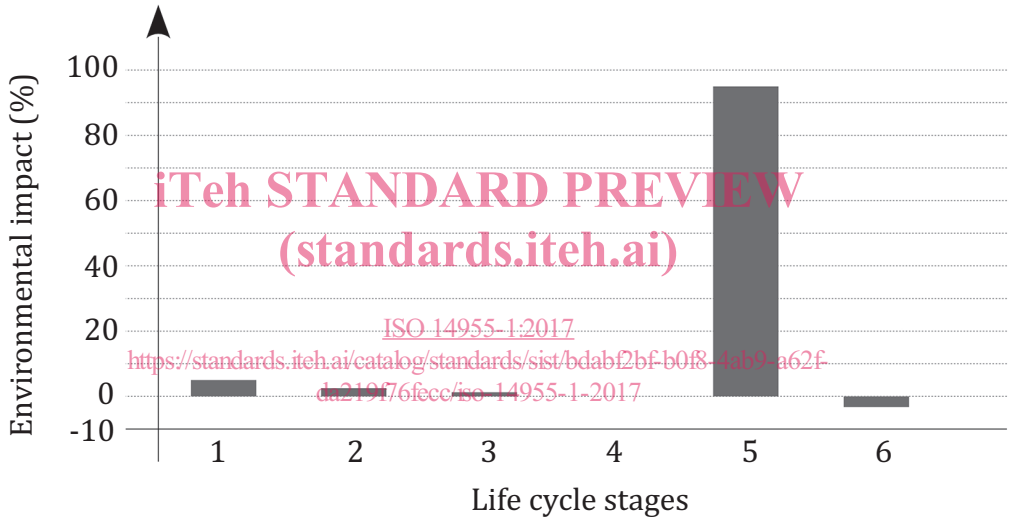
Note 1 to entry: Efficiency is defined as relationship between the result achieved and the resources used (ISO 9000:2015, 3.7.10).

Note 2 to entry: Statements of energy efficiency can be given e.g. in cycles per total energy supplied, in workpieces per energy supplied. If machining of test pieces is involved, specification of workpiece machining and quality of workpiece are part of the definition of the result.

4 Restriction to energy efficiency during use stage

For the environmental impact of a machine tool, different stages of the product life cycle shall be investigated: acquisition of raw material for the machine tool, manufacturing of the machine tool, transportation of the machine tool, installation of the machine tool, use of the machine tool, and recycling of the machine tool (for more details on life cycle assessment, see ISO 14040).

If the environmental impacts are compared in the different stages of a machine tool, the typical profile is as shown in Figure 1, which gives the profile of a NC milling machine. The largest impact is in the use stage, and the largest contributor in the use stage is the energy supplied to the machine tool. This is the result of many life cycle assessments for machine tools[8][11][12][14] if the machine tool is used for 8 h a day/5 d a week or more, which is typical for the use of machine tools in an industrial manufacturing environment.



Key

1	raw material	4	set-up
2	production	5	use
3	transport	6	recycling

Figure 1 — Typical environmental impacts during life cycle stages for an NC milling machine tool

Therefore, ISO 14955 concentrates on the evaluation and improvement of machine tool energy efficiency during the use stage.

If the machine tool is not used in a typical industrial manufacturing environment, a complete life cycle assessment, e.g. according to ISO 14040, might be needed in order to identify the relevant environmental impacts. Measures other than increasing energy efficiency during use stage to change the environmental impact might be of importance.

5 Integrating environmental aspects into machine tool design and development (design procedure for energy-efficient machine tools)

5.1 General

This is the application of ISO/TR 14062 for achieving energy-efficient machine tools in the use stage.

5.2 Goal and potential benefits

The goal of integrating environmental aspects into machine tool design and development is the reduction of adverse environmental impacts of machine tools, especially the increase of energy efficiency during the use stage of the average machine tool in an industrial manufacturing environment.

Benefits for the machine tool supplier/manufacturer and user may include the following:

— energy efficiency during use stage;

— cost reduction in machine tools operations;

— potential cost reduction of machine tool components, e.g. by downsizing of drives and electric components;

— increased competitiveness of the metal working sector;

— stimulation of innovation and creativity;

— enhancement of organization image and/or brand;

— attraction of financing and investment, particularly from environmentally conscious investors;

— enhancement of employees' motivations;

— increased knowledge about the product;

— improved relations with regulators.

5.3 Strategic considerations

Strategic considerations that are taken into account for integration of environmental aspects into machine tool design and development may include the following:

— organizational issues, (e.g. competitor's activities, machine tools user's needs, requirements and demands), organization's environmental aspects and impacts, activities of regulators and legislators, activities of industry associations;

— product-related issues such as early integration, (i.e. addressing the environmental aspects early in the design and development process), functionality (i.e. how well the product suits the purpose of the machine tool user in terms of usability, useful lifetime, productivity, accuracy, etc.), multi-criteria concept (i.e. consideration of all relevant impacts and aspects), and trade-offs (i.e. seeking optimal solutions);

— communication (e.g. internal communication to employees on product-related environmental impacts, training courses on environmental issues, programmes, and tools, site-specific impacts on the environment, and feedback from employees), external communication on product properties (performance and environmental aspects), and proper use of machine tool.

5.4 Management considerations

Top management support and action should enable effective implementation of procedures and programmes to integrate environmental aspects in design and development of machine tools, including

allocation of sufficient financial and human resources and time for the tasks involved. An effective programme should engage those involved in product design and development, marketing, production, environment, procurement, service personnel, and machine tool users. More detailed aspects on the multidisciplinary approach are given in ISO/TR 14062:2002, 6.5.

Details on how to formalize management's commitment and how to establish the organization's framework to integrate environmental aspects into machine tool design and development are given in ISO/TR 14062:2002, 6.2.

The integration of environmental aspects in machine tool design and management can be supported by existing management systems, e.g. management systems according ISO 14001 or ISO 9001. This integration can also influence the supply-chain management; for details, see ISO/TR 14062:2002, 6.6.

5.5 Machine tool design and development process

An overview of integrating environmental aspects into the design and development process of machine tools is given in Figure 2.

NOTE Additional details are listed in ISO/TR 14062:2002, Clause 8. Eco-performance indicators, e.g. according to ISO 14031, might be rather useful for formulating measurable targets and transferring the targets into specifications.