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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 de machines-outils économes en énergie

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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.

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The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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ISO 14955-1 was prepared by Technical Committee ISO/TC 39, *Machine tools*

ISO 14955 consists of the following parts, under the general title *Environmental evaluation of machine tools* —

— *Part 1: Design methodology for energy-efficient machine tools*

— *Part 2: Testing energy supplied to system*

— *Part 3: Test pieces/test procedures and parameters for metal cutting machine tools*

— *Part 4: Test pieces/test procedures and parameters for metal forming machine tools*

Introduction

As environmental impact is a common challenge for all products and as natural resources become scarce, environmental performance criteria for machine tools have to be defined and the use of these criteria has to be 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 depending on the part which is being 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.

This standard tries to overcome this deficiency by breaking down the machine tool to machine components which come closer to a functional unit for environmental evaluation. The machine components are objects of specific improvements keeping the application of the system in mind. These improvements are subject for quantification together with the overall system design to achieve a product with an improved environmental performance. The provisions and procedures specified in this standard should also allow the calculation of 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 this product shall be evaluated in order to quantify the environmental improvements achieved over a defined period.

The standards series 14955 will take care of relevant environmental impacts during the use stage. Besides the design and engineering of machine tools also the utilisation of these products will be addressed.

Machine tools as manufacturing devices might have a significant influence on the environmental performance of the products being manufactured together with their final use stage. This aspect has to be treated very sensitively and might produce quite different results, when an assessment is made with a broader definition of the system boundaries.

Machine tools — Environmental evaluation of machine tools —

Part 1:
Design methodology for energy-efficient machine tools

1 Scope

This standard is the application of eco-design standards to machine tools, mainly for metal working numerically controlled (NC) machine tools.

This standard addresses the energy efficiency of machine tools during the use stage, i.e. the working life of the machine tool. Environmental relevant stages other than the use stage and other relevant impacts than energy supplied to machine tools are not within the scope of this standard and need a special treatment, e.g. according to ISO/TR 14062:2002.

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.

This part of ISO 14955 is not for the evaluation of machine tools, but for setting up a process for integrating environmental aspects into product design and development and evaluating the integration of design procedures for energy efficiency. This part of ISO 14955 does not deal with the effect of different user behaviour or different manufacturing strategies during the use phase.

Lists of environmentally relevant improvements and machine components, control of machine components and combinations of machine components are given in two informative annexes, one for metal cutting machine tools (Annex A) and one for metal forming machine tools (Annex B). Other machine tools, e.g. laser cutting machine tools, material additive machine tools, woodworking machine tools, are currently not covered by informative annexes.

NOTE Certain machining processes and specific machine tools may 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 [3, 5]. 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 standard, but might be important if different machining processes or different machine tools have to be compared related to environmental impact of products. However, the accuracy of a machined workpiece might be a significant parameter for the environmental impact of the workpiece in its use stage.

2 Normative references

The following referenced documents are indispensable for the application 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 9000:2005, *Quality management systems -- Fundamentals and vocabulary*

ISO 14001:2004, *Environmental management systems -- Requirements with guidance for use*

ISO 14021:1999, *Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)*

ISO 14031:1999, *Environmental management -- Environmental performance evaluation -- Guidelines*

ISO 14040:2006, *Environmental management -- Life cycle assessment -- Principles and framework*

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

3 Definitions

For the purpose of this document, the terms and definitions given in ISO/TR 14062:2002 and the following apply.

3.1
design and development
set of processes that transforms requirements into specified characteristics or into the specification of a product, process or system

[ISO 9000:2005, 3.4.4]

NOTE 1 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 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 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 Surroundings in this context extend from within an organization to the global system.

[ISO 14001:2004, 3.5]

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

NOTE A significant environmental aspect is an environmental aspect that has or can have significant environmental impact.

[ISO 14001:2004, 3.6]

3.4
environmental impact
any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's environmental aspects

[ISO 14001:2001, 3.7]

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

[ISO 14040:2006, 3.1]

NOTE The stages of a product's life cycle are raw material acquisition, manufacture, distribution, use and disposal (Introduction of ISO/TR 14062:2002 based on 5.2.3 of ISO 14040:2006).

3.6
modes of operation
types of operating and controlling a machine tool, whereby different modes of operation are defined by safety standards for machine tools

NOTE 1 Examples for modes of operation are manual mode, automatic mode, setting mode.

NOTE 2 Different machine activities require certain modes of operation as laid down in safety standards for machine tools.

3.7
operating states
defined combinations of ON, HOLD and OFF states of mains, peripheral units, machine control, machine processing unit and machine motion unit including machine activities when operating state is other than OFF

NOTE 1 Peripheral units are e.g. units for machine cooling, process cooling, workpiece and tool handling, recyclables and waste handling.

NOTE 2 Machine processing units are e.g. 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 Machine motion units are e.g. linear axes of a turning machine, linear and rotary axes of a machining centre, linear axes of a wire electro-discharge machine.

NOTE 4 For measurement and testing energy efficiency of machine tools operating states like OFF, STAND BY, EXTENDED STAND BY, WARM UP, READY FOR OPERATION, PROCESSING, CYCLING, have to be defined (see e.g. ISO 14955-2). An example for such a definition for a metal-cutting machine tool is as follows:

Examples of operating states	Mains	Machine control	Peripheral units	Machine processing unit	Machine motion unit	Machine axes
OFF	OFF	OFF	OFF	OFF	OFF	NOT MOVING
STAND BY WITH PERIPHERAL UNITS OFF	ON	ON	OFF	OFF	OFF	NOT MOVING
STAND BY WITH PERIPHERAL UNITS ON	ON	ON	ON 1)	OFF	OFF	NOT MOVING
READY FOR OPERATION	ON	ON	ON 1)	HOLD	HOLD	NOT MOVING
WARM UP	ON	ON	ON 1)	ON NO MACHINING	ON	MOVING
PROCESSING	ON	ON	ON 1)	ON MACHINING	ON	MOVING

1) ON for peripheral unit might be just the state ENABLED, because operation of peripheral unit might depend on additional conditions, e.g. operation of workspace cooling unit might depend on environmental temperature.

NOTE 5 Examples for machine activities are tool loading, workpiece loading, axes movements, waiting, machining or cycling, or complete test cycles.

NOTE 6 Depending on the operating state and the machine 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 of a product, a component or packaging

NOTE 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.

[ISO 14021:1999, 3.1.3]

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

[ISO 14021:1999, 3.1.4]

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

[ISO 14021:1999, 3.1.6]

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

[ISO 14021:1999, 3.1.7]

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

Note 1 Any machine tool function may be realised by one machine component or by a combination of machine components. Some machine components may realise more than one machine tool function.

Note 2 Figure 7 shows an example relation between machine components and machine tool functions.

Note 3 Machine tool functions may be used for identifying machine components (3.12) relevant for energy supplied to the machine tool.

3.13
machine component

mechanical, electrical, hydraulic, or pneumatic device of a machine tool, or a combination thereof

3.14
qualified environmental claim
environmental claim which is accompanied by an explanatory statement that describes the limits of the claim

[ISO 14021:1999, 3.1.12]

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

[ISO 14021:1999, 3.1.13]

3.16
machine tool
mechanical device which is fixed (i.e. not mobile) and powered (typically by electricity and compressed air), typically used to fabricate metal components of machines by the selective removal or mechanical deformation of metal

Note Machine tools operation can be mechanical, controlled by humans or by computers. Machine tools have also a number of peripherals used for feeding, safety, waste and chip removal, lubrication 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 input

Note 1 Efficiency is defined as relationship between the result achieved and the resources used (ISO 9000:2005, 3.2.15).

Note 2 Statements of energy efficiency can be given e.g. in cycle per total energy supplied, in workpiece 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 have to 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 14040:2006).

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 an NC milling machine. The largest impact is in the use stage, and the largest contributor in the use stage is energy supplied to the machine tool. This is the result of many life-cycle assessments for machine tools [1, 4, 5, 7] if the machine tool is used during 8 hours a day/5 days a week or more, which is typical for the use of machine tools in an industrial manufacturing environment.

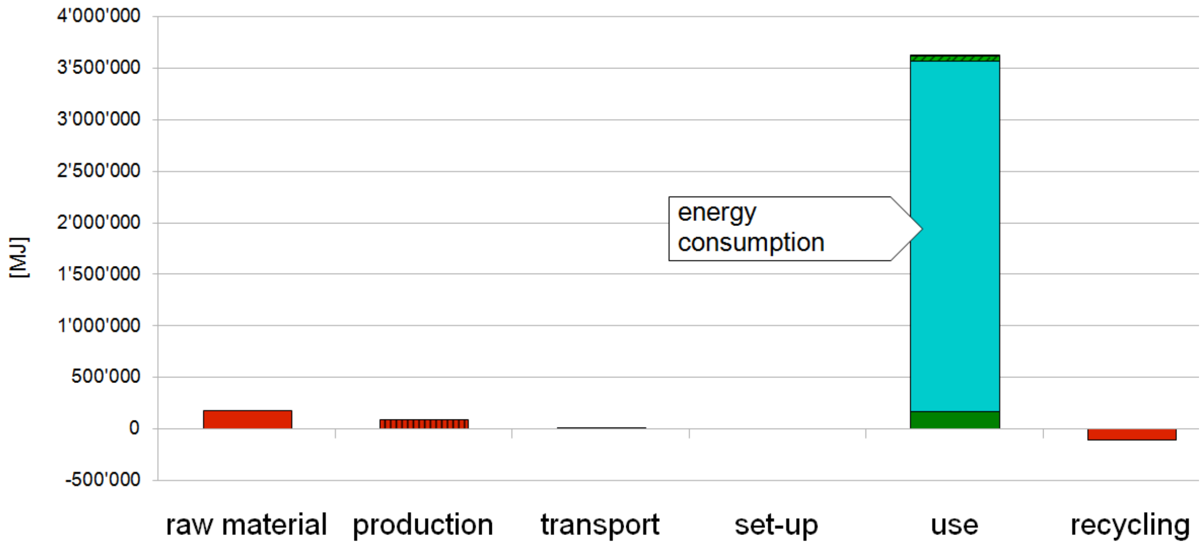

Figure 1 — Example of an eco-profile for a milling machine

Therefore this standard concentrates on the environmental impact, and specifically on the possibility of improving the energy efficiency during the use stage.

NOTE If the machine tool is not used in a typical industrial manufacturing environment a complete life-cycle assessment, e.g. according to ISO 140 40:2006 might be needed in order to identify the relevant environmental impacts. Other measures than increasing energy-efficiency during use stage to change the environmental impact might be of importance.

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

This is the application of ISO/TR 14062:2002 for achieving energy-efficient machine tools in the use stage.

5.1 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:

- energy efficiency during use stage;

- cost reduction in machine tools operations;

- 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.

5.2 Strategic considerations

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

- organizational issues, like 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, like 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; trade-offs, i.e. seeking optimal solutions;

- communication, like 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.

5.3 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, clause 6.5.

NOTE 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, clause 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, clause 6.6.

5.4 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.

NOTEFurther details are listed in ISO/TR 14062:2002, clause 8. Eco-performance indicators, e.g. according to ISO 14031:1999, might be rather useful for formulating measurable targets and transferring the targets into specifications.

