INTERNATIONAL STANDARD

ISO 14955-5

First edition
2020-05

Machine tools — Environmental evaluation of machine tools —

Part 5: Principles for testing woodworking machine tools with respect to energy supplied

Machines-outils — Évaluation environnementale des machines-outils —

Partie 5: Principes d'essai des machines-outils pour le travail du bois concernant l'énergie fournie

Reference number
ISO 14955-5:2020(E)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Fax: +41 22 749 09 47
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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).

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.*

This document is intended to be used in conjunction with ISO 14955-1 and ISO 14955-2.

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

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

Woodworking machine tools are complex products for industrial use to manufacture workpieces ready for use or semi-finished products. Their environmental impact includes waste raw material, use of auxiliary substances such as lubricants and other material flows as well as conversion of electrical energy into heat, dissipation of heat to the ambient or heat exchange by fluids and eventually the use of other resources such as compressed air.

Based on relevance considerations, the ISO 14955 series is focussed on environmental impacts during the use phase.

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. The energy supplied to the same machine tool can vary depending on the workpiece being manufactured and the conditions under which the machine tool is operated. Therefore, the environmental evaluation of a machine tool cannot be done without considering these aspects.

Machine tools — Environmental evaluation of machine tools —

Part 5: Principles for testing woodworking machine tools with respect to energy supplied

1 Scope

This document specifies technical requirements for testing procedures for evaluation of energy supplied during use phase for the design of machine tools to process wood and materials with similar physical characteristics to wood.

This document, along with ISO 14955-1 and ISO 14955-2, covers all significant energy requirements relevant to woodworking machine tools, when they are used as intended and under the conditions foreseen by the manufacturer/supplier.

This document defines relevant operating states, optional shift regimes and optional machine tool activities for several types of woodworking machine tools.

This document also applies to peripheral devices which are supplied as an integral part of the machine. This document also applies to machine tools which are part of an integrated manufacturing system where the energy required is comparable to those of machine tools working separately.

This document applies to the following woodworking machine tools:

— NC boring and routing machines;

— horizontal beam panel sawing machines;

— vertical panel sawing machines;

— edge banding machines fed by chains;

— wide belt calibrating and sanding machines;

— four-sided moulding machines;

— tenoning and/or profiling machines;

— foiling/laminating machines;

— dimension saws and circular saw benches;

— single spindle vertical moulding machines (toupie);

— surface planing, thickness planing, combined surface/thickness planing machines;

— band sawing machines;

— combined machines;

— multi-blade rip-sawing machines;

— presses and bending presses;

— mounting presses.

A list of energy efficiency improvements for woodworking machine tools is given in Annex A.

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, *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*

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
numerically controlled boring and routing machine
NC boring and routing machine
integrated fed machine designed for the machining of workpieces by the use of milling and/or boring tools having at least two orthogonal axes programmable by the user (e.g. X, Y) for positioning and/or machining, where the axes operate in accordance with a NC work programme

[SOURCE: ISO 19085-3:2017, 3.1, modified — Note 1 to entry and the examples have been deleted.]

3.2
horizontal beam panel sawing machine
machine, designed for cutting panels, fitted with one travelling saw carriage per cutting line incorporating one or more circular saw blades

[SOURCE: ISO 19085-2:2017, 3.1, modified — Note 1 to entry has been deleted.]

3.3
vertical panel sawing machine
machine designed for cutting panels where the workpiece is supported in a near vertical plane during cutting and where the saw unit is mounted in front of the workpiece support

[SOURCE: ISO 19085-4:2018, 3.1, modified — Note 1 to entry has been deleted.]

3.4
edge banding machine fed by chains
machine designed for banding in one pass the edge band on one end of the workpiece (single end edge banding machine) or on both ends of the workpiece (double end edge banding machine), consisting of an edge banding zone with various units (e. g. heating, bonding, and pressing for flexible or solid edges) and of a zone for additional operations such as snipping, trimming, milling, sanding, polishing, chamfering etc., in addition the edge banding zone, can be preceded by a sizing/profiling zone

[SOURCE: ISO 18217:2015, 3.1, modified — Note 1 to entry and Figure 1 have been deleted.]

3.5
wide belt calibrating and sanding machine
machine used to calibrate and/or to sand panels and/or linear workpieces, fitted with an integrated feed and sanding belts positioned above and/or below the workpiece level, with manual or automatic loading and/or unloading

[SOURCE: ISO 19085-8:2018, 3.1, modified — In the term, "wide belt" has been added; the Notes to entry, Figure 1 and Figure 2 have been deleted.]

3.6
four-sided moulding machine
machine for four-sided longitudinal processing with four or more working units with spindles, which can be equipped with planing and/or moulding tools, at least one unit on each side of the workpiece, and with integrated feed of the workpiece

3.7
tenoning and/or profiling machine
machine designed for production of a tenon and/or profile on one side of the workpiece (single end machines) or on opposing sides of the workpiece (double end machine) in one pass, where the tenons and/or profiles are cut by means of milling tools and/or saw blades mounted on one or more spindles (on each machine half), and where the workpiece is fed manually or mechanically

3.8
foiling/laminating machine
machine tool to foil/laminate flat surfaces with sheets or rolls of, for example, high gloss foils or foils of paper

Note 1 to entry: Example of a flat surface is a board.

3.9
dimension saw
hand-fed machine fitted with a single main circular saw blade, which is fixed in position during the cutting operation, and a sliding table adjacent to the saw blade

[SOURCE: ISO 19085-5:2017, 3.1, modified — The Notes to entry and Figure 1 have been deleted.]

3.10
circular saw bench
table saw
hand-fed machine fitted with a single main circular saw blade which is fixed in position during the cutting operation, and a horizontal table fixed during operation

[SOURCE: ISO 19085-9:2017, 3.1, modified — The Notes to entry and Figure 1 have been deleted.]

3.11
single spindle vertical moulding machine
toupie
hand-fed machine fitted with a single vertical spindle (interchangeable or not interchangeable), which is fixed in position during cutting operation and a horizontal table, which is fixed in total or in part during cutting operation

[SOURCE: ISO 19085-6:2017, 3.1, modified — "toupie" has been added as admitted term. In the definition, "arbor" has been replaced with "spindle". The Notes to entry and Figure 1 have been deleted.]

3.12
surface planing, thickness planing, combined surface/thickness planing machine
machine designed for cutting off layers of the upper or lower surface of a workpiece by a cutter-block rotating around a horizontal axis, mounted at right angles to the infeed direction between two tables or above a table designed to position and support the workpiece that is fed into the machine against the direction of the cut

[SOURCE: ISO 19085-7:2019, 3.2 to 3.4, modified — The 3 definitions have been merged.]

3.13
band sawing machine
sawing machine with one saw blade in the form of a continuous band mounted on and running between two or more band saw blade wheels

3.14
combined machine
machine incorporating two or more separately usable working units, i.e. a sawing unit, a moulding unit and/or a planning unit

[SOURCE: ISO/FDIS 19085-11:2019, 3.1, modified — The Notes to entry have been deleted.]

3.15
multi-blade rip-sawing machine
machine designed to be used with circular saw blades at different positions on the spindles which are fixed in position during cutting, where the workpiece is fed to the tools by an integrated power feed, i.e. rollers, or chain conveyor

[SOURCE: ISO/FDIS 19085-13:2019, 3.1, modified — The Notes to entry have been deleted.]

3.16
press
bending press
machine used to laminate and/or join together flat panels consisting of solid wood and wood-based materials such as chipboard, fibreboard, plywood, where pressing force is applied between two flat surfaces by actuators pushing top or bottom surface against each other, and loading and/or unloading is manual and gluing and/or shaping process is cold

[SOURCE: ISO/FDIS 19085-15:2019, 3.1 to 3.3, modified — The 3 definitions have been merged.]

3.17
mounting press
machine used to assemble cabinets, window frames, and similar products

3.18
chips and dust extraction system
CADES
system used for extraction, conveyance, separation and temporary storage of chips and dust from woodworking machine tools

4 Basics for measurement and calculation of energy supplied

4.1 General

Ambient conditions according to ISO 14955-2:2018, 4.2, shall be reported.

Stable conditions are assumed if the average power from two random measurements differ less than ±5 % of the nominal power of the connected load or not larger than 100 W.

Examples of machine tool components that are supplied with energy are listed in Table 1.

Table 1 — Examples of machine tool components that are supplied with energy

Machine tool component	Example
Machine CONTROLS	PC, CNC, auxiliary circuits
PERIPHERAL UNITS	Chiller, cabinet cooling Chip conveyor, vacuum pump, lighting, cleaning blow
PROCESSING UNITS	Glue or edge melting unit tool spindles, sanding belts unit
MOTION UNITS	Format change axis Process axes, including feeding

Descriptions of operating states are given in 4.2 to 4.6.

4.2 Operating state OFF

The main switches for electrical power supply shall be OFF.

The compressed air supply isolation valves shall be closed.

The air flow at each extraction connection outlet of the machine tool is assumed to be zero.

4.3 Operating state ON

The main switches for electrical power supply shall be ON.

The compressed air supply isolation valves shall be open.

The measurement shall be performed after more than 60 min of OFF state or when stable conditions are reached. The measurement shall last at least 5 min.

The electrical power measured is mainly the power applied to PC, CNC, control system, auxiliary circuits. Compressed air flow is mainly sealing air, if existent, or due to leakage.

In this state, manual operated tool change or manual operated tool magazine loading/unloading or die change can be done, when operating state STANDBY is not provided.

4.4 Operating state STANDBY

In this state, all available energy saving features of the machine tool shall be activated.

The measurement shall be performed 10 min after PROCESSING state has ended.

The average power shall be measured over a time of at least 5 min.

In this state, manual operated tool change or manual operated tool magazine loading/unloading or die change can be done.

4.5 Operating state WARM UP

WARM UP is the transition from STANDBY or ON, if STANDBY is not provided, to PROCESSING.

The measurement shall be performed after more than 30 min of STANDBY or ON, if STANDBY is not provided.

The average power shall be measured over the full time of the transition. The WARM UP time shall be reported.

4.6 Operating state PROCESSING

As this is the operating state the machine tool is made for, power measured at the system boundary shall be converted to energy.

The definition of this operating state is left to the agreement between manufacturer/supplier and user.

Workpiece loading/unloading are included in this operating state.

5 Evaluation of energy supplied to different types of woodworking machine tools

5.1 General

Measuring equipment installed shall not reduce the level of safety of the machine tool.

For each operating state, energy supplied shall be reported in terms of:

a) measured average electric active power in kW supplied to the machine and its peripherals;

b) measured average pneumatic air flow in Normal-litre/h (N.L./h) supplied to the machine and its peripherals;

c) calculated average air flow in m^3/h (anr) of contaminated airflow extracted from the machine and related pressure drop.

   This value shall be assumed as 0 m^3/h (anr) in operating state OFF.

   For all other operating states, it shall be conventionally calculated as the sum of average airflows through all extraction hoods of the machine tool. Each of these average airflows shall be calculated multiplying the theoretical maximum airflow through the extraction hood when the related gate valve is fully open, for the ratio of the time share during which the gate valve remains fully open and the total duration of the considered operating state.

NOTE 1 In all operating states other than OFF, it is assumed that CADES is activated.

NOTE 2 The user can truly benefit from machines with gate valves management only if the CADES is provided with the possibility to manage variable air flows with automatic reaction.

Measured values for compressed air and contaminated air flow shall be converted to electrical energy according to ISO 14955-2:2018, 7.9, in order to apply ISO 14955-1.

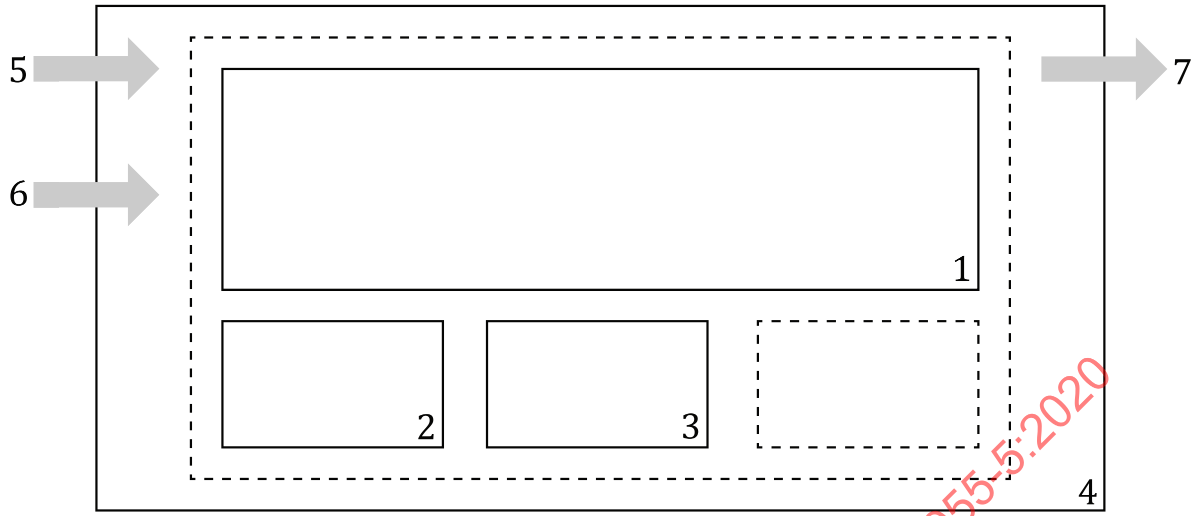
In particular, for operating state PROCESSING, the energy supplied shall be evaluated with reference to each machine tool activity.

The types of energy supplied to be considered at the system boundary are (see Figure 1):

— electrical energy inputs;

— compressed air supply inputs (if any);

— contaminated air flow outputs (if any).



Key

1 machine tool
2 peripheral A
3 peripheral B
4 system boundary
5 electrical energy
6 compressed air
7 contaminated air

Figure 1 — Energy supplied to be considered for woodworking machine tools

Operating states relevant to each woodworking machine tool technology are given in Table 2. Where an operating state is not provided, it shall be declared.

Activities to be considered for operating state PROCESSING shall be agreed between the manufacturer/supplier and the user or conventionally assumed.

Where different edge banding technologies are available on a machine, data for energy supplied in each relevant operating state other than OFF according to Table 2 shall be declared for each technology (e.g. laser, hot air, different glue types).

Table 2 — Relevant operating states depending on the woodworking machine tool technology

Machine tool technology	Relevant operating states				
	OFF	ON	STANDBY	WARM UP	PROCESSING
NC boring and routing machines	✓	✓	✓	Where edge banding facility is provided	✓
Horizontal beam panel sawing machines	✓	✓	✓		✓
Vertical panel sawing machines	✓	✓			✓
Edge banding machines fed by chains	✓	✓	✓	✓	✓
Wide belt calibrating and sanding machines	✓	✓	✓		✓
Four-sided moulding machines	✓	✓	✓		✓
Tenoning and/or profiling machines	✓	✓	✓	For high speed machines (>100m/min)	✓
Foiling/laminating machines	✓	✓	✓	✓	✓
Dimension saws and circular saw benches	✓	✓			✓

Table 2 *(continued)*

Machine tool technology	Relevant operating states				
	OFF	ON	STANDBY	WARM UP	PROCESSING
Single spindle vertical moulding machines (toupie)	✓	✓			✓
Surface planing, thickness planing, combined surface/thickness planing machines	✓	✓			✓
Band sawing machines	✓	✓			✓
Combined machines	✓	✓			✓
Multi-blade rip-sawing machines	✓	✓			✓
Presses and bending presses	✓	✓	✓	✓	✓
Mounting presses	✓	✓			✓

5.2 Test scenarios

A machine-based scenario may be agreed between the manufacturer/supplier and the user following the example given in Table 3, which reflects the operating states relevant for woodworking machine tools.

NOTE Example of machine-based test scenario given in ISO 14955-2:2018, Table 1, does not consider all operating states relevant for woodworking machine tools.

Clustering of time shares for test scenarios shall be done according to ISO 14955-2:2018, 5.2.3.2.

Operating state PROCESSING may be subdivided into different activities.

In alternative to machine-based test scenario, a task-based test scenario may be agreed between the manufacturer/supplier and the user, according to ISO 14955-2:2018, 5.3.

Table 3 — Example for a machine-based test scenario

Operating state	Activity	Time share (h)
OFF	—	0
ON	—	0,5
STANDBY	—	1
WARM UP	—	0,5
PROCESSING (e.g. different activities)	1	1
	2	2
	3	1
	4	2
Total		8

6 Reporting

6.1 Machine tool description

1) Manufacturer/supplier, machine type, serial number, year of construction;

2) machine configuration;

3) description of tools;

4) nominal electrical power;

5) nominal pneumatic pressure and flow;

6) nominal data of contaminated air flow and pressure drop;

7) nominal data (flow and temperature) of external heat supply for presses.

6.2 Measurement setup description

1) Ambient conditions during measurement;

2) if material is processed during test run: material specification;

3) list of measuring points;

4) specification of measurement devices (e.g. brand, accuracy);

5) test scenario details according to 5.2, including description of activities in operating state PROCESSING.

6.3 Results

1) Measurement results according to 5.1 for all operating states;

2) conventional equivalent energy supplied in kWh for the selected testing scenario; for equivalent values (see ISO 14955-2:2018, Annex A) or indication from the user;

3) WARM UP time, if relevant.

Annex A
(informative)

List of energy efficiency improvements for woodworking machine tools

Table A.1 is a non-exhaustive checklist of energy efficiency improvements for woodworking machine tools.

Although the features listed in Table A.1 can generally improve energy efficiency, their implementation should be considered within the given circumstances, the system design, the technologies used, and the application of the machine tool under investigation. Decisions about their implementation can be further subject to consideration of multiple criteria including functionality, standardization, reliability, cost, and others.

“X” in columns from "A" to "P" indicates the applicability and in general the significance for the related woodworking machine tool, see recital.

A	NC boring and routing machines
B	Horizontal beam panel sawing machines
C	Vertical panel sawing machines
D	Edge banding machines fed by chains
E	Wide belt calibrating and sanding machines
F	Four-sided moulding machines
G	Tenoning and/or profiling machines
H	Foiling/laminating machines
I	Dimension saws and circular saw benches
J	Single spindle vertical moulding machines (toupie)
K	Surface planing, thickness planing, combined surface/thickness planing machines
L	Band sawing machines
M	Combined machines
N	Multi-blade rip-sawing machines
O	Presses and bending presses
P	Mounting presses

Table A.1 — Well tried design principles for machine tool components, control components and combinations of machine tool components for energy-efficient woodworking machine tools

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**Overall machine concept**																	
1-1	Minimization of moved masses	If masses are accelerated, the energy required depends on the mass ($E = 1/2*m*v^2$). Even if some part of the energy is recovered during braking, energy is supplied and recovered with an efficiency factor below one. The best way to reduce energy needed for acceleration is mass reduction.	X	X	X	X												
1-2	Reduction of friction	Reduction of friction means less mechanical wear and higher quality and also should lead to energy reduction; various types of bearings possible (rolling bearing, sliding bearing, hydrostatic bearing, magnet bearing); ecological aspect is considered by the choice of bearing as well. Reduction of speed-dependent friction should be optimized with respect to the characteristic of the chosen drive technology.	X	X	X	X	X	X	X		X	X	X	X	X	X		
1-3	Optimization of the overall machine design	Check if the machine tool has been designed according to customer requirements and operational range has been specified close to optimal working point; avoid adding up spare capacities (avoid oversizing/over-engineering).	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
1-4	Design for instant machining without warm-up	Provisions for automatic temperature compensation.																
1-5	Workpiece clamping	Eliminate or minimize energy required to maintain workpiece clamping.	X	X	X		X	X	X									
1-6	Tool unclamping	Minimize energy to unclamp the tool.	X															
1-7	Multi-spindle/multi-workpiece machine tools	Depending on the application, consider multi-spindle or multi-workpiece machine tools. One-time mounting, shared auxiliary units and lower part transfer time deliver higher energy efficiency, compared to several independent machine tools.	X	X			X											
1-8	Minimizing the number of reclamping	Reduction of non-productive time increases energy efficiency.																

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1-9	Combination of various processing technologies	Combination of various processing techno-logies in one machine tool, one-time mounting and adjusting can result in higher quality and higher yield and also causing increased energy efficiency (consider, for example, "turning and milling", "milling, boring and edge banding").	X	X					X									
1-10	Axis clamping	Usage of axis clamping instead of active motor brake.	X		X	X		X										
1-11	Redundant axis	High acceleration with short-stroke axis reducing acceleration for long-range, heavy axis.																
1-12	Increased productivity	Without utilization (production) or low output, the efficiency is degraded, e.g. maximize productivity by adaptive optimization of cutting parameters.																
1-13	Provide customer interaction to reduce supply of resources	Give the operator provisions to intervene when he expects downtime, e.g. button to activate standby condition.	X	X	X	X	X	X	X								X	X
1-14	Tool change during running spindle	Provision to allow a tool change (e.g. boring head) during running spindle to avoid deceleration and acceleration of spindle (milling machine tools used in a way to change tools very frequently).	X															
1-15	Reduce tool changing	Consider allowing multi-profile tools or different tools mounted on the same spindle (e.g. double shaft).	X			X		X	X			X						
1-16	Counterbalance system for vertical axes	Counterbalancing systems reduce the potential energy in vertical moving systems. Additional reduction of accelerating and decelerating (consider, for example, spring-type mounting).	X		X													
1-17	High efficient cushion	Cushions are needed for restraining material flow. Without energy efficiency the energy required is mostly transferred into heat. Minimize energy transferred into heat by using a cushion control system with low-energy consumption or regenerative feedback.																
1-18	Use regenerative circuit for differential cylinders	Reduction of pressure drop on control valves.																

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1-19	Die clamping	Choose clamping system with best efficient technology. Prefer passive clamping systems (consider, for example, spring loaded clamping, electric clamping, magnetic clamping).																
1-20	Handling technologies	Use of handling robots and/or automated handling devices to optimize non-production and setup time.																
2	**Drive units**																	
2-1	Regenerative feedback of inverter system [e.g. servo motor, spindle, Active Front End technology (AFE)]	The in feed unit is capable to feed back the braking energy to the main power supply.	X	X														
2-2	Motors																	
2-2-1	Use of energy efficient motors	Use of an energy efficiency class according to IEC 60034-30 and the motor size (IE/capacity), or use of variable reluctance motors.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2-2-2	Use of magnetic flux control	Magnetic flux to be controlled in order to reduce losses, e.g. on asynchronous motors.	X															
2-3	Use of high-quality reducers	— Use of gear sets quality as defined in International Standards (ISO 1328) — Use of low-friction seals — Optimize lubrication	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2-4	Use of brake for non-moving axes	Axes that are not involved in the interpolation during the part program are switched off (pulses deleted) and clamped by a brake.	X															
2-5	Highly efficient inverter	Use of inverter with highly efficient power device.	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
2-6	Higher voltage systems (e.g. 400 V) to substitute 200 V systems (where applicable)	Higher voltage systems (e.g. 400 V) lead to higher energy efficiency due to reduced ohmic losses.	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
2-7	DC voltage link to balance the energy between different drives	The DC voltage link balances the energy between different drives and can reduce the size of the in-feed unit.	X	X		X												

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
2-8	Optimization of the dynamic parameters	Option to limit the acceleration or speed in the set point signal results in a better exploitation of the motors' efficiency or speed optimization according to the process. In this case, the overload capability of the motor is not utilized.	X	X														
2-9	Optimization of installed motor power	Select motor operating close to optimum of efficiency factor, oversizing and overloading creates energy losses.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2-10	Provide most efficient drive system	Provide most efficient drive system for operating conditions in which the machine tool is mostly working. Compare energy efficiency of different types of drive systems (consider, for example, direct pump drive for processes with short cycle time, accumulator drive for processes with long cycle time) (see 3-1).															X	
2-11	Use of multi-pressure accumulator system for main axis	Multi-pressure accumulator systems reduce pressure drop between accumulator and actuator.															X	
2-12	Direct coupled energy storing drive systems for main drives	Direct coupled energy storage support can reduce installed power of main motors (consider, for example, flywheel).																
2-13	Indirect coupled energy storing drive systems for main drives	Use energy-storing drive systems to reduce power peaks (consider, for example, electrically coupled flywheels, capacitor banks).																
2-14	Intelligent management of drives	Intelligent management of drives turns off energy users when not needed (consider, for example, electric motors).	X	X	X	X	X	X	X	X							X	X
2-15	Minimization of spare capacity/customer specific layout of inverter system	Select an appropriate inverter: — select inverter close to motor size; — oversizing can create energy losses.	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
3	**Hydraulic systems**																	
3-1	Selection of the optimal drive subsystem (motor-pump system)																	

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
3-1-1		Different functions/sequences create the need for pump systems which match the requirements profile (pump combinations, e.g. high pressure/low pressure, variable or fixed-displacement pumps).	X	X													X	
3-1-2		Power on demand depending on the load cycle [constant speed in intermittent operation, variable speed (pole change, speed control/regulation) with servo motors or asynchronous motors].	X	X													X	
3-1-3		Select the correct size and type of motor and pump to avoid over dimensioning and to operate the pump in the optimal efficiency range.	X	X													X	
3-1-4		Temporary storage of hydraulic energy to achieve the best possible match between the pump drive and the load cycle and to compensate for demand peaks (potential downsizing) (consider, for example, accumulator charging operation).															X	
3-1-5		Speed-controlled pumps and variable displacement pumps allow pressure control with variable speed instead of control valve.																
3-2	Match the pressure level to the load cycle and to the different actuators on the machine tool																	
3-2-1		Pressure adjustment using a variable displacement pump, speed-controlled pump or zero-pressure circulation.															X	
3-2-2		Use actuators which are designed to operate at the same pressure level (no pressure reduction losses).															X	
3-2-3		Pressure adjustment using pressure-controlled drive systems (consider, for example, variable speed drives, adjustable-pressure variable capacity pumps).															X	
3-2-4		Use pressure intensifiers for individual actuators which require higher pressure.															X	
3-2-5		On/Off or standby mode, giving due consideration to safety criteria.															X	

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
3-3	Reduce hydraulic losses/leakage																	
3-3-1		Use displacement control systems in place of throttle control systems.															X	
3-3-2		Reduce internal leakage (consider, for example, seat valves in the accumulator charging unit or the clamping hydraulics).															X	
3-3-3		Optimize the design of the hydraulic lines and reduce hydraulic resistance.															X	
3-3-4		Consider distributed supply strategies.															X	
3-3-5		Use of pilot operated valves with low pilot oil consumption.															X	
3-3-6		Use of manifolds with low pressure drops.															X	
3-4	Dimensioning of tubes and pipes	Optimize the design of piping (length, diameter, etc.) and reduce flow resistance. Tubes and pipes cause friction losses and thus energy losses. Finally, the tube or pipe causes a pressure drop which negatively affects the energy efficiency of the machine tool. Length, inner diameter, flow rate, and installation radius of tubes, pipes, and fittings to be optimized to the application. Functions to be identified and described where this requirement is applicable.	X	X													X	
3-5	Increase energy efficiency on solenoid operated valves																	
3-5-1		Use pulse valves (with detent) which only draw power during switching.	X	X													X	
3-5-2		Use valve connectors with built-in automatic reduction of holding current, e.g. Pulse Width Modulation.	X	X													X	
3-5-3		Use valves with 8 W solenoids when applicable. The possible use of low Watt solenoids is depending on the function, because of reduced switching forces.	X	X													X	

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
3-6	Leakage monitoring	Internal leakage leads to energy losses. Leakage monitoring detects exceeding flow (consider, for example, loose fittings in reservoir, worn valves or pumps).															X	
3-7	Low flow resistance	Avoid losses caused by flow resistance (consider, for example, by choosing valve dimension and spring characteristics in respect to optimized pressure drop).	X	X													X	
3-8	High efficient auxiliary pressure generation	Avoid pressure relief valves or pressure reducing valves for pressure adjustment, generate pressure at appropriate level (consider, for example, speed-controlled pumps, pumps with variable flow, discontinuously operating pumps) (see 3-1).															X	
3-9	Warm-up cycle	End warm-up cycle as soon as possible, use actual oil temperature to control warm-up. If applicable change to hydraulic heating instead of electrical heaters in respect to start temperature.															X	
3-10	Oil temperature	Operate in optimal temperature range. Select oil viscosity grade suitable for the expected ambient temperature range.															X	
3-11	Oil cooling	Use water cooling instead of air cooling. Water cooling is more efficient, and water can be used in facility for other purposes. Recovering cooling energy can be used for floor heating, warm water supply, etc.															X	
3-12	Overall system	Optimization of total hydraulic system, e.g. amount of required oil.	X	X													X	
4	**Pneumatic systems**																	
4-1	Optimized compressed air system with minimum losses (differentiation between sealing air and pneumatic drives)																	
4-1-1		Single master switch-off.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4-1-2		Individual switch-off capability for specific modules.	X	X	X	X	X	X	X	X							X	X

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
4-1-3		Intelligent shut-down procedures.	X	X	X	X	X	X	X	X							X	
4-1-4	Leakage prevention	Leak indicator, on-demand monitoring. One of the main avoidable causes of poor energy efficiency is leakage in pressure piping and tubes. Leakage and condition monitoring systems as part of the control system of the machine tool to be implemented in order to easily locate and eliminate leakage.	X															
4-1-5	Reduction of dead volume	Distance between valve and cylinder should be kept as short as possible. Long tubes are dead volumes which cause a major loss of energy in each switching cycles as they are pressurized and exhausted. This amount of compressed air is wasted.	X															
4-1-6	Directed switch off of not needed branches.	Check if all branches of pneumatic circuits need to be pressurized in all operating states of the machine tool. If not, consider switching these branches off in order to prevent energy losses caused by undesired volume.																
4-1-7	Dimensioning of tubes and pipes	Optimize the design of piping (length, diameter, etc.) and reduce flow resistance. Tubes and pipes cause friction losses and thus energy losses. Finally, the tube or pipe causes a pressure drop which negatively affects the energy balance of the machine tool. Length, inner diameter, flow rate, and installation radius of tubes, pipes, and fittings should be optimized to the application.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4-1-8	Correct layout of pneumatic drives	Pneumatic drives, e.g. cylinder forces, should not be oversized. This results in lower air consumption and thus lower use of energy. The layout of the pneumatic system and its components should be tailored to suit the machine tools' needs.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4-1-9	Reduction of pressure	The interaction of pressure supply reduction and machine tool performance should be verified. (Depending on the application, a reduction by 1 bar can result in up to 10 % increased efficiency). The reduction of pressure should not have any negative influence on the correct function of the machine tool.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
4-2	Optimize cylinder force for the required function		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4-3	Sealing air	When larger lots of sealing air (P < 0,2 MPa) are needed (more than 0,3 m^3/min), a small low-pressure compressor, or similar means, is usually much more efficient than compressed air from a pressure-reducing regulator.																
4-4	High efficiency cleaning blowers	Optimized design of cleaning blowers reduces need for air supply.	X	X	X	X	X	X	X									
4-5	Switch off cleaning blowers when not needed by the process	Direct switch off of not needed cleaning blowers prevents losses in air pressure supply when cleaning is not needed.	X	X	X	X	X	X	X									
4-6	Optimized position of sensors	Optimized position of sensors avoids using sensor cleaning blowers.	X	X	X	X	X	X	X									
4-7	Overall system	Optimization of total system after optimization of subsystems.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5	**Vacuum systems**																	
5-1	Use of energy-efficient vacuum pumps	Different pump principles lead to different pump efficiencies. Dry claw pumps are more efficient than rotary vane vacuum pumps.	X		X		X				X							
5-2	Use of speed controlled vacuum pumps (with inverter)	Self-optimized rotation of pump motor according to the vacuum request (with help of a vacuum meter).	X		X		X				X							
5-3	Optimized vacuum control on workpiece support	Manage different vacuum areas on workpiece support.	X		X		X											
6	**Electric systems**																	
6-1	Minimize energy losses in power supplies	Usage of high-efficiency transformer or voltage-proof converters instead of conventional transformers (consider, for example, controlled switching power for auxiliary power 24 V).	X	X	X	X	X	X	X	X								
6-2	High efficiency transformer	Load requirement of a machine tool is not constant during the cycle. Therefore, it is more efficient to install transformers optimized on low Fe-losses instead of transformers optimized on low Cu-losses.																

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
6-3	Apply the simultaneity factor when designing the power system	Avoiding oversizing of power supply leads to lower absolute energy losses. Avoid overload as well.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6-4	Converter/inverter with power factor correction	Regenerative drives can be used to correct the supply line power factor, reducing related power losses	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6-5	Thermal management regarding control cabinet																	
6-5-1		Minimization of waste heat, e.g. use of high efficient components.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6-5-2		If waste heat is not avoidable, it is dissipated (air cooling or water cooling). For reuse of thermal energy, water is preferred over air. Further use of waste heat is checked/discussed with customer.																
6-5-3		Use controlled ventilation (fan) when applicable.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6-5-4		Use low maintenance air conditioner (no air filter) and thermostatic air conditioning with open-door-shut off.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6-6	Lighting systems																	
6-6-1		Use of energy efficient lighting systems.	X	X	X	X	X	X	X	X								
6-6-2		Automatic switch off of lighting systems when not needed.	X	X	X	X	X	X	X	X								
6-7	Overall System	Optimization of overall system after optimization of subsystems.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7	**Process heating system**																	
7-1	Automatic switch off of infrared lamps according to the process		X			X				X								
7-2	Automatic switch off of hot air jet to low consumption mode according to the process	Switching to low consumption mode instead of switching off allows faster reach of working temperature.	X			X				X								
7-3	Automatic switch off of glue pot heating to low consumption mode according to the process	Switching to low consumption mode instead of switching off allows fast reach of working temperature.	X			X				X								

Table A.1 *(continued)*

No.	Feature for improvement	Description	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
7-4	Instant process heating system	Consider, for example, using laser technology for edge banding.	X			X				X								
7-5	Automatic switch of plates heating system to low consumption mode according to the process	Switching to low consumption mode instead of switching off allows a quick return to the processing temperature.															X	
8	**Cooling/lubrication system**																	
8-1	Thermal management of all cooling devices including cooling device for machine tool and/or its modules	Optimized concept for thermal management of all cooling devices regarding the following:																
8-1-1		Minimization of thermal power losses.																
8-1-2		If thermal power loss is not avoidable, it is dissipated by air or water cooling. For reuse of thermal energy, water is preferred over air. Further reuse of thermal energy is checked/discussed with customer (e.g. standardized interface).	X	X		X		X	X									
8-1-3		Use controlled ventilation (fan) when applicable.	X	X		X		X	X									
8-2	Temperature controlled components	Apply direct cooling of components depending on process (cooling at the source).																
8-3	Demand-depending cooling	Apply demand-depending cooling (consider, for example, substituting line connected motors by inverter motors, temperature-controlled coolant water flow, etc.).																