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Verktygsmaskiner – Miljöutvärdering av verktygsmaskiner – Del 4: Principer för mätning av metallbearbetande verktygsmaskiner och laserbearbetande verktygsmaskiner med avseende på energieffektivitet (ISO 14955-4:2019, IDT)

Machine tools – Environmental evaluation of machine tools – Part 4: Principles for measuring metal-forming machine tools and laser processing machine tools with respect to energy efficiency (ISO 14955-4:2019, IDT)

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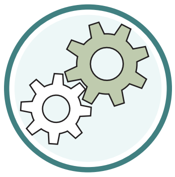

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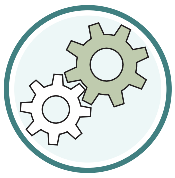

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Den internationella standarden ISO 14955-4:2019 gäller som svensk standard. Detta dokument innehåller den officiella engelska versionen av ISO 14955-4:2019.

The International Standard ISO 14955-4:2019 has the status of a Swedish Standard. This document contains the official English version of ISO 14955-4:2019.

Upplysningar om sakinnehållet i standarden lämnas av SIS, Swedish Standards Institute, telefon 08-555 520 00. Standarder kan beställas hos SIS som även lämnar allmänna upplysningar om svensk och utländsk standard.

Information about the content of the standard is available from the Swedish Standards Institute (SIS), telephone +46 8 555 520 00. Standards may be ordered from SIS, who can also provide general information about Swedish and foreign standards.

Denna standard är framtagen av kommittén för Uppmätning av verktygsmaskiner, SIS/TK 491.

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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).

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).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 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

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.

Machine tools are complex products for used by industry 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 the conversion of electrical energy into heat, the dissipation of heat to the atmosphere 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 manufactured and the conditions under which the machine tool is operated. Therefore, the environmental evaluation of a machine tool cannot be performed without considering of these aspects.

Machine tools — Environmental evaluation of machine tools —

Part 4: Principles for measuring metal-forming machine tools and laser processing machine tools with respect to energy efficiency

1 Scope

This document specifies technical requirements and measures for testing procedures for evaluation of energy required to be adopted by persons undertaking the design, manufacture and supply of metal forming and laser processing machine tools in order to achieve reproducible data about the energy supplied under specified conditions. Furthermore, it provides methods for quantifying the energy supplied to components in order to assign their share to generalized machine tool functions as described in ISO 14955-1.

Along with ISO 14955-1 and ISO 14955-2, it covers all significant energy requirements relevant to hydraulic (servo) and mechanical (servo) presses, turret punch presses and press brakes, pipe benders, laser processing machine tools, when they are used as intended and under the conditions foreseen by the manufacturer. Examples of how to perform energy evaluation on metal-forming machine tools are given in the annexes.

This document is applicable to machine tools which transmit force mechanically or transmit energy by laser light to cut, form, or work metal or other materials by means of dies attached to or operated by slides, punches or beams as well as to lasers ranging in size from small high speed machine tools producing small work-pieces to large relatively slow speed machine tools and large work-pieces. This document covers machine tools whose primary intended use is to work metal, but which can be used in the same way to work other materials (e.g. cardboard, plastic, rubber, leather, etc.).

It also applies to auxiliary devices supplied as an integral part of the machine tool and 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 does not give test procedures for the energy requirements of tools or dies attached to the machine tools.

It is not applicable to machine tools whose principal designed purpose is:

— metal-cutting by milling, drilling or turning;

— metal-cutting by oxygen or water cutting;

— attaching a fastener, e.g. riveting, stapling or stitching;

— bending or folding by folding machine tools;

— straightening;

— extruding;

— drop forging or drop stamping;

— compaction of metal powder;

— single purpose punching machine tools designed exclusively for profiles, e.g. used in the construction industry;

— working by pneumatic hammer;

— working by pneumatic presses.

NOTE Mechanical servo presses are also known as servo electric presses.

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 and 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
press
machine tool designed or intended to transmit energy to a tool/punch for the purpose of the working (e.g. forming or shaping) of metal or other material worked in the same way between the tools

3.2
hydraulic press
hydraulic servo press
press (3.1) designed or intended to transmit energy by linear movement between closing tools by hydraulic means

[SOURCE: ISO 16092-1:2017, 3.1.4, modified — The Note 1 to entry has been deleted.]

3.3
mechanical press
press (3.1) designed or intended to transmit energy from a prime mover to a tool/punch by mechanical means using a clutch mechanism which transmits torque to impart motion of the flywheel to the slide

[SOURCE: ISO 16092-1:2017, 3.1.2, modified — The Note 1 to entry has been deleted.]

3.4
mechanical servo press
press (3.1) designed or intended to transmit energy to a tool/punch by mechanical means using a servo drive mechanism without clutch mechanism to generate torque to impart motion to the slide

[SOURCE: ISO 16092-1:2017, 3.1.3, modified — The Note 1 to entry has been deleted.]

3.5
double action press
press (3.1) containing a die cushion for deep drawing purposes

3.6
press brake
machine tool designed or intended to transmit energy to the moving part of the tools by hydraulic means and/or mechanical means with or without using a servo drive mechanism, principally for the purpose of bending between narrow forming tools along straight lines

3.7
pipe bender
machine tool designed or intended to transmit energy to constrain or strain to tension by bending pipes

3.8
turret punch press
type of *press* (3.1) used to cut holes in material, which can be small and manually operated holding one simple die set, or very large and NC controlled with a single or multi-station turret holding a much larger and complex die set

3.9
laser processing machine tool
machine tool in which (an) embedded laser(s) provide(s) sufficient energy/power to melt, evaporate, or cause a phase transition in at least a part of the workpiece, and which has the functional and safety completeness to be ready-to-use

[SOURCE: ISO 11553-1:2005, 3.2 modified — "machine" is substituted by "machine tool"]

3.10
slide/ram
main reciprocating *press* (3.1) member which holds the tool/punch

[SOURCE: ISO 16092-1:2017, 3.2.12]

3.11
beam
main reciprocating press brake member which normally holds the punch on a down-stroking press brake, and which normally holds the die on an up-stroking press brake

[SOURCE: EN 12622:2009, 3.1.1]

3.12
die cushion
accessory for a die which accumulates and releases, or absorbs, force as required in some *press* (3.1) operations

[SOURCE: ISO 16092-1:2017, 3.2.6]

3.13
tool/die
device for imparting a desired shape, form, or finish to a material

EXAMPLE Hardened steel forms for producing the patterns on coins and medals by pressure, and the hollow moulds into which metal or plastic is forced.

3.14
moving bolster
movable plate carrying the *tools or dies* (3.13) and moving during tool change

3.15
automation system
system for loading and/or unloading of workpieces by highly automatic means, reducing human process intervention to a minimum

3.16
spacer
device to hold a space open [e.g. between slide and moving bolster or between slide and *die cushion* (3.12)] on hydraulic or mechanical presses

3.17
regenerative circuit
shaft side of a double action cylinder connected to the head side, so that fluid exiting the shaft side is added to the fluid entering the head side

3.18
total power
power applied to a machine tool component at the feeding point of the machine tool component

3.19
power loss
loss of power applied to a machine tool component, mostly transferred to heat (e.g. due to friction or throttle losses)

3.20
inverter system
system generating variable frequency to energize electric motors for variable speed, consisting of line reactor and/or line filter and the inverter itself

3.21
dead centre
point at which the tool/punch, during its travel, is:

— either nearest/closest to the die (generally, it corresponds to the end of the closing stroke), known as bottom dead centre (BDC);

— or furthest from the die (generally, it corresponds to the end of the opening stroke), known as top dead centre (TDC)

[SOURCE: ISO 16092-1:2017, 3.2.4]

4 Operating states for measurement procedure

4.1 Operating state OFF

The main switch shall be turned off during measurement.

4.2 Operating state MAIN SWITCH ON

Main switch and control voltage are turned on. The power measured is mainly the power applied to the control system and includes the power applied in operating state OFF.

The power needed for air conditioning of the control cabinets depends on ambient conditions during measurement.

4.3 Operating state AUXILIARY DRIVES ON

The auxiliary drives shall be turned on and the average power shall be measured over a time of at least 15 min. If auxiliary drives are used to charge accumulators for control pressure and an on/off-charging mode is used, the measurement shall be done at least for the time specified in the shift regime and at least 5 charging cycles. If an auxiliary drive is charging an accumulator system, the measurement shall cover at least five charging cycles.

The power measured includes the power applied to the control system when the main switch is on. The difference to the applied power in operating state “MAIN SWITCH ON” is the power applied to the auxiliary drives.

In laser processing machine tools, the oscillator and the chiller are turned on and the warm-up is performed until the heat generated by the oscillator and the heat dissipated by radiation/cooling is balanced.

NOTE The warm-up time can vary between different types of oscillators.

4.4 Operating state MAIN DRIVES ON

The main drives shall be turned on and the average power shall be measured over a time specified in the shift regime.

If the main drives are controlled by inverters (e.g. servo motor) and a rotating drive leads directly to a movement (e.g. of the slide or die cushion), MAIN DRIVES ON is when main drives are powered with rotation speed zero.

The power measured includes the power applied when auxiliary drives are on. The difference to the applied power in operating state AUXILIARY DRIVES ON is the idling power applied to the main drives.

4.5 Operating state READY TO RUN IN PRODUCTION MODE

The power measured includes the power applied to auxiliary functions, e.g. automation systems. The difference to the applied power in operating state MAIN DRIVES ON is the power applied to automation systems.

4.6 Operating state PROCESSING

As this is the operating state the machine tool is designed for, the energy shall be determined by measurement at the system boundary.

The efficiency factor shall be calculated as described in Clause 5 for the different types of machine tools.

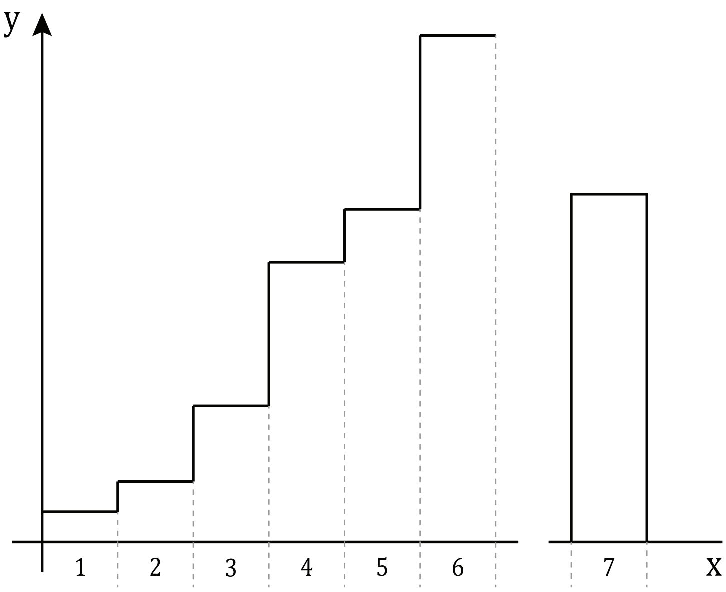
4.7 Operating state TOOL CHANGE

Due to the fact that the tool change sequence is different from production cycle, TOOL CHANGE is seen as a separate operating state and the energy supplied in this state shall be measured. This measurement should be done using tools/dies with a mass typical for the press size and agreed upon between manufacturer and user.

The energy supplied during TOOL CHANGE may be determined using the methodology as described in ISO 14955-2.

4.8 Typical result of power measurement

Figure 1 shows the result of a power measurement supplied in different operating states.



Key

x operating states
1 OFF
2 MAIN SWITCH ON
3 AUXILIARY DRIVES ON
4 MAIN DRIVES ON
y power [kW]
5 READY TO RUN IN PRODUCTION MODE
6 PROCESSING
7 TOOL CHANGE

Figure 1 — Typical average power supplied in different operating states

5 Evaluation of energy supplied to different types of machine tools

5.1 General

Measuring equipment installed shall not reduce the level of safety of the machine tool[1][2][3].

NOTE This reduction can occur, for example, by bypassing of interlocking guard(s), modifications in the safety-related control system or installing stroke-initiating devices in place of two hand control devices.

5.2 Energy supplied to presses

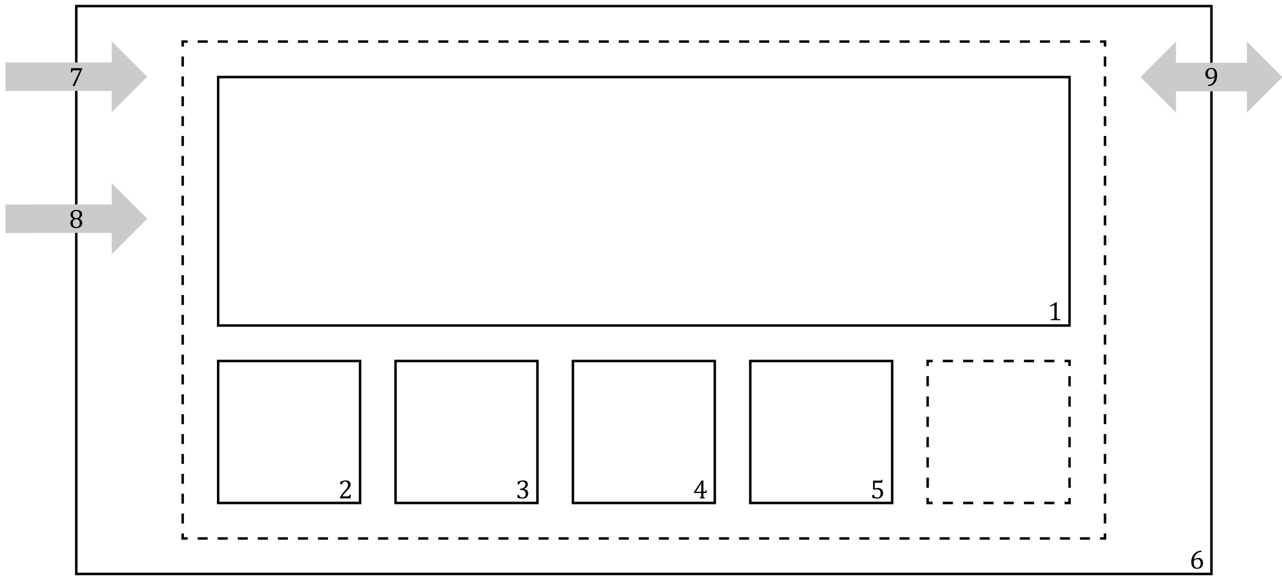
5.2.1 General

Examples for hydraulic and mechanical presses are given in Annex A and Annex B.

5.2.2 System boundary

The energy flow at the system boundary during test-run shall be as close as possible to the energy flow at the system boundary during production.

Figure 2 shows an example for the system boundary of a hydraulic (servo) and mechanical (servo) press.



Key

1 machine tool
2 machine tool component A, e.g. slide
3 machine tool component B, e.g. die cushion
4 machine tool component C
5 machine tool component D
6 system boundary
7 electrical energy
8 compressed air
9 heat exchange

Figure 2 — System boundary of hydraulic (servo) and mechanical (servo) presses

The system boundary during the test-run does not include energy required for dies and/or die functions (e.g. workpiece lifters, die heating in cure processes, die cooling in hot forming processes). These die functions have a broad variety in terms of the type of energy required (e.g. electrical energy, hydraulic energy, steam, die coolant, workpiece lubricant flow) and the amount. Die functions depend on the process and the die itself and not on the machine tool.

5.2.3 Shift regime

As shift regimes are dependent on the equipment (e.g. equipped with automatic or manual tool change) and therefore can be different for each machine tool and machine tool user (e.g. number of tool changes per shift), a specific shift regime according to ISO 14955-2:2018, 5.2.2, can be set up for measurement. The shift regime and the clustered shift regime shall be reported.

5.2.4 Minimum measuring period

The default measuring period is the observation period. During measurement it can be decided to shorten the measuring period. In this case the energy supplied shall be extrapolated to match the respective shift regime. The reason for the shortening shall be stated, e.g. observation of a repetitive pattern or stabilization of power supplied after some time.

In a specific shift regime, the measuring periods for each operating state under stable conditions are at least as given in Table 1.

Table 1 — Minimum measuring periods in specific shift regime

Operating state	Measuring period
1: OFF	5 min
2: MAIN SWITCH ON	5 min

Table 1 *(continued)*

Operating state	Measuring period
3: AUXILLIARY DRIVES ON	10 min
4: MAIN DRIVES ON	10 min
5: READY TO RUN IN PRODUCTION MODE	10 min
6: PROCESSING: INTERMITTENT RUN	30 min and 10 cycles
7: PROCESSING: CONTINOUS RUN (Presses with automatic feeding only)	30 min and 10 cycles
8: TOOL CHANGE	1 complete tool change sequence

The measuring time in operating state processing shall be at least 30 min. If less than 10 cycles are performed during this time (e.g. in presses for curing processes), the measuring shall continue until 10 complete cycles are performed.

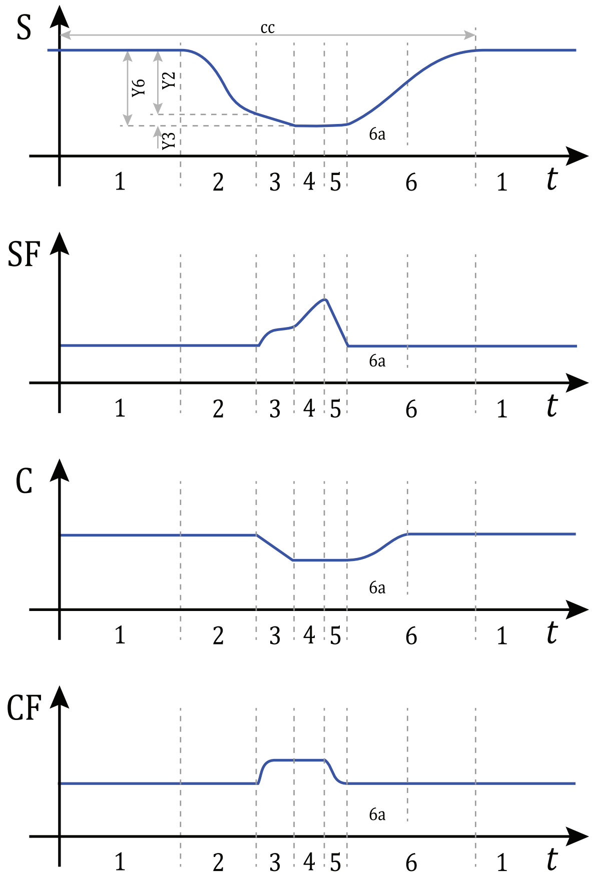
In operating state processing, measurement shall be made on a cycling machine tool. Interruptions (e.g. by failure) leading to a total time of measurement interruption longer than 10 % of the scheduled measuring time requires a restart of the measurement. A total interruption time less than or equal to 10 % of the scheduled measuring time shall prolong the measuring period.

5.2.5 Typical press cycle diagram

Due to the fact that deep drawing processes are one of the most run processes on presses worldwide, this example reflects a typical deep drawing process on a double action downstroking press (on upstroking presses, slide stroke is upside down and formulae are to be matched to this situation). Even if processes other than deep drawing or other presses than double action have different cycle diagrams, the principle of this cycle diagram remains valid.

If an energy recovery/energy saving feature can be disabled by the user, the measurement shall be performed having the energy recovery/energy saving feature engaged as well as disengaged.

In order to obtain detailed information about energy supplied and energy efficiency in the operating state PROCESSING, the press cycle shall be broken down in machine tool activities, see Figure 3.



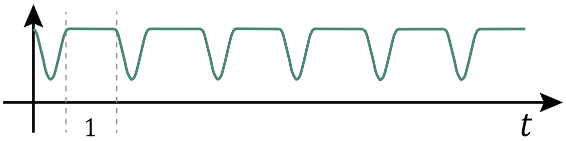
Key

S	slide stroke	
SF	slide force	
C	cushion stroke	
CF	cushion force	
t	time	
1	machine tool activity 1: slide waiting in TDC:	Slide is waiting for start signal while workpiece is loaded into die.
2	machine tool activity 2: slide close:	*S*lide is closing the die.
3	machine tool activity 3: forming:	Slide is forming the workpiece and the cushion is displaced by the slide
4	machine tool activity 4: embossing:	Slide applies set-force in BDC and starts BDC dwell time.
5	machine tool activity 5: decompression:	Decompression of press frame, die cushion and slide cylinder (hydraulic press)/gear and drive mechanism (mechanical press). Decompression is not adjustable by the user.
6	machine tool activity 6: slide return:	Slide moves back to TDC.
6a	machine tool activity 6a: workpiece ejection:	Die cushion lifts workpiece for unloading.
cc	complete cycle	
Y2	slide stroke between TDC and workpiece contact	
Y3	distance the cushion is displaced	
Y6	complete slide stroke	

Figure 3 — Typical press cycle diagram with machine tool activities for a downstroking press

5.2.6 Reference and test cycle for hydraulic (servo) presses in PROCESSING

The press shall be measured in intermittent run and continuous run (press with automatic feeding) for a time period given in the shift regime, see Figure 4.



Key

1 TDC dwell time

t time

Figure 4 — Typical press cycles for hydraulic presses

Table 2 shows set-values for test cycle (if adjustable by the user, values in % are related to nominal value).

Table 2 — Settings for test cycle of hydraulic presses

Machine tool component	Machine tool activity	Parameter	Set-value
Slide	Waiting in TDC (1)	TDC dwell time for manual fed presses with a nominal cycle time of less than 5 s	1 s
		TDC dwell time for manual fed presses with a nominal cycle time of equal or more than 5 s but less than 30 s	4 s
		TDC dwell time for manual fed presses with a nominal cycle time of equal or more than 30 s	8 s
	Closing (2)	Closing stroke (Y2, % of nominal value)	60 %
		Closing speed (% of nominal value)	100 %
	Working (3)	Working stroke (Y3, % of closing stroke)	20 %
		Working speed (% of nominal value)	70 %
	BDC dwell time (4)	Force (% of nominal value)	70 %
		Presses with a nominal cycle time of less than 5 s	0,3 s
		Presses with a nominal cycle time of equal or more than 5 s but less than 30 s	1 s
		Presses with a nominal cycle time of equal or more than 30 s	20 s
	Return (6)	Return stroke (Y6, % of nominal value)	80 %
		Return speed (% of nominal value)	100 %
Die cushion(s)	Die cushion stroke (Y3, % of nominal value)		80 %
	Die cushion force (% of nominal value)		80 %
	Die cushion force (% of nominal value)		80 %
Automation system	Moving speed of all axis		80 %

The press cycle shall take into account the intended manufacturing process (e.g. stamping, forging, curing) to allow realistic energy evaluation. If a press is designed for more than one manufacturing process (e.g. stamping and curing), energy evaluation shall be done for all processes the press is designed for.

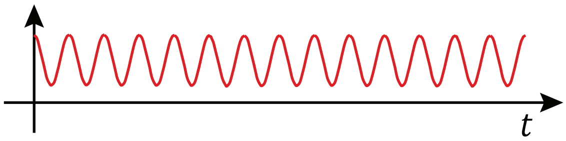
On manually fed presses, the test cycle shall include the time needed for manual feeding (TDC dwell time). On presses with automatic loading/unloading, the test cycle shall imply the operation of the automation system and the TDC dwell time is depending on the cycle time of the automation system.

If energy recovery/conservation means are selectable by the user, measurement shall be made with and without energy recovery/conservation means active.

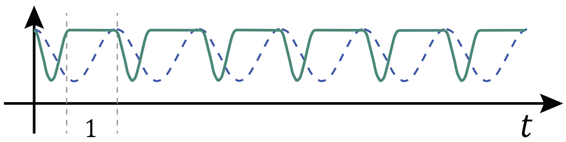
To allow repetitive measurement under reproducible conditions, the energy relevant process data shall be documented in the report.

5.2.7 Reference and test cycle for mechanical (servo) presses in PROCESSING

Figure 5 shows typical press cycles for mechanical (servo) presses.



a) Continuous run @ 70 % SPM



b) Intermittent run @ 30 % SPM and 70 % speed

Key

1 TDC dwell time

t time

Figure 5 — Typical press cycles for mechanical (servo) presses

The press shall be measured in continuous run and intermittent run for a time period given in 5.2.4.

Tables 3 and 4 show set-values for test cycle (if adjustable by the user, values in % are related to nominal value).

Table 3 — Settings for test cycle of mechanical presses

Machine tool component	Parameter	Set-value
Slide	Flywheel speed	70 %
	TDC dwell time for intermittent run of presses with a nominal SPM of equal or more than 12 SPM	1 s
	TDC dwell time for intermittent run of presses with a nominal SPM of less than 12 SPM	2 s
Stroke length adjustment	Stroke length (Y6)	≥80 %
Die cushion(s)	Die cushion force at 25 % cushion stroke (% of nominal value)	30 %
	Die cushion force at 40 % cushion stroke (% of nominal value)	10 %
	Die cushion ejection speed (if adjustable, % of nominal value)	80 %
Automation system	Moving speed of all axis	80 %