BS ISO 14955-4:2019

BSI Standards Publication

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

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee MTE/1, Machine tools.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2019

ISBN 978 0 580 94688 2

ICS 25.080.01

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This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 July 2019.

Amendments/corrigenda issued since publication

Date	Text affected

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INTERNATIONAL STANDARD

ISO 14955-4

First edition
2019-07

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

Machines-outils — Évaluation environnementale des machines-outils —

Partie 4: Principes de mesurage de l'efficacité énergétique des machines-outils de formage des métaux et des machines-outils à laser

Reference number
ISO 14955-4:2019(E)

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Contents

Page

Foreword ... **v**

Introduction ... **vi**

1 Scope ... **1**

2 Normative references ... **2**

3 Terms and definitions ... **2**

4 Operating states for measurement procedure ... **4**
4.1 Operating state OFF ... 4
4.2 Operating state MAIN SWITCH ON ... 4
4.3 Operating state AUXILIARY DRIVES ON ... 4
4.4 Operating state MAIN DRIVES ON ... 5
4.5 Operating state READY TO RUN IN PRODUCTION MODE ... 5
4.6 Operating state PROCESSING ... 5
4.7 Operating state TOOL CHANGE ... 5
4.8 Typical result of power measurement ... 5

5 Evaluation of energy supplied to different types of machine tools ... **6**
5.1 General ... 6
5.2 Energy supplied to presses ... 6
5.2.1 General ... 6
5.2.2 System boundary ... 6
5.2.3 Shift regime ... 7
5.2.4 Minimum measuring period ... 7
5.2.5 Typical press cycle diagram ... 8
5.2.6 Reference and test cycle for hydraulic (servo) presses in PROCESSING ... 10
5.2.7 Reference and test cycle for mechanical (servo) presses in PROCESSING ... 11
5.2.8 Use of spacers instead of a die during test-run ... 12
5.3 Energy supplied to press brakes ... 13
5.3.1 General ... 13
5.3.2 System boundary ... 13
5.3.3 Shift regime ... 14
5.3.4 Minimum measuring period ... 14
5.3.5 Typical press brake cycle diagram ... 15
5.3.6 Reference and test cycle of hydraulic (servo)/mechanical (servo) press brake in operating-state PROCESSING ... 16
5.4 Energy supplied to pipe benders ... 18
5.4.1 General ... 18
5.4.2 System boundary ... 18
5.4.3 Shift regime ... 18
5.4.4 Minimum measuring period ... 18
5.4.5 Test cycle ... 19
5.5 Energy supplied to turret punch presses ... 20
5.5.1 General ... 20
5.5.2 System boundary ... 20
5.5.3 Shift regime ... 21
5.5.4 Minimum measuring period ... 21
5.5.5 Reference and test cycle for turret punch presses in operating state PROCESSING ... 22
5.6 Energy supplied to laser processing machine tools ... 24
5.6.1 General ... 24
5.6.2 System boundary ... 24
5.6.3 Shift regime ... 24
5.6.4 Minimum measuring period ... 24

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Documents
Document Sharing Hub
Full document details: BS ISO 14955-4:2019

5.6.5 Reference and test cycle for laser processing machine tools in operating state PROCESSING ... 25
5.7 Energy supplied to auxiliary devices ... 29
5.7.1 System boundary ... 29
5.7.2 Shift regime ... 30
5.7.3 Pneumatic energy and heat exchange measurement ... 30
6 Reporting ... 30
Annex A (informative) **Hydraulic presses ... 32**
Annex B (informative) **Mechanical presses ... 49**
Annex C (informative) **Hydraulic press brakes ... 63**
Annex D (informative) **Turret punch presses ... 72**
Annex E (informative) **Laser processing machine tools ... 80**
Annex F (informative) **Pipe bender ... 94**
Bibliography ... 101

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Documents
Document Sharing Hub
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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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.

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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.

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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;

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— 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.]

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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

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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

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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.

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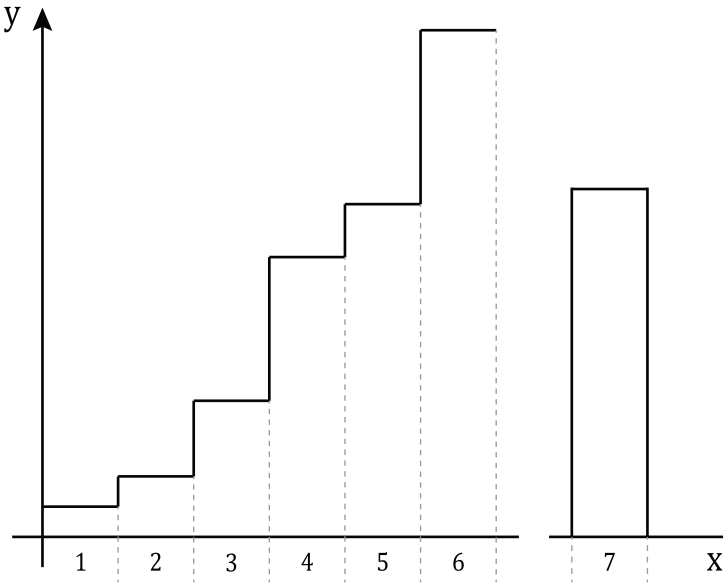

Key

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

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.

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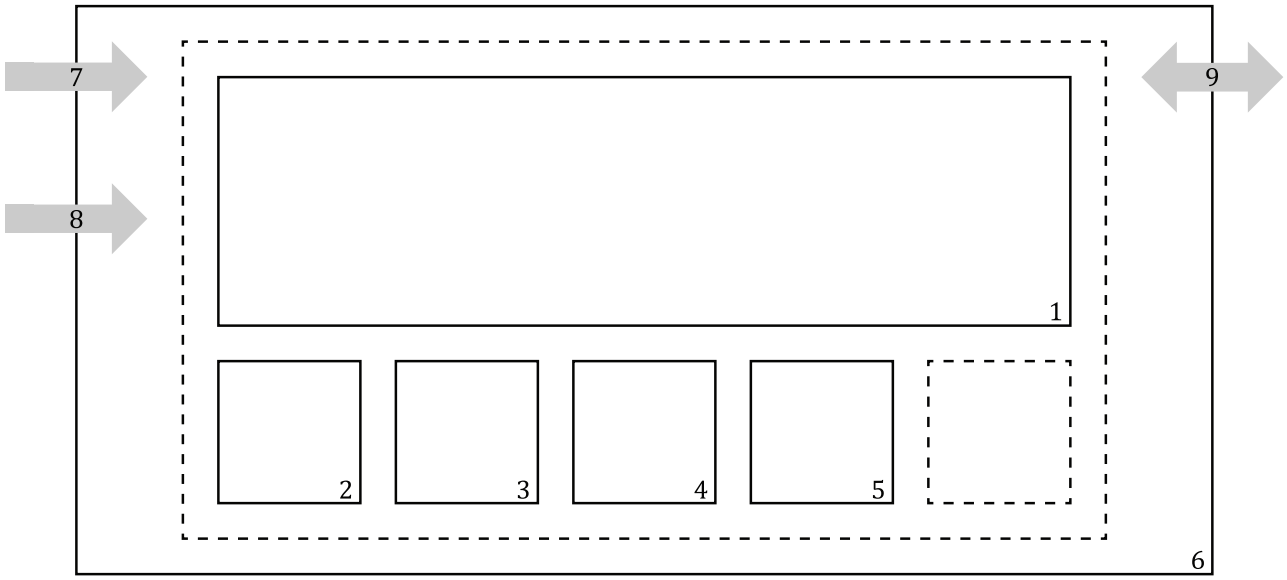

Key

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

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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.

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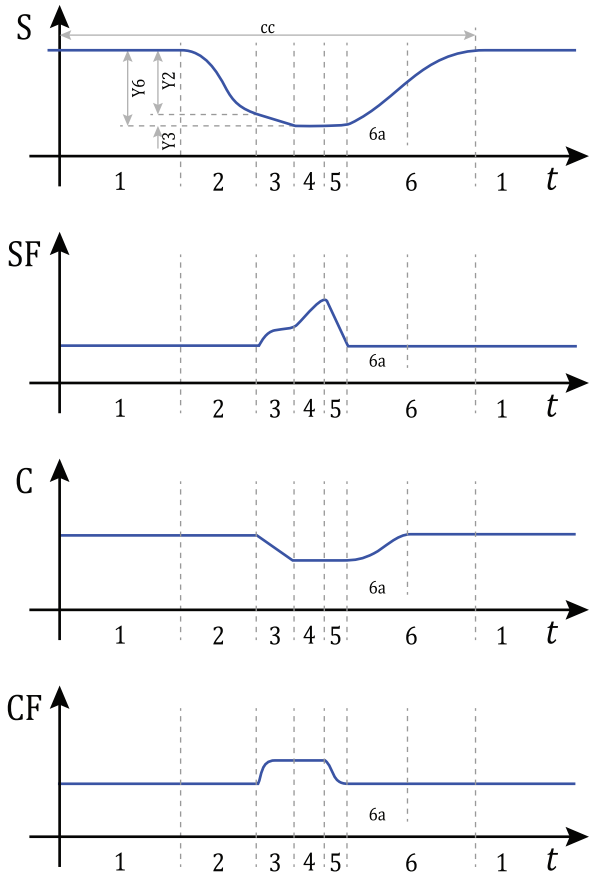

Key

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:	Slide 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

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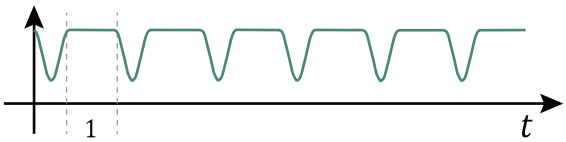
5.2.6 Reference and test cycle for hydraulic (servo) presses in PROCESSING

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.

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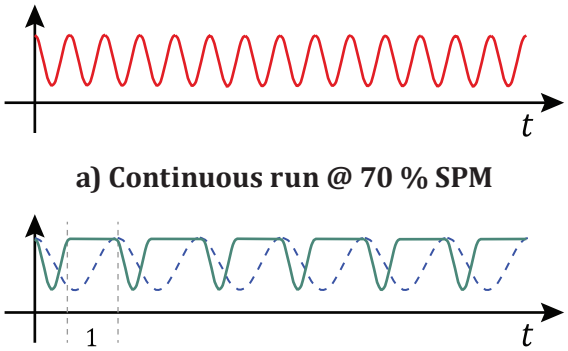
If energy recovery/conservation means are selectable by the user, measurement shall be made with and without energy recovery/conservation means active.

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 %

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Table 4 — Settings for test cycle of mechanical servo presses

Machine tool component	Machine tool activity	Parameter	Set-value
Slide	Waiting in TDC (1)	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
	Closing (2)	Closing stroke (Y2, % of nominal value)	70 %
		Closing speed (% of nominal value)	100 %
	Working (3)	Working stroke (Y3, % of nominal value)	70 %
		Working speed (% of nominal value)	70 %
	Return (6)	Return stroke continous run (Y6, % of nominal value)	100 %
		Return stroke intermittent run (Y6, % of nominal value)	50 %
		Return speed (% of nominal value)	100 %
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 %

5.2.8 Use of spacers instead of a die during test-run

Workpieces being formed on presses covered by this document require individual dies. These dies are made solely for this workpiece and are recycled or sold as soon as the production of this product is stopped or sourced out.

The energy supplied to form a workpiece is mainly depending on type of material (e.g. steel, stainless steel, high alloy steel, aluminium), degree of shaping, workpiece temperature (e.g. hot/cold), friction of the workpiece in the die (mainly influenced by tribology) and die wear.

If a test-run for energy evaluation is done using a specific die, it cannot be guaranteed that the same measurement condition can be found for a repetitive measurement after a longer period of time (e.g. one year). A practicable way to achieve reproducible conditions for the test-run for energy evaluation is to use spacers which allow a realistic (production) cycle.

NOTE These spacers are mostly made out of solid steel blocks with top and bottom side machined. The number of spacers installed depends on their size and force applied during test-run.

These spacers shall:

— allow a test-cycle according to the reference cycle;

— withstand all forces and velocities applied during measurement; and

— be kept at user site or be easy to rent or purchased in an acceptable time.

Figure 6 shows an example of a hydraulic or mechanical double action press with spacers installed.

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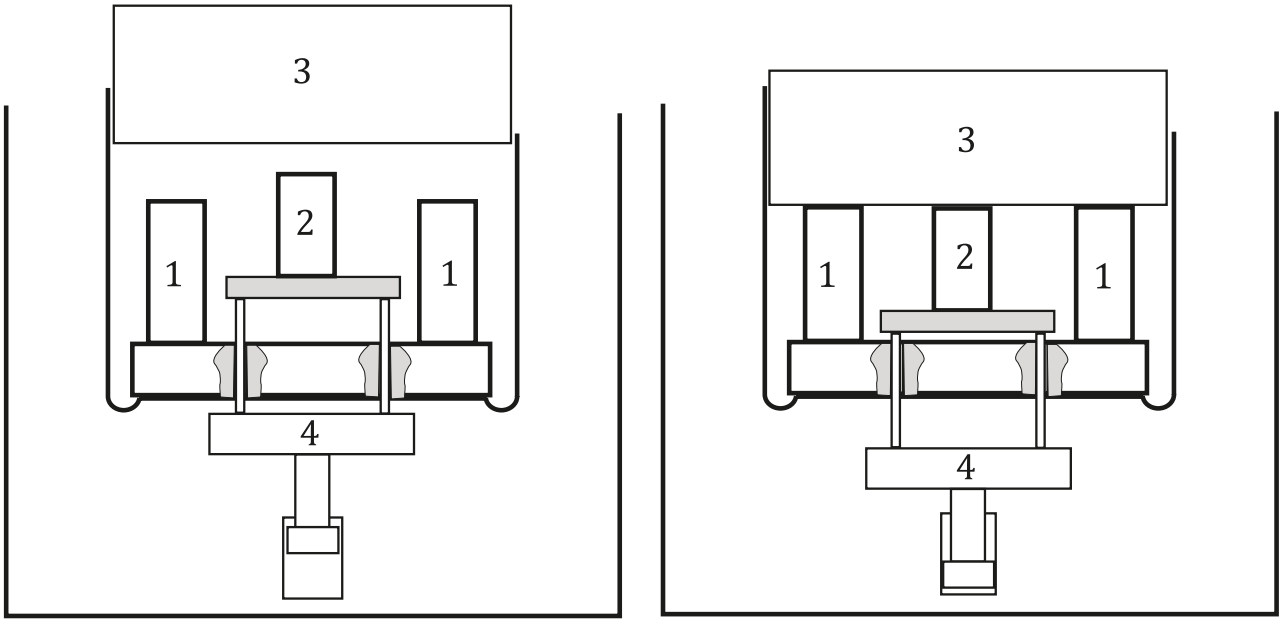

a) Slide at top dead centre

b) Slide at bottom dead centre (end of closing stroke)

Key

1 spacers for slide
2 spacer for die cushion
3 slide
4 die cushion

Figure 6 — Example of a hydraulic or mechanical double action press with spacers installed

If no die cushion is installed in the press, springs can be used as spacers on presses with spring decompression feature. In other cases, the measurement shall be done with the slide force generated on spacer(s).

The technical data and dimensions of the spacer(s) shall be reported and given to the user to allow reproducible measurements at a later date.

5.3 Energy supplied to press brakes

5.3.1 General

An example for a hydraulic press brake is given in Annex C.

The type of press brakes dealt with in this document is driven by hydraulic means (including hybrid systems) and direct electric means.

5.3.2 System boundary

The energy flow at the system boundary during test-run test shall be as close as possible to the energy flow at the system boundary during production, see Figure 7.

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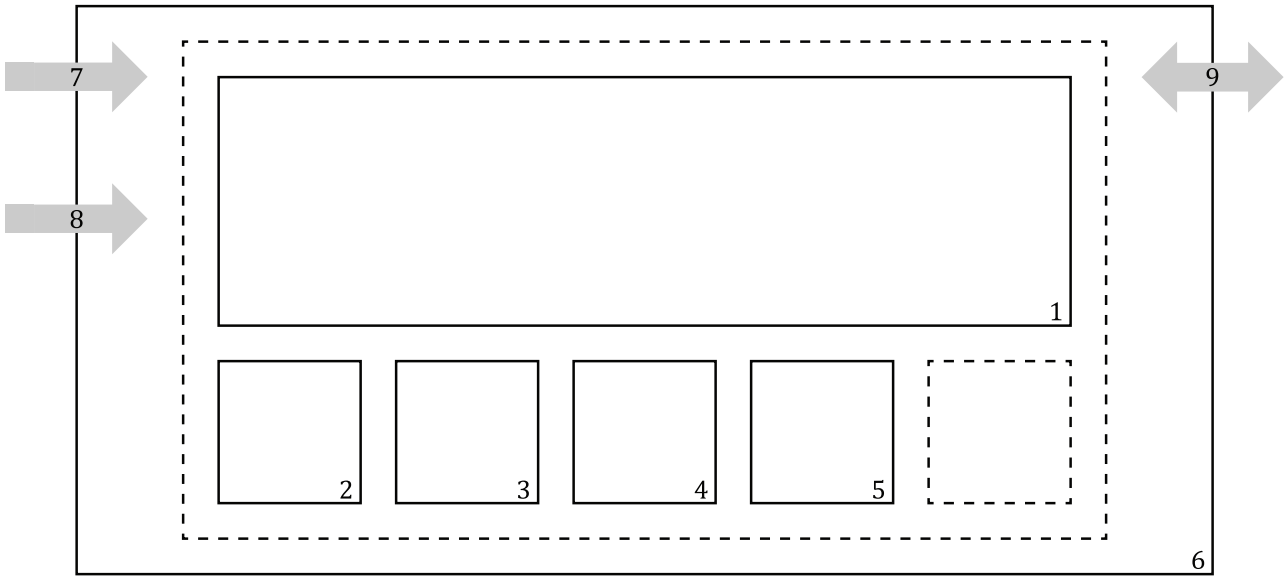

Key

1 machine tool
2 machine tool component A, e.g. beam
3 machine tool component B, e.g. back gauge
4 machine tool component C, e.g. feed unit
5 machine tool component D
6 system boundary
7 electrical energy
8 compressed air
9 heat exchange

Figure 7 — System boundary of press brakes

The system boundary during test-run does not include energy required for specific auxiliary functions (e.g. follow-up device and support robot), automatic tool change systems and process accuracy improvement devices (bending indicator, etc.).

5.3.3 Shift regime

As shift regimes are dependent on the equipment (e.g. NC unit, die layout and die equipment) and, therefore, can be different for each machine tool and machine tool user, 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.

5.3.4 Minimum measuring period

The default measuring period is the observation period. Based on monitoring of measuring results during the measurement, the measuring period may be shortened and the energy supplied shall be extrapolated to match the respective shift regime. The reason for the shortening shall be stated. Typical reasons for shortening are the observation of repetitive pattern or of a stabilization of power supplied after some time.

In a specific shift regime, the measuring periods for each operating state under stable conditions shall be at least as given in Table 5.

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Table 5 — Minimum measuring periods in specific shift regime

Operating state	Measuring period
1: OFF	5 min
2: MAIN SWITCH ON	5 min
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	20 min and 100 cycles
7: TOOL CHANGE	1 complete tool change sequence

The measuring time in operating state PROCESSING shall be at least 20 min. If less than 100 cycles are performed during this time, the measuring shall continue until 100 complete bending 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. Total interruption time shorter or equal than 10 % of the scheduled measuring time shall prolong the measuring period.

5.3.5 Typical press brake cycle diagram

Figure 8 shows a typical press brake cycle diagram.

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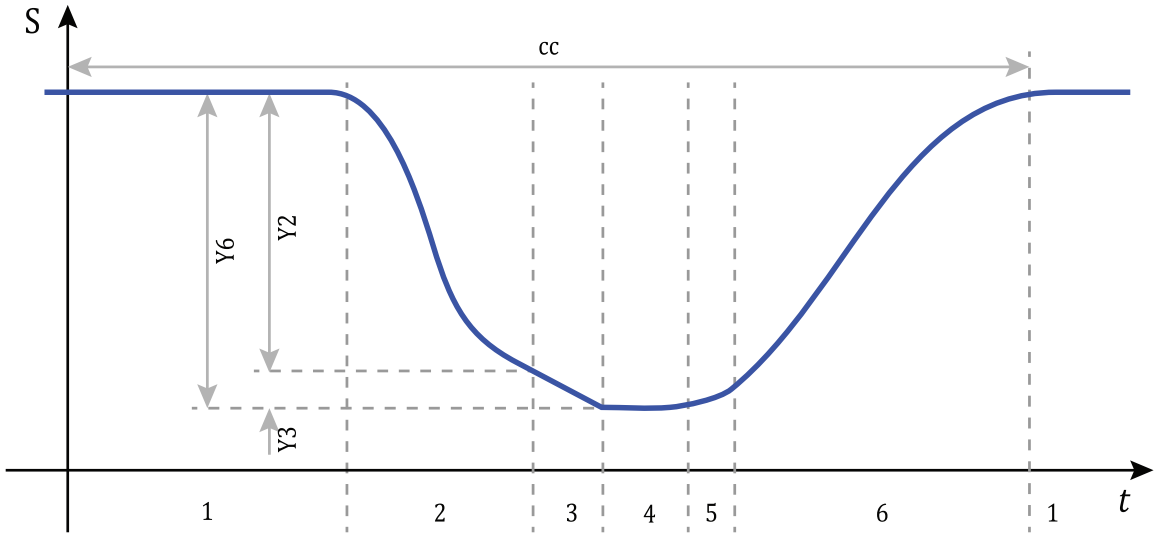

Key

S beam stroke

t time

1 machine tool activity 1: waiting for start: Waiting for start signal while workpiece is loaded into die.

2 machine tool activity 2: beam close: High speed descent (distance Y2).

3 machine tool activity 3: bending: Bending (distance Y3).

4 machine tool activity 4: pressing: Appliance of set-force and start of BDC dwell time.

5 machine tool activity 5: decompression: The decompression is not adjustable by the user.

6 machine tool activity 6: return: High speed ascent (distance Y6).

cc complete cycle

Y2 beam stroke between TDC and workpiece contact

Y3 bending distance

Y6 complete beam stroke

Measuring conditions:

— Pressurization operation by spacer, etc.;

— 100 cycle operations;

— 20 min operation time.

Figure 8 — Typical press brake cycle diagram with machine tool activities

5.3.6 Reference and test cycle of hydraulic (servo)/mechanical (servo) press brake in operating-state PROCESSING

Figure 9 shows a typical test cycle of a hydraulic (servo)/mechanical (servo) press brake in intermittent operation.

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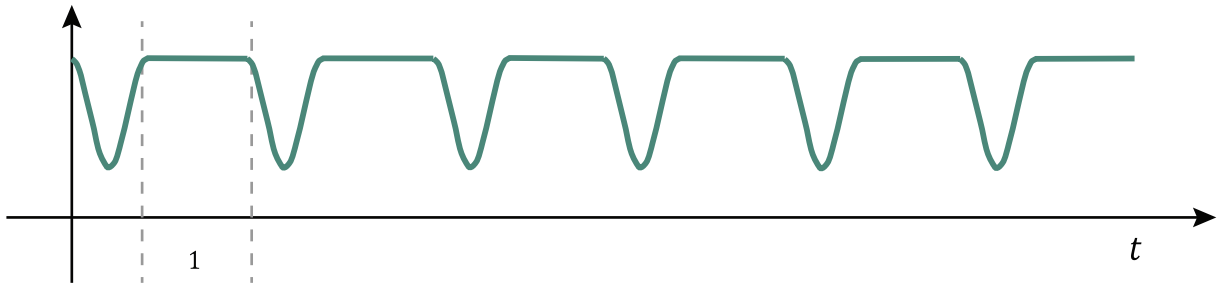

Key

1 TDC dwell time

t time

Figure 9 — Typical cycles of hydraulic (servo)/mechanical (servo) press brake (intermittent operation)

Press brake shall be measured by the intermittent operation of the time period shown in the above-stated shift regime.

Set-values for test cycle are given in Table 6 (if adjustable by the user, values in % are related to nominal value):

Table 6 — Settings for test cycle of hydraulic (servo)/mechanical (servo) press brakes

Machine tool component	Parameter	Set-value
Beam	High speed descent speed (2)	100 %
	High speed descent stroke (Y2) (% of nominal stroke)	35 %
	Bending speed (3)	70 %
	Bending stroke (Y3)	10 mm
	Ascent speed	100 %
	Ascent stroke	Y6
	Force (4)	50 %
	BDC dwell time	0,5 s
	TDC dwell time	2 s
Backgauge etc.	Moving speed of all axis	100 %

NOTE The test cycle is done using a spacer without a bending plate in order to achieve reproducible conditions.

If the workpiece is manually fed to the press brake, the test cycle shall include the time required for feeding the workpiece (TDC dwell time).

If the press brake is equipped with automatic workpiece-feed-units, the test cycle shall include the operation of the automatic feed-unit (feeding workpiece). And an operating time of automatic feed-unit becomes the dwell time (waiting time), which is dependent on ability of the automatic feed-unit.

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.

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

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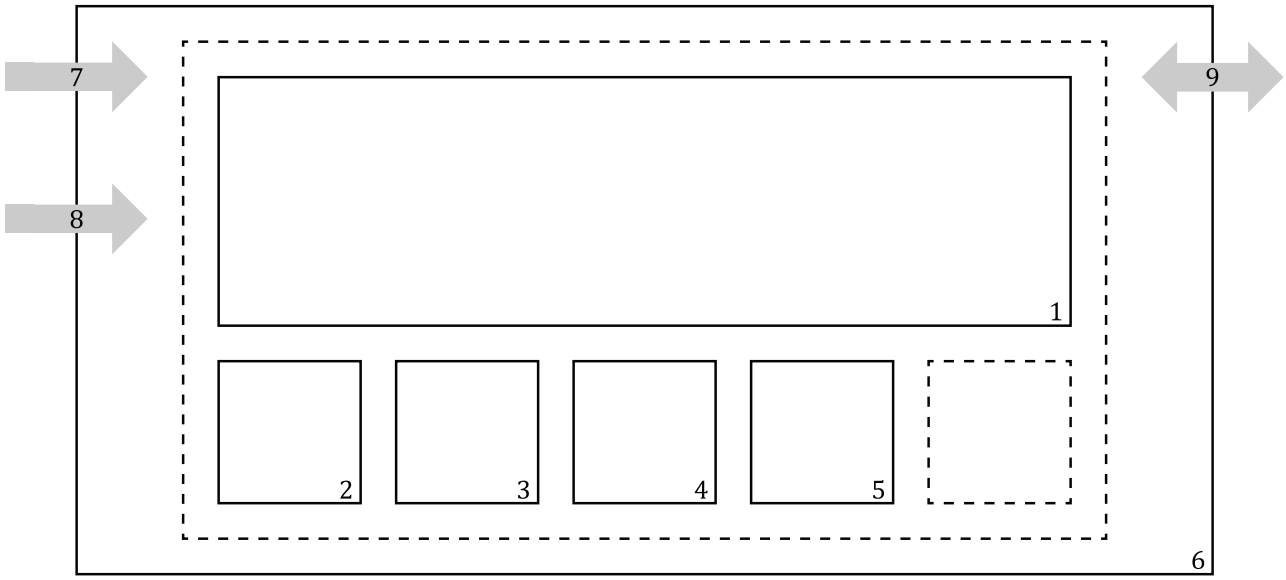
5.4 Energy supplied to pipe benders

5.4.1 General

An example for a pipe bender is given in Annex F.

5.4.2 System boundary

The energy flow at the system boundary during test-run test shall be as close as possible to the energy flow at the system boundary during production, see Figure 10.



Key

1 machine tool
2 machine tool component A
3 machine tool component B
4 machine tool component C
5 machine tool component D
6 system boundary
7 electrical energy
8 compressed air
9 heat exchange

Figure 10 — System boundary of pipe benders

5.4.3 Shift regime

As shift regimes are dependent on the equipment (e.g. NC unit, die layout and die equipment) and, therefore, can be different for each machine tool and machine tool user, a specific shift regime according to ISO 14955-2:2018, 5.2.2, may be set up for measurement. The shift regime and the clustered shift regime shall be reported.

5.4.4 Minimum measuring period

The default measuring period is the observation period. Based on monitoring of measuring results during the measurement, the measuring period may be shortened and the energy supplied shall be extrapolated to match the respective shift regime. The reason for the shortening shall be stated. Typical reasons for shortening are the observation of repetitive pattern or of a 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 7.

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Table 7 — Minimum measuring periods in specific shift regime

Operating state	Measuring period
1: OFF	5 min
2: MAIN SWITCH ON	5 min
3: AUXILLIARY DRIVES ON	10 min
4: MAIN DRIVES ON	10 min
5: READY TO RUN IN PRODUCTION MODE	10 min
8: PROCESSING	5 cycles

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.

5.4.5 Test cycle

The minimum measuring periods in specific shift regime is 5 cycles (i.e. five tubes, with multiple bends on each tube), see Table 8 and Figure 11.

Table 8 — Settings in test cycle for pipe benders

Material/process	Parameter	Settings
Test material	— Carbon-steel pipe for machine tool structure, or, if different, the standard pipe material for the tested machine, e.g. copper — or other material agreed upon between manufacturer and user	SPCC[5], DC01[6], 1,033[7]
	Pipe diameter	100 %
	Pipe thickness	To get 90 % of the nominal bending torque
Bending process (5 bends for each tube)	(L) Feed length	200 mm
	(A) Bending angle	90°
	(R) Rotation between successive bends	90°
	Bending radius	2 * diameter

The adopted bending tools (e.g. mandrel, wiper dies) and the actual bending torque (measured by the machine drive) shall be reported.

If the machine tool can adopt different bending strategies (e.g. draw bending, compression bending), all technologies shall be tested and documented.

Figure 11 shows a test workpiece with 90° bend every 200 mm.

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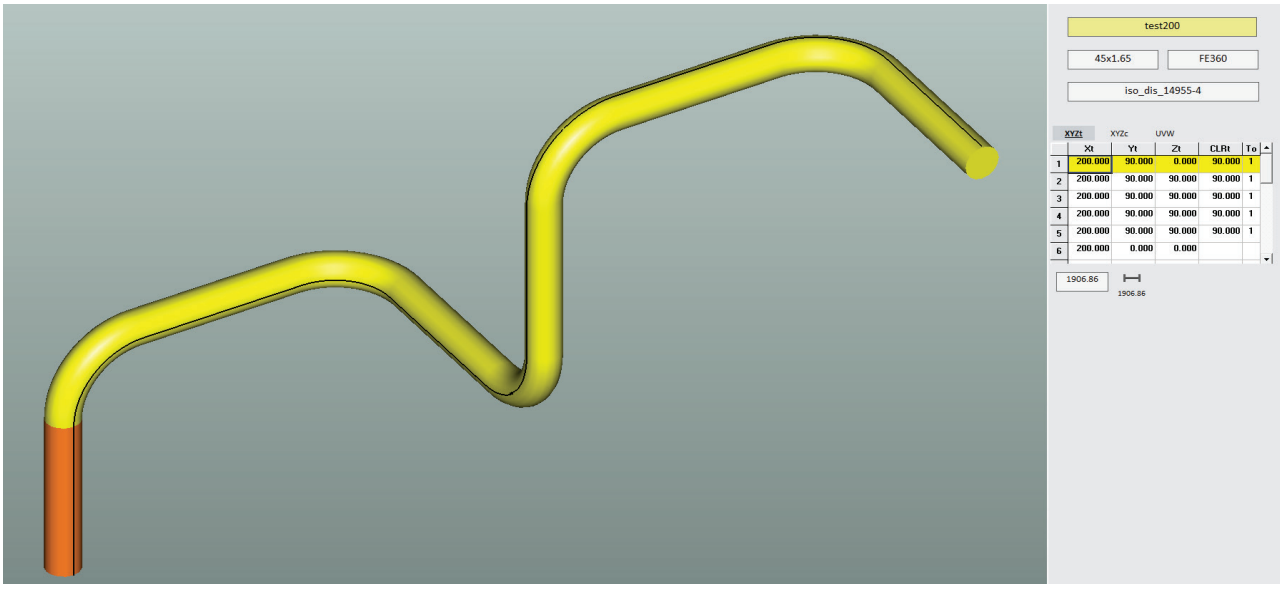

Figure 11 — Test workpiece with 90° bend every 200 mm

5.5 Energy supplied to turret punch presses

5.5.1 General

An example for a turret punch press is given in Annex D.

The type of turret punch press dealt in this standard is driven by electric means.

5.5.2 System boundary

The energy flow at the system boundary during test-run test shall be as close as possible to the energy flow at the system boundary during production, see Figure 12.

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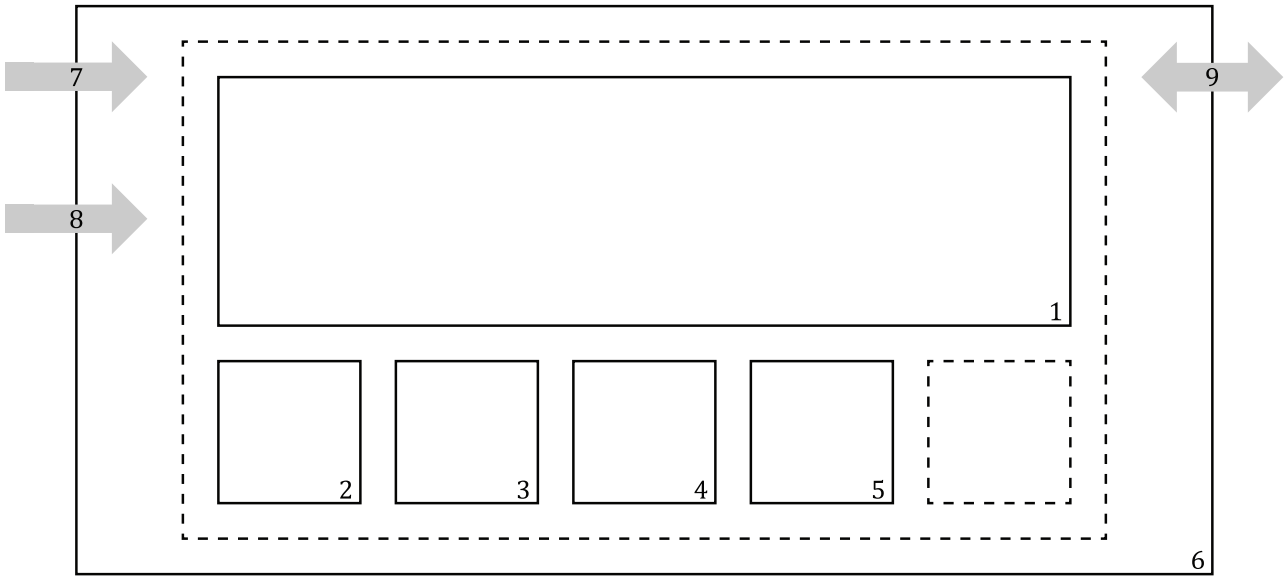

Key

1 machine tool
2 machine tool component A, e.g. frame
3 machine tool component B, e.g. press drive
4 machine tool component C, e.g. turret
5 machine tool component D, e.g. transfer table
6 system boundary
7 electrical energy
8 compressed air
9 heat exchange

Figure 12 — System boundary of turret punch presses

5.5.3 Shift regime

As shift regimes are dependent on the equipment (e.g. NC unit, sheet loader and unloader) and therefore can be different for each machine tool and machine tool user, a specific shift regime according to ISO 14955-2:2018, 5.2.2, may be set up for measurement. The shift regime and the clustered shift regime shall be reported.

5.5.4 Minimum measuring period

The default measuring period is the observation period. Based on monitoring of measuring results during the measurement, the measuring period may be shortened and the energy supplied shall be extrapolated to match the respective shift regime. The reason for the shortening shall be stated. Typical reasons for shortening are the observation of repetitive pattern or of a stabilization of power supplied after some time.

In a specific shift regime, the measuring periods for each operating state under stable conditions shall be at least as given in Table 9.

Table 9 — Minimum measuring periods in specific shift regime

Operating state	Measuring period
1: OFF	5 min
2: MAIN SWITCH ON	5 min
3: AUXILLIARY DRIVES ON	10 min
4: READY TO RUN IN PRODUCTION MODE	10 min and 1 sheet
6: PROCESSING	10 min
7: TOOL CHANGE	1 complete tool change cycle

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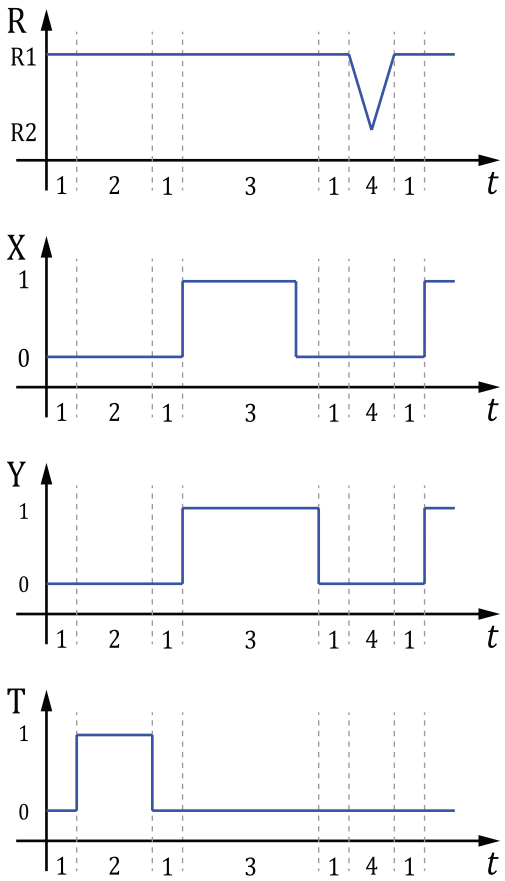
The measuring time in operating state PROCESSING shall be at least 10 min. If less than 1 sheet is processed during this time, the measuring shall continue until 1 sheet is processed completely.

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. Total interruption time shorter or equal than 10 % of the scheduled measuring time shall prolong the measuring period.

5.5.5 Reference and test cycle for turret punch presses in operating state PROCESSING

Figure 13 shows a typical turret punch press cycle diagram.



Key

R ram

R1 ram upper end

R2 ram lower end

X X-axis active

Y Y-axis active

T T-axis active

t time

1 machine tool activity 1: STANDBY – waiting for the start signal of axes

2 machine tool activity 2: die positioning – T-axis is rotated for setting the die into the punch centre

3 machine tool activity 3: workpiece positioning – X-axis and Y-axis move for setting the workpiece to processing position

4 machine tool activity 4: punching – ram descends and processes punch holes, then moves to upper end

Figure 13 — Typical turret punch press cycle diagram with machine tool activities

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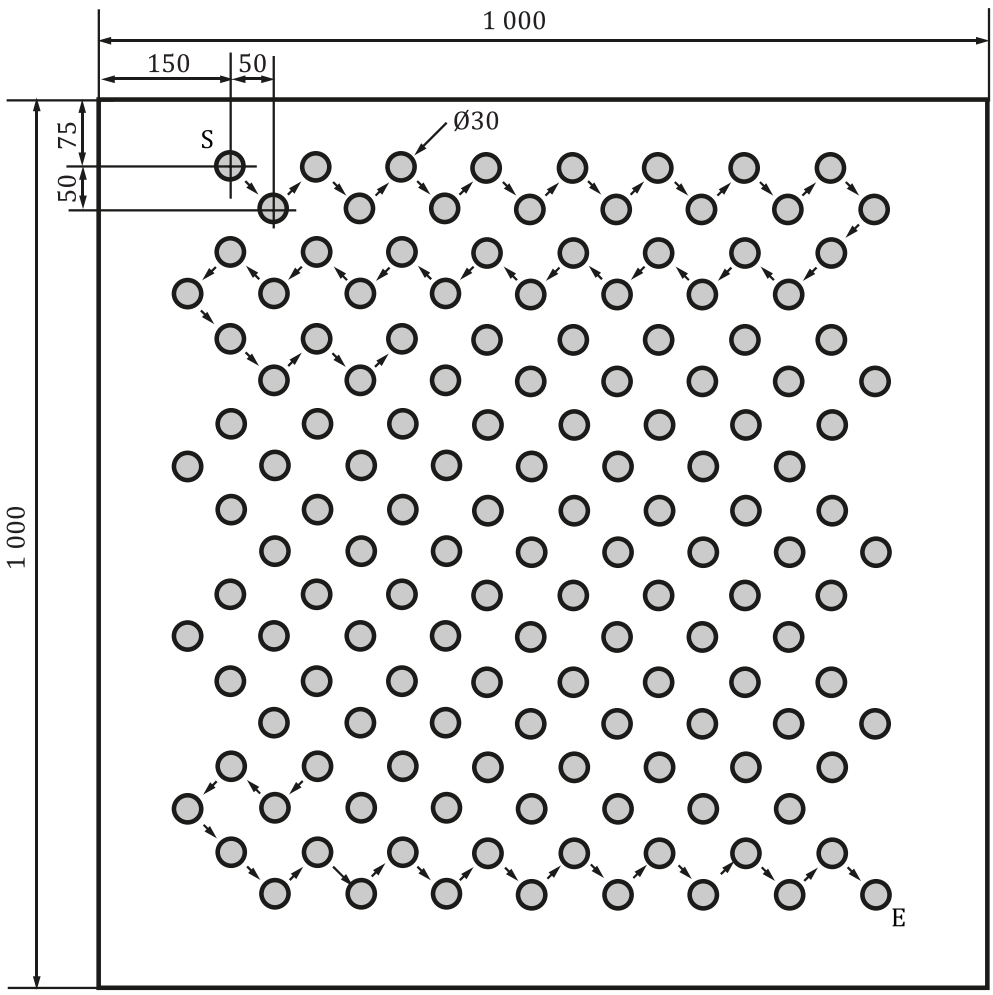
Axial feed rate and ram speed shall be set at maximum of machine tool specification.

Simultaneous positioning of X-axis and Y-axis, and ram descent and rise after completion of both axis positions, shall be performed.

The specification of a recommended test piece used during measurement is given in Table 10. If the specification is not met, set values and other relevant data shall be documented [see Clause 6 prescriptions d) and j)].

Table 10 — Recommended specification of test piece used in test cycle of turret punch presses

Property	Value
Test material	SPCC[5], DC01[6], 1,033[7]
Sheet thickness	1 mm or 2 mm
Sheet size	1 000 mm × 1 000 mm
Pattern	Pattern according to Figure 14
Cut shape	30 mm round
Number of processed holes	144
Pitch (X, Y staggered array)	50 mm



Key

S first cut (start of cycle)

E last cut (end of cycle)

Figure 14 — Processing pattern for turret punch presses

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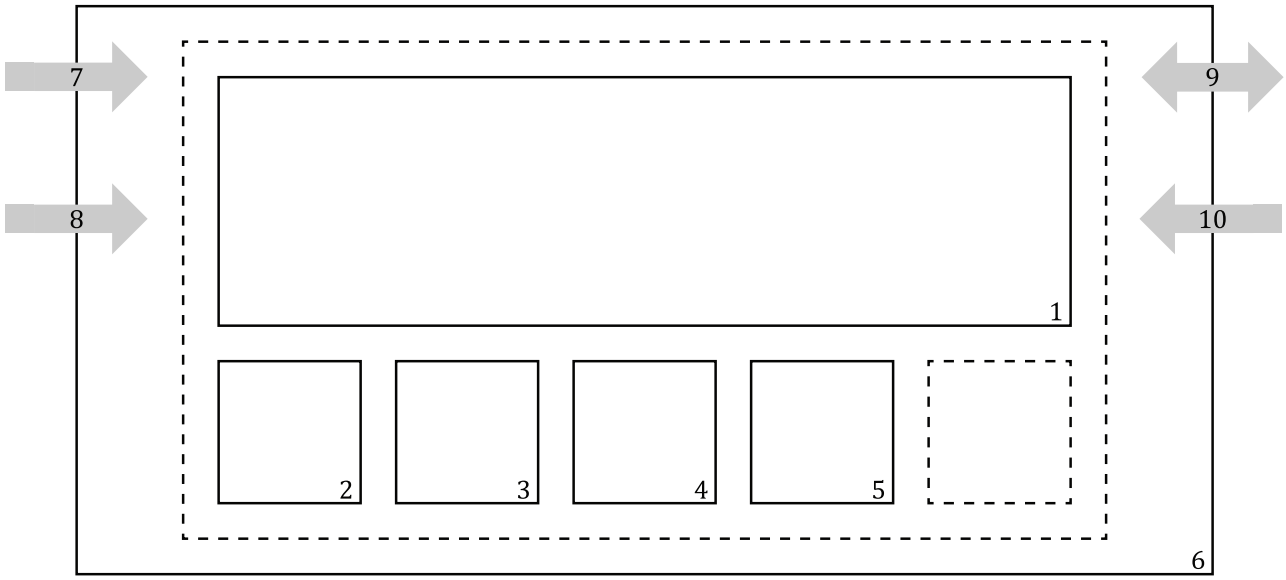
5.6 Energy supplied to laser processing machine tools

5.6.1 General

An example for a laser processing machine tool is given in Annex E.

5.6.2 System boundary

The energy flow at the system boundary during test-run test shall be as close as possible to the energy flow at the system boundary during production, see Figure 15.



Key

1	machine tool	6	system boundary
2	machine tool component A, e.g. frame	7	electrical energy
3	machine tool component B, e.g. oscillator	8	compressed air
4	machine tool component C, e.g. chiller	9	heat exchange
5	machine tool component	10	cutting gas

Figure 15 — System boundary of laser processing machine tools

5.6.3 Shift regime

As shift regimes are depending on the equipment (e.g. NC unit, sheet loader and unlader) and therefore can be different for each machine tool and machine tool user, 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.

5.6.4 Minimum measuring period

The default measuring period is the observation period. Based on monitoring of measuring results during the measurement, the measuring period may be shortened and the energy supplied shall be extrapolated to match the respective shift regime. The reason for the shortening shall be stated. Typical reasons for shortening are the observation of repetitive pattern or of a stabilization of power supplied after some time.

In a specific shift regime, the measuring periods for each operating state under stable conditions shall be at least as given in Table 11.

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Table 11 — Minimum measuring periods in specific shift regime

Operating state	Measuring period
1: OFF	5 min
2: MAIN SWITCH ON	5 min
3: AUXILLIARY DRIVES ON (oscillator warm up)	15 min
4: MAIN DRIVES ON	10 min
5: READY TO RUN IN PRODUCTION MODE	10 min
6: PROCESSING	10 min and 5 test pieces

The measuring time in operating state PROCESSING shall be at least 10 min. If less than five test pieces are processed during this time, the measuring shall continue until five test pieces are processed completely.

The chiller repeats ON and OFF according to coolant fluid temperature for cooling of the oscillator. At least five or more cooling cycles of the chillers shall be measured for the chiller average power measurement. If less than that, processing shall be continued until reaching five or more cooling cycles.

In operating state PROCESSING, measurement shall be made on a processing 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.

5.6.5 Reference and test cycle for laser processing machine tools in operating state PROCESSING

Figure 16 shows a typical reference and test cycle for laser processing machine tools.

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