AS 4024.3001—2009

Australian Standard®

Safety of machinery

Part 3001: Materials forming and shearing—Mechanical power presses

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- WorkCover New South Wales
- WorkSafe Victoria

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Australian Standard®

Safety of machinery

Part 3001: Materials forming and shearing—Mechanical power presses

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PREFACE

This Standard was prepared by the Standards Australia Committee SF-008, Guarding of Power Presses to supersede, in part, AS 1219—1994, *Power presses—Safety requirements*.

This Standard is based upon but not equivalent to EN 692:1997, *Mechanical presses—Safety* and is part of the AS 4024, *Safety of machinery* series of Standards.

Requirements for hydraulic power presses are set out in AS 4024.3002, *Safety of machinery*, Part 3002: *Materials forming and shearing—Hydraulic power presses*.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for information and guidance.

CONTENTS

Page

STANDARDS AUSTRALIA

Australian Standard
Safety of machinery

Part 3001: Materials forming and shearing—Mechanical power presses

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies technical safety requirements and measures for the design, manufacture and supply of mechanical presses that are intended to work cold metal or material partly of cold metal. In operations involving hot working and the use of tongs during the machine cycle, the principles given in AS 4024.1 (series) should be considered, but may not be capable of being fully applied. This Standard should be read in conjunction with AS 4024.1 (series).

This Standard also covers presses whose primary intended use is to work cold metal, but which are used in a similar way to work other materials (e.g. cardboard, plastic, rubber or leather), and metal powder.

The requirements in this Standard take account of intended use. This Standard presumes access to the press from all directions and specifies the safety measures for both the operator and other exposed persons.

This Standard also applies to ancillary devices that are integral parts of the press. For the safeguarding of integrated manufacturing systems using presses, see also ISO 11161.

This Standard does not cover machines whose principal designed purpose is—

(a) sheet metal or paper cutting by guillotine (see AS 1893);

(b) attaching a fastener, e.g. riveting, stapling or stitching;

(c) bending or folding by brake presses;

(d) straightening;

(e) turret punch pressing;

(f) extruding;

(g) drop forging or drop stamping;

(h) compaction of metal powder;

(i) single purpose punching machines designed exclusively for profiles, e.g. for the construction industry; or

(j) printing presses.

1.2 OBJECTIVE

The objective of this Standard is to enable designers, manufacturers, suppliers and users of mechanical power presses to reduce the risks to the health and safety of those persons working with or near mechanical power presses.

1.3 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1657 Fixed platforms, walkways, stairways and ladders—Design, construction and installation

1893 Code of practice for the guarding and safe use of metal and paper cutting guillotines

2671 Hydraulic fluid power—General requirements for systems (ISO 4413:1998, MOD)

2788 Pneumatic fluid power—General requirements for systems (ISO 4414:1998, MOD)

4024.1 Safety of machinery (series)

4024.1202 Part 1202: General principles—Technical principles

4024.1301 Part 1301: Risk assessment—Principles of risk assessment

4024.1501 Part 1501: Design of safety related parts of control systems—General principles for design

4022.1502 Part 1502: Design for safety related parts of control systems—Validation

4024.1601 Part 1601: Design of controls, interlocks and guarding—Guards—General requirements for the design and construction of fixed and movable guards

4024.1602 Part 1602: Design of controls, interlocks and guarding—Interlocking devices associated with guards—Principles for design and selection

4024.1603 Part 1603: Design of controls, interlocks and guarding—Prevention of unexpected start-up

4024.1801 Part 1801: Safety distances to prevent danger zones being reached by the upper limbs

4024.1803 Part 1803: Safety distances and gaps—Minimum gaps to prevent crushing of parts of the human body

4024.1907 Part 1907: Displays, controls, actuators and signals—System of auditory and visual danger and information signals

4024.2601 Part 2601: Design of controls, interlocks and guarding—Two-hand control devices—Functional aspects and design principles

4024.2801 Part 2801: Safety distances and gaps—Positioning of protective equipment with respect to the approach speed of parts of the human body

60204 Safety of machinery—Electrical equipment of industrial machines

60204.1 Part 1: General requirements (IEC 60204-1, Ed.5 (FDIS), (MOD)

60529 Degrees of protection provided by enclosures (IP Code)

62061 Safety of machinery—Functional safety of safety-related electrical, electronic and programmable electronic control systems

AS/NZS

3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)

4586 Slip resistance classification of new pedestrian surface materials

ISO

11161 Safety of machinery—Integrated manufacturing systems—Basic requirements

IEC

61496 Safety of machinery—Electro-sensitive protective equipment

61496-1 Part 1: General requirements and tests

61496-2 Part 2: Particular requirements for equipment using active opto-electronic protective devices (AOPDs)

1.4 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.4.1 Band brake

Brake where a flexible band lined with friction material is arranged around the circumference of a drum.

1.4.2 Brake

Mechanism (usually friction) intended to stop and hold the slide when the clutch, if provided, is disengaged.

1.4.3 Clutch

Mechanism used to impart the movement of the flywheel to the slide.

1.4.4 Clutch—full revolution

Type of clutch that, when tripped or actuated, cannot be disengaged until the slide has completed a complete stroke, e.g. most positive key clutches. It also includes clutches that can only be disengaged at certain positions in the operating cycle.

1.4.5 Clutch—part revolution

Type of clutch that can be engaged or disengaged at any point in the stroke of the slide, e.g. most friction clutches.

1.4.6 Cycle

1.4.6.1 *Automatic*

Operating mode where the slide repeats, continuously or intermittently, and all functions are achieved without manual intervention after initiation.

1.4.6.2 *Operating*

Movement of the slide from the cycle start position (normally the top dead centre) to the bottom dead centre and back to the cycle stop position (normally the top dead centre). The operating cycle includes all operations carried out during this movement.

1.4.6.3 *Single*

Operating mode where each operating cycle of the slide has to be positively actuated by the operator.

1.4.7 Dead centres

Points at which the tool, during its stroke, is—

(a) either nearest/closest to the die (generally corresponding to the end of the closing stroke), known as the bottom dead centre; or

(b) furthest from the die (generally corresponding to the end of the opening stroke), known as the top dead centre.

1.4.8 Die

The fixed part of the tools used in a press.

1.4.9 Die cushion

Accessory for a die that accumulates and releases, or absorbs, force as required in some press operations.

1.4.10 Direct drive

Type of driving arrangement where no clutch is used. Movement of the slide is accomplished by energizing and de-energizing the motor, possibly in conjunction with a brake.

1.4.11 Early opening interlocking guard

Guard associated with an interlocking device that, if opened when any dangerous movement in the tools area has ceased, does not interrupt the operating cycle.

1.4.12 Extractor

Device for disengaging a full revolution clutch. Also known as a ‘latch’.

1.4.13 Guard locking device

Mechanical device to maintain an interlocking guard gate in the closed and locked position until the risk of injury from the hazardous machine functions has passed.

1.4.14 Limited movement control device

Control device whose actuation permits only a limited amount of travel of a machine element, thus minimizing risk as much as possible. Further movement is precluded until there is a subsequent and separate actuation of the control. Also known as an ‘inching device’.

1.4.15 Mechanical press

Machine designed or intended to transmit energy from a prime mover to a tool by mechanical means for the working (e.g. forming or shaping) of cold metal or material partly of cold metal between the tools. Such energy may be transmitted by a flywheel and clutch or by means of a direct drive mechanism (see Figure 1.1).

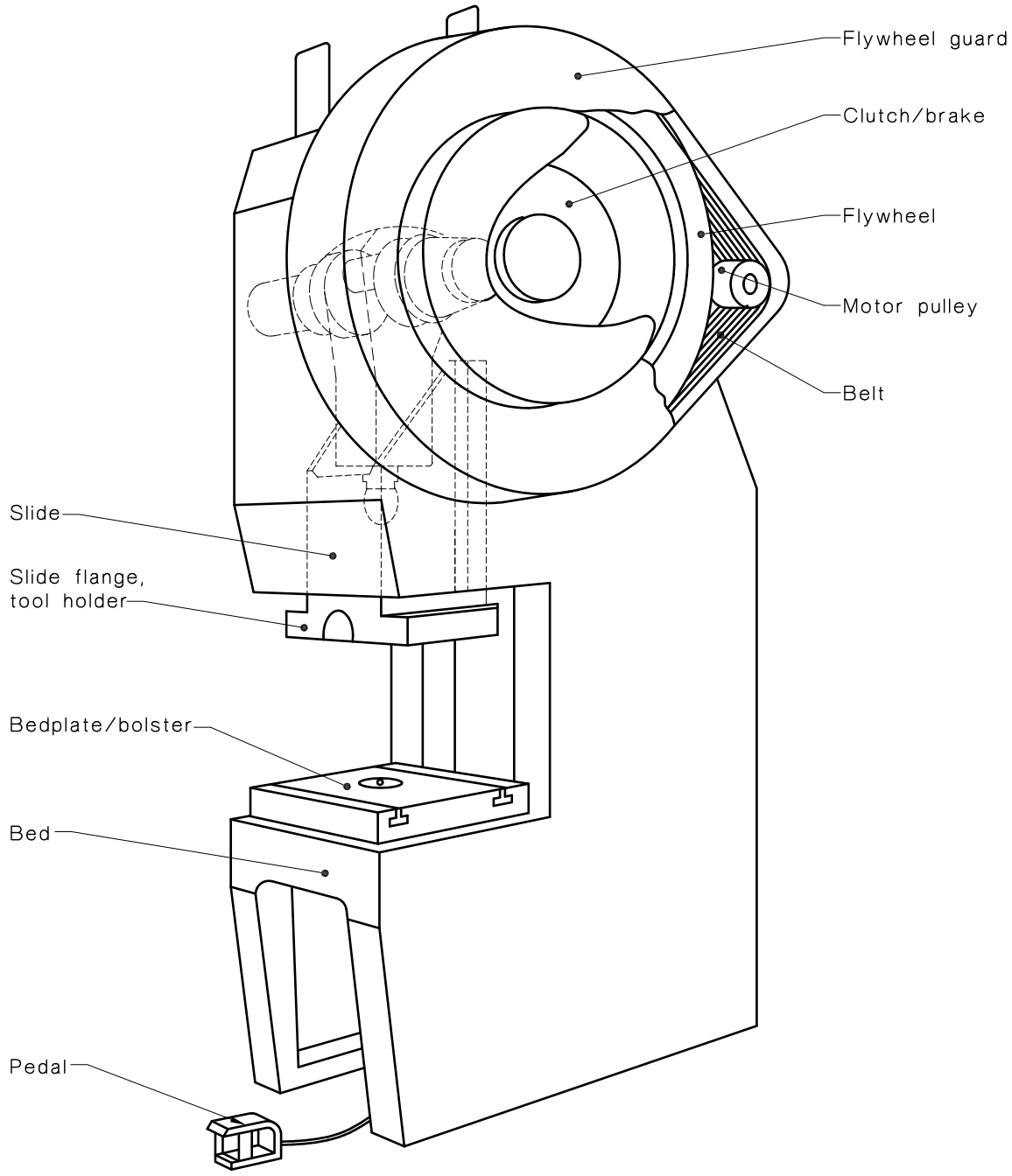


FIGURE 1.1 EXAMPLE OF MECHANICAL POWER PRESS

1.4.16 Monitoring

Safety function that ensures that a safety measure is initiated if the ability of a component or an element to perform its function is diminished, or if process conditions are changed in such a way that hazards are generated.

1.4.17 Muting

Temporary automatic suspension of the safety function(s) by safety related parts of the control system during the normal operation of the machine.

1.4.18 Overall system stopping performance

The time from actuating the protective device to the cessation of hazardous motion, or to the machine assuming a safe condition. Also known as ‘overall response time’.

1.4.19 Overrun

Movement of the crankshaft past a defined stopping point, e.g. top dead centre.

1.4.20 Overrun monitoring device

Device that provides a signal to inhibit further machine initiation when the overrun exceeds the pre-set limit(s).

1.4.21 Position switch

Switch that is operated by a moving part of the machine when this part reaches or leaves a predetermined position.

1.4.22 Redundancy

Application of more than one device or system, or part of a device or a system, to ensure that, in the event of one failing to perform its function, another is available to perform that function.

NOTE: Where the term ‘redundant’ is used, the provision of a redundancy feature is implied.

1.4.23 Shut height

Distance from the bedplate surface to the slide surface measured with the maximum variable stroke, stroke down and slide adjustment up.

1.4.24 Single stroke function

Feature used to limit the motion of the tool to one operating cycle at each engagement of the clutch even if the stroke initiating means (e.g. a pedal) is held in the operating position.

1.4.25 Slide

Main reciprocating press member that holds the tool.

1.4.26 Tool

In general, the moving parts of the tools used in a press. Also known as a ‘punch’.

1.4.27 Tools

The combination of tool and die.

1.4.28 Tools—closed

Tools designed and constructed to be inherently safe (see Figure 1.2).

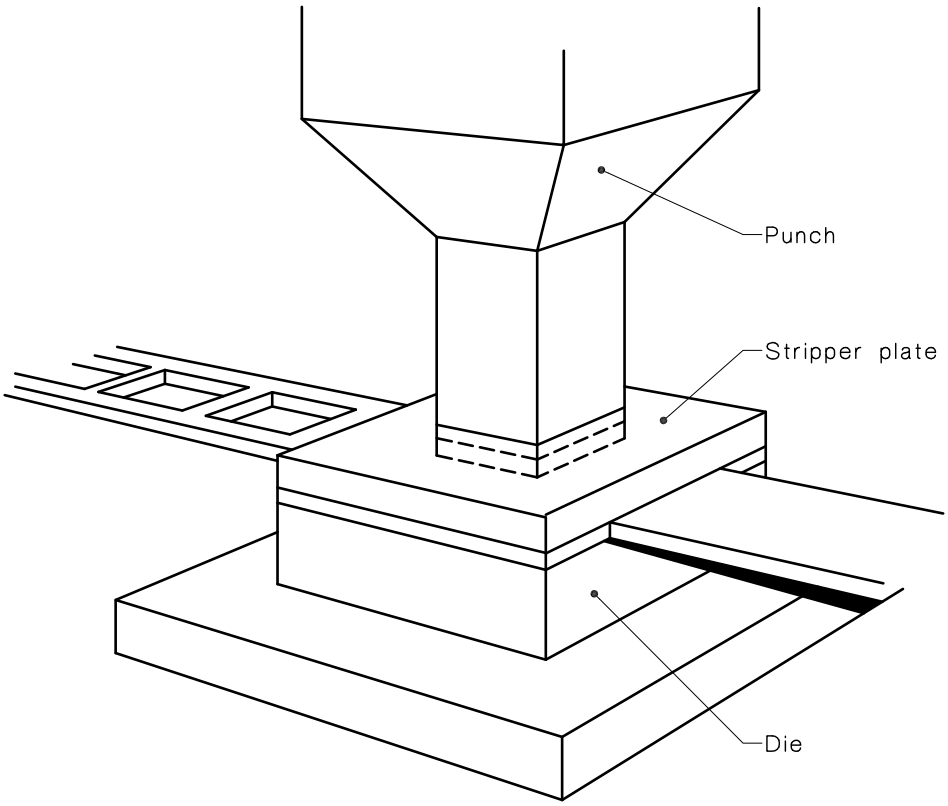


FIGURE 1.2 CLOSED TOOLS AT A MECHANICAL PRESS

SECTION 2 HAZARDS

2.1 GENERAL

Table 2.1 of this Standard lists significant hazards and their related danger zones normally associated with a mechanical power press. It was derived from a risk assessment of mechanical presses covered by the scope of this Standard. The risk assessment took into account foreseeable access from all directions, as well as overruns, unexpected and unintended strokes and gravity falls. Risks to operators and other persons who may have access to the danger zones were identified, taking into account all hazards that might occur during the life of the press. The assessment included an analysis of the effect of failure in the control system.

The technical measures and information for use provided in this Standard are based on the risk assessment and deal with the identified hazards by either eliminating them, or reducing the effects of the risks they generate.

AS 4024.1501 specifies conditions and procedures to be followed for the validation (by both analysis and testing) of safety functions and the category achieved by the safety related parts of the control systems. It should be used when validating the items chosen to make up the control systems for the press.

2.2 RISK ASSESSMENT

A risk assessment in accordance with AS 4024.1301 shall be carried out. The risk assessment shall pay particular attention to—

(a) the intended use of the press including maintenance, tool setting and cleaning;

(b) foreseeable misuse of the press; and

(c) whether the list of hazards given in Table 2.1 is both exhaustive and applicable to the press under consideration.

TABLE 2.1

TYPICAL HAZARDS, DANGERS AND PREVENTIVE MEASURES

Hazards	Danger zone	Preventive measures: Reference
Mechanical hazards		
Crushing Shearing Cutting or severing Entanglement Drawing-in or trapping	Tools area: — between moving tools —moving slide —moving die cushions —workpiece ejectors —guards —workpieces and off cuts	Clauses 3.3 to 3.5 Appendices A, B
Impact	Moving parts of electrical, hydraulic and pneumatic equipment	
	Motor and drive machinery	Clause 3.6.1
	Mechanical handling device	Clause 3.6.1 to 3.6.3
	Ancilliary equipment	

(*continued*)

TABLE 2.1 (*continued*)

Hazards	Danger zone	Preventive measures: Reference
Mechanical hazards (cont.)		
Ejection	Machine components Workpieces and tools	Clause 3.6.3 Clauses 3.3.8 and 3.3.9
High pressure fluid ejection	Hydraulic systems	Clause 3.8.3
Slips, trips or falls	All work at heights Floor area around the press	Clause 3.7
Electrical hazards		
Direct contact	Electrical equipment	Clause 3.8.1
Indirect contact Thermal radiation (burns)	Electrical equipment Parts made live by electrical equipment under fault conditions	Clause 3.8.1
Thermal hazards resulting in burns and scalds to persons	Brakes, clutches, parts of the hydraulic system	Clause 3.8.2
Hazards generated by noise resulting in hearing loss	Any area at the press where there is a risk to hearing	Clause 3.8.4
Hazards generated by vibration	Parts of the press where the risk occurs, e.g. the workstation(s)	Clause 3.8.5
Hazards generated by materials and substances processed, used or exhausted by machinery, e.g. resulting from contact with or inhalation of harmful fluids, gases, mists, fumes and dusts	Hydraulic system; pneumatic systems and their controls; toxic work materials	Clause 3.8.6
Fire or explosion	Exhaust ventilation and dust collection equipment	Clause 3.8.6.4
Hazards generated by neglecting ergonomic principles in machine design (mismatch of machinery with human characteristics and abilities) e.g. caused, by poor posture or excessive effort	The working position and controls for operators and maintenance staff handling tools	Clause 3.8.7

SECTION 3 SAFETY REQUIREMENTS AND MEASURES

3.1 INTRODUCTION

The mechanical presses covered by this Standard range in size from small, high speed machines with a single operator producing small workpieces to large, relatively slow speed machines with several operators and large complex workpieces. They are classified by their design, i.e. presses with part revolution clutches and full revolution clutches.

The methods or measures to be implemented to eliminate the significant hazards or reduce their associated risks are detailed in this Section in the following manner:

(a) Basic design considerations for major press components or systems (see Clause 3.2).

(b) Safeguarding against mechanical hazards in the tools area under different modes of production (see Clause 3.3 and Tables 3.1, 3.2 and 3.3).

(c) Protection against hazards due to control system or control component failures (see Clause 3.4).

(d) Safeguarding against hazards that can occur during toolsetting, trial strokes, maintenance and lubrication (see Clause 3.5).

(e) Safeguarding against other hazards (see Clauses 3.6 to 3.8).

3.2 BASIC DESIGN CONSIDERATIONS

3.2.1 Brakes and clutches

3.2.1.1 *Fluid power*

Fluid or air pressure shall not be used to apply a brake unless means are provided to ensure that, in the event of loss of fluid or air pressure, the integrity of the brake is maintained and the clutch is disengaged.

Diaphragms shall not be used to apply a brake.

3.2.1.2 *Use of springs*

Measures shall be in place to ensure the following:

(a) The springs used for applying the brake or disengaging the clutch are compression type.

(b) Multiple spring assemblies are used.

(c) All the springs are closely uniform in dimension, quality and rating.

(d) The means of loading the springs are such that, when adjusted, the spring anchorages can be locked to prevent slackening back.

(e) The arrangements for spring housing and guiding, and of guide pins, are such as to minimize binding.

(f) The brake will function even if 50% of the spring assembly has failed.

3.2.1.3 *Engagement*

The engagement and disengagement of the clutch and brake shall not affect their safe function.

NOTE: Combined clutch and brake units are recommended to reduce the possibility of overlapping of their engagement.

3.2.1.4 *Component failure*

The brake and the clutch shall be designed so that failure of any component does not stress other components in such a way that rapid consequential dangerous failure is possible.

3.2.1.5 *Heat dissipation*

Any heat generated that can cause a hazardous situation shall be dissipated.

3.2.1.6 *Lubricant penetration*

Effective arrangements shall be made to prevent penetration of lubricants to the brake friction surfaces, when this is not intended by the brake design.

3.2.1.7 *Influence on function*

The clutch and brake shall be designed in such a way that any moisture, dust or lubricating oil that breaks or corrodes the packing material (e.g. gaskets and seals), cannot adversely affect the required function, e.g. by obstructing an air channel or otherwise affecting their efficiency.

3.2.1.8 *Material accumulation*

The design shall be such that the accumulation of dust, fluid or debris is minimized in areas likely to give rise to inefficient brake performance. Broken or loose components shall not cause brake failure.

3.2.2 Presses with part revolution clutches (friction clutches)

3.2.2.1 *Capacity*

Clutches shall be capable of engaging and disengaging the stroke in the correct position without excessive temperature rise, under conditions of maximum use of the clutch.

3.2.2.2 *Clearances*

Sufficient working clearances shall be provided to ensure that, under the severest conditions of operation, friction drag leading to undesired movement of the driven members will not occur.

3.2.2.3 *Accumulation of debris*

Arrangements shall be made to prevent the accumulation of debris evolved from frictional surfaces in places where it can give rise to inefficient clutch performance, and for its effective dispersal.

3.2.2.4 *Supply failure*

The clutch and its control system shall be designed so that, in the event of failure of pneumatic, hydraulic or electrical supply, the clutch is disengaged and the brake is immediately applied.

3.2.2.5 *Use of diaphragms*

If diaphragms are used in a clutch system, measures shall be taken to avoid their damage from sharp edges and by rough surfaces.

Evacuation of air shall not be prevented due to slackening of the diaphragm, e.g. due to material fatigue.

3.2.3 Presses with full revolution clutches

For presses with full revolution clutches, the additional requirements given in Appendix A shall be met. These requirements relate to the design of the extractor and the prevention of overrun and fall-back to prevent an unintended descent of the slide.

3.2.4 Hydraulic and pneumatic systems—common features

3.2.4.1 *General*

The requirements in AS 2671 and AS 2788 shall be taken into consideration in designing hydraulic and pneumatic systems, which shall comply with the relevant requirements in Clauses 3.2.4, 3.2.5 and 3.2.6 of this Standard.

3.2.4.2 *Auxiliary equipment*

Filters, pressure regulators and low pressure cut-off arrangements shall be provided.

Devices shall be provided to ensure that the permitted range of working pressure is maintained.

3.2.4.3 *Guarding of bowls*

Bowls of glass and plastic (unless resistant to solvents) shall be guarded to prevent flying particles if the bowl should break.

3.2.4.4 *Foreign matter*

All piping, pipe fittings, passages, surge or storage tanks and cored or drilled holes shall be free from burrs or foreign matter that could cause damage to valves or clutch and brake operating parts.

3.2.4.5 *Piping*

The following requirements apply to piping:

(a) Each run of piping shall be continuous from one piece of apparatus to another. Precautions shall be taken to prevent damage due to thermal expansion.

(b) Rigid piping shall be securely supported at frequent intervals to avoid vibration or movement.

(c) Care shall be taken to avoid kinking of flexible pipes used to carry fluids. This applies particularly to piping feeding the running joint of the clutch and brake.

NOTE: Such kinking can cause traps which prevent the fluid exhausting.

3.2.4.6 *Pressure drop*

Where a drop in pressure could lead to unintended dangerous motion of the slide, pipes and pipe connections shall be chosen to prevent such a loss of pressure.

Pipe connections shall not be made with compression fittings, glued rings or similar devices.

3.2.4.7 *Support of valves*

Operating valves shall not depend on connected piping for support.

NOTE: This is to avoid undesirable effects from vibration affecting both valves and piping.

3.2.4.8 *Prevention of pressure build-up*

Operating valves shall be designed to ensure that, when in the non-operating position, leakage past the inlet valve will escape sufficiently freely to prevent build-up of pressure in the clutch operating cylinder.

3.2.4.9 *Port positioning*

Operating valves shall be designed so that it is not possible for both the inlet port and the exhaust ports to remain closed at the same time.

3.2.4.10 *Capacity of pipes and ports*

Exhaust ports and piping between the clutch operating cylinders and valves shall have sufficient capacity to ensure prompt release of fluid from clutch operating cylinders. Precautions shall be taken to ensure that the exhaust ports of operating valves are adequately sized to prevent residual pressure in the cylinder. The valve shall be selected so that the pressure ratio between clutch and brake is such that the residual pressure in the cylinder will not become excessive in the event of a valve fault.

NOTE: Normally, a ratio of at least 3.5 to 1 between spring pressure in the brake and residual pressure in the cylinder is satisfactory.

3.2.4.11 *Valve location*

Control valves shall be mounted in positions that provide adequate accessibility and avoid damage.

3.2.4.12 *Manual or mechanical valves*

Where valves are manually or mechanically (as distinct from electrically) operated, the arrangements for restoring the valves to the position of clutch disengagement at the end of the cycle shall be positive in character (see also Clause 3.4.9).

3.2.5 Pneumatic systems

3.2.5.1 *Lubrication*

Where valves or other parts of the press control system require lubrication, visible automatic means of lubrication shall be provided to introduce the oil into the air line in a suitable form.

3.2.5.2 *Silencers*

Where silencing systems are fitted, they shall comply with and be installed in accordance with the valve manufacturer's instructions and their effect on braking performance shall be taken into account. Only non-clogging direct to atmosphere silencers are permissible to brake/clutch manufacturers' specifications.

3.2.5.3 *Water separators*

Water separators shall be provided.

3.2.6 Hydraulic systems

3.2.6.1 *Pressure relief valves*

Suitable pressure relief valve(s) shall be provided in hydraulic systems having a hydraulic pumped supply. Means shall be provided to release trapped air either by a bleed device or a self-evacuating system.

3.2.6.2 *Injury prevention*

Hydraulic systems shall be designed so that escaping fluid does not cause injury.

3.2.6.3 *Accumulators*

Hydraulic systems that include accumulators shall allow the fluid pressure to fall when the pressure generating unit is stopped. If this is impossible, the parts of the circuit that are maintained under pressure shall be supplied with a manual discharge valve in addition to the other devices required by standards or rules concerning accumulators (relief valves, pneumatic gauges, etc.) and bear a plate or notice warning of the hazard.

3.2.7 Slide adjustment and stroke adjustment

3.2.7.1 *Prevention of motion*

Provision shall be made to ensure that a slide adjustment motor cannot be set in motion while the clutch control circuit is energized. This requirement shall not apply when the slide adjustment motor is operable in presses for automatic cycle and programmable control systems to compensate, for example, for wear of the tools during the press operation.

3.2.7.2 *Control identification*

The means of controlling the slide adjustment shall be clearly identified.

3.2.7.3 *Adjustment limitation*

The slide adjustment shall be limited by suitable means.

3.2.7.4 *Adjustment locking*

Means shall be provided for securing, e.g. by locking, the slide adjustment and the stroke adjustment in the set position during production.

3.2.7.5 *Stroke prevention*

Securing means shall be provided to prevent a stroke being made while the powered stroke adjustment motor is in operation.

3.2.8 Electrical systems

3.2.8.1 *General*

The electrical system shall comply with AS 60204.1. The designer of a press should consider the limits of the electrical supply, the physical environment and the operating conditions of components.

3.2.8.2 *Emergency stop*

The emergency stop shall immediately remove power to the machine actuators, i.e. an uncontrolled stop in accordance with Category 0 of AS 60204.1.

3.2.8.3 *Two-hand controls*

Two-hand control devices shall comply with the requirements of Clause 3.3.14 and Table 3.1.

3.2.8.4 *Enclosure protection*

The degree of protection for operator interface and press-mounted control devices shall be not less than IP54 (see AS 60529). The degree of protection for control gear shall be not less than IP54.

3.2.8.5 *Wiring*

Wiring shall be in accordance with AS/NZS 3000.

3.3 MECHANICAL HAZARDS IN THE TOOLS AREA

3.3.1 General

The major danger zone at mechanical presses is the tools area and preventive measures shall be taken to deal with the relevant hazards. This Standard indicates in Clauses 3.3 to 3.5 how the danger zone at the tools and associated areas, such as moving die cushions and workpiece ejectors, shall be safeguarded. Tables 3.1, 3.2 and 3.3 summarize the requirements for safeguarding the tools area.

3.3.2 Safeguarding measures

Safeguarding measures described in AS 4024.1601, AS 4024.1602 and AS 4024.1603, appropriate for the protection of any operator at the tools, are listed below.

Safeguarding methods shall be selected considering the significant hazards (see Table 2.1) and the mode of production (see Tables 3.1, 3.2 and 3.3). The safeguards include the following:

(a) Closed tools.

(b) Fixed enclosing guards.

(c) Interlocking guards with guard locking (see Appendix B).

(d) Control guards with guard locking.

(e) Early opening interlocking guards (see Appendix B).

(f) Electro-sensitive protective equipment (see AS 4024.2801, IEC 61496-1 and IEC 61496-2).

(g) Two-hand control devices.

(h) Hold-to-run control devices and slow closing speed (less than 10 mm/s) principally for toolsetting (see Clause 3.5).

Presses with full revolution clutches shall only be safeguarded by the options listed in Items (a), (b), (c), and (d) above.

The methods of safeguarding shall also protect against risks at ancillary loading and unloading devices that are an integral part of the machine.

3.3.3 Limits of protection

The selected combination of safeguards shall protect all exposed persons, i.e. those who can gain access to the danger zone during operation, setting, maintenance, cleaning and inspection activities, as described in Clause 2.1.

3.3.4 Control system category

The control system of the press shall be of the same category as the guards and protective devices, as a minimum. Safety-related parts of the control systems should be maintained to the appropriate level of safety integrity in accordance with AS 4024.1501 and AS 4024.1502.

TABLE 3.1

SUMMARY OF REQUIREMENTS FOR THE OPERATOR SAFEGUARDING OF TOOLS FOR DIFFERENT MODES OF OPERATION— MODE OF PRODUCTION: SINGLE CYCLE, MANUAL FEED OR REMOVAL

Operator safety system (see Note 1)	Clutch type (see Note 2)	Cycle initiation	Clutch and brake control system (see Notes 2 and 3)		Overrun monitoring	Muting	Single stroke function	Remarks
Closed tools	F or P	Any	S	S	—	—	—	See Clause 3.3.7
Fixed enclosing guard	F or P	Any	S	S	—	—	—	See Clause 3.3.8
Interlocking guard with guard locking (see Note 4)	F or P	Any other than the guard itself	See Note 1	See Note 1	—	—	—	See Clause 3.3.9 1 R & M shall be required when there is no mechanical interlock (see Appendix B). 2 Early opening gates are not permitted.
Control guard with guard locking	F or P	Guard itself	See Note 1	See Note 1	—	—	—	See Clause 3.3.10 As remarks 1 and 2 above.
Early opening interlocking guard	P	Any other than the guard itself	R & M	R & M	Yes	M	R & M	Either use required safety distance (see Clause 3.3.15) or guard locking that is effective during the dangerous movement of the tools (see Clause 3.3.11).
Control guard without guard locking	P	Guard itself	R & M	R & M	Yes	M	R & M	As above.
Electro-sensitive protective equipment	P	Any, but see note 2	R & M	R & M	Yes (each S & M)	M	R & M	See Clause 3.3.12 1 Use the required safety distance (see Clause 3.3.15). 2 Where the tools area is large enough to permit whole-body entry, additional means of detection or protection shall be provided. e.g. a separate stroke initiation device.

(*continued*)

TABLE 3.1 (*continued*)

Operator safety system (see Note 1)	Clutch type (see Note 2)	Cycle initiation	Clutch and brake control system (see Notes 2 and 3)		Overrun monitoring	Muting	Single stroke function	Remarks
Two-hand control device	P	Two-hand control device	R & M	R & M	Yes (each S & M)	M	R & M	See Clause 3.3.14. Use the required safety distance (see Clause 3.3.15).
Hold-to-run control device and slow closing speed	P	Hold-to-run control device	S	S	—	—	—	1 Principally for toolsetting (see Clause 3.5). 2 Maximum closing speed: 10 mm/s 3 Where this speed is adjustable above 10 mm/s, safety devices appropriate for all closing speeds shall be provided.

LEGEND:
F = full revolution
M = monitoring (see Clause 1.4.16)
P = for part revolution
R = redundancy (see Clause 1.4.22)
S = single system
— = not applicable

NOTES:

1 For toolsetting, see Clause 3.5.

2 On direct drive machines without a flywheel, the same safeguards should be provided as listed for part revolution clutch machines. However, on direct drive machines with a flywheel, the same safeguards should be provided as listed for full revolution clutch machines.

3 See Clause 3.4.1.1 for the objectives of the control system.

4 An additional guard lock can be provided, operated by signal that the latch of the full revolution clutch has returned to non-repeat position.

TABLE 3.2
SUMMARY OF REQUIREMENTS FOR THE OPERATOR SAFEGUARDING OF TOOLS FOR DIFFERENT MODES OF OPERATION—MODE OF PRODUCTION: AUTOMATIC CYCLE, MANUAL FEED OR REMOVAL

Operator safety system (see Note 1)	Clutch type (see Note 2)	Cycle initiation	Clutch and brake control system (see Notes 2 and 3)		Overrun monitoring	Muting	Single stroke function	Remarks
			Electrical	Valve				
Closed tools	F or P	Any	S	S	—	—	—	See Clause 3.3.7
Fixed enclosing guard	F or P	Any	S	S	—	—	—	See Clause 3.3.8 No insertion of the hand between tools during production (manual feeding from outside the guard, e.g. through a slot).
Interlocking guard with guard locking (see Note 4)	F or P	Any other than the guard itself	See Note 1	See Note 1	—	—	—	See Clause 3.3.9 1 R & M shall be required when there is no mechanical interlock (see Appendix B). 2 Early opening gates are not permitted. 3 If on large presses it is possible to be in the danger zone with guard closed, use special reset outside this zone (S & M).
Electro-sensitive protective equipment	P	Any other than the protective device itself.	R & M	R & M	Yes (each S & M)	M	R & M	See Clause 3.3.12 Use of required safety distance (see Clause 3.3.15).

LEGEND:
F = full revolution
M = monitoring (see Clause 1.4.16)
P = for part revolution
R = redundancy (see Clause 1.4.22)
S = single system
— = not applicable

NOTES:
1 For toolsetting, see Clause 3.5.
2 On direct drive machines without a flywheel, the same safeguards should be provided as listed for part revolution clutch machines. However, on direct drive machines with a flywheel, the same safeguards should be provided as listed for full revolution clutch machines.
3 See Clause 3.4.1.1 for the objectives of the control system.
4 An additional guard lock can be provided, operated by signal that the latch of the full revolution clutch has returned to non-repeat position.

TABLE 3.3

SUMMARY OF REQUIREMENTS FOR THE OPERATOR SAFEGUARDING OF TOOLS FOR DIFFERENT MODES OF OPERATION—MODE OF PRODUCTION: AUTOMATIC CYCLE, MANUAL FEED OR REMOVAL

Operator safety system (see Note 1)	Clutch type (see Note 2)	Cycle initiation	Clutch and brake control system (see Notes 2 and 3)		Overrun monitoring	Muting	Single stroke function	Remarks
			Electrical	Valve				
Closed tools	F or P	Any	S	S	—	—	—	See Clause 3.3.7
Fixed enclosing guard	F or P	Any	S	S	—	—	—	See Clause 3.3.8
Interlocking guard with guard locking (see Note 4)	F	Any other than the guard itself	See Note 1	See Note 1	—	—	—	See Clause 3.3.9 1 R & M shall be required when there is no mechanical interlock (see Appendix B). 2 Early opening gates are not permitted. 3 If on large presses it is possible to be in the danger zone with guard closed, use special reset outside this zone (S & M).
Interlocking guard with guard locking	P	Any other than the guard itself	R & M	S	—	—	—	See Clause 3.3.9 If on large presses it is possible to be in the danger zone with guard closed, use special reset outside this zone (S & M).
Early opening interlocking guard	P	Any other than the guard itself	R & M	R & M	—	—	—	1 Either use required safety distances (see Clause 3.3.15) or guard locking that is effective during the dangerous movement of the tools (see Clause 3.3.11). 2 If on large presses it is possible to be in the danger zone with guard closed, use special reset outside this zone (S & M).
Electro-sensitive protective equipment	P	Any other than the protective device itself	R & M	R & M	—	—	—	See Clause 3.3.12 Use required safety distance (see Clause 3.3.15).

LEGEND TO TABLE 3.3:

F = full revolution
M = monitoring (see Clause 1.4.16)
P = for part revolution
R = redundancy (see Clause 1.4.22)
S = single system
— = not applicable

NOTES TO TABLE 3.3:

1 For toolsetting, see Clause 3.5.

2 On direct drive machines without a flywheel, the same safeguards should be provided as listed for part revolution clutch machines. However, on direct drive machines with a flywheel, the same safeguards should be provided as listed for full revolution clutch machines.

3 See Clause 2.4.1.1 for the objectives of the control system.

4 An additional guard lock can be provided, operated by signal that the latch of the full revolution clutch has returned to non-repeat position.

3.3.5 Access required to more than one side

If the work performed on the press requires access to the danger zone from more than one side, arrangements shall be provided for the fitting of a guard giving the same level of protection for the operator on each side from which access is possible, as specified in Appendix B.

3.3.6 Safe methods of work

Where a very large press may be used for special 'one-off' pressing of large components, e.g. pressure vessel ends, and use of a guard is impracticable, provision shall be made for allowing a safe method of work, e.g. provision for controls to be moved to a safe position or audible warning or visual danger signals (see AS 4024.1907).

NOTE: This concession does not affect the need to provide a guard or other protective device for usual operations and control at the press.

3.3.7 Closed tools

Closed tools shall be inherently safe. Their openings and the corresponding distances shall meet the requirements of AS 4024.1801 or not exceed 6 mm. Any additional crushing hazard outside the closed tools shall be avoided.

3.3.8 Fixed enclosing guards

Fixed enclosing guards shall comply with AS 4024.1601. They shall be firmly secured to the machine, another rigid structure or the floor. Feed openings shall comply with AS 4024.1801.

3.3.9 Interlocking guards

Interlocking guards with guard locking shall comply with AS 4024.1601 and prevent, in conjunction with fixed guards, access to the danger zone in the tools area until the slide is at rest in its correct stopping position. Initiation of the stroke shall be prevented until the guard is closed. The associated interlocking devices shall be designed and constructed in accordance with AS 4024.1602.

3.3.10 Control guards

Control guards with guard locking shall comply with AS 4024.1601 and prevent, in conjunction with fixed guards, access to the danger zone in the tools area, until the slide is at rest in its correct stopping position. Initiation of the stroke shall be prevented until the guard is closed.

Interlocking devices shall be designed and constructed in accordance with AS 4024.1602.

3.3.11 Early opening guards

Early opening interlocking guards shall comply with AS 4024.1601 and prevent, in conjunction with fixed guards, access to the danger zone in the tools area. Initiation of the stroke shall be prevented until the guard is closed. The interlocking devices shall be designed and constructed in accordance with AS 4024.1602.

They shall be—

(a) provided with guard locking, to prevent the opening of the guard gate until any dangerous movement in the tools area has ceased; or

(b) without guard locking, but designed to bring the dangerous movement to a stop before the danger zone can be reached.

Early opening interlocking guards can also be control guards without guard locking.

3.3.12 Presence sensing systems

Electro-sensitive protective equipment shall comply with the following:

(a) It shall be designed and constructed according to IEC 61496-1 and IEC 61496-2.

(b) Access to the danger zone shall only be possible through the detection zone of the electro-sensitive protective equipment. Additional safeguarding shall prevent access to the danger zone from any other direction.

(c) Where it is possible to stand in a position between a light curtain and the danger zone of the press, additional means, e.g. further beams, shall be provided to detect any person standing there.

The maximum permissible unprotected gap shall be calculated from AS 4024.2801 (see Figure 3.1).

(d) Access to the hazardous area during any movement of the slide shall be permitted only for machine setting or essential maintenance purposes, and not for production purposes.

(e) The means of resetting shall be positioned so that, from that position, there is a clear view of the danger zone. There shall not be more than one reset control device for each detection zone. If the press is safeguarded by means of side and back electro-sensitive protective equipment, a reset control device shall be provided on each detection zone.

(f) Where the electro-sensitive protective equipment operates by reflecting the transmitted light beam back along its own path and additional reflector(s) are placed within the detection zone, then the configuration of the additional reflector(s) shall not allow an item of thickness equal to or greater than the specified test piece size to be undetected by the electro-sensitive protective equipment at any location within the detection zone, unless other measures are taken to ensure that it is not possible to reach the danger zone.

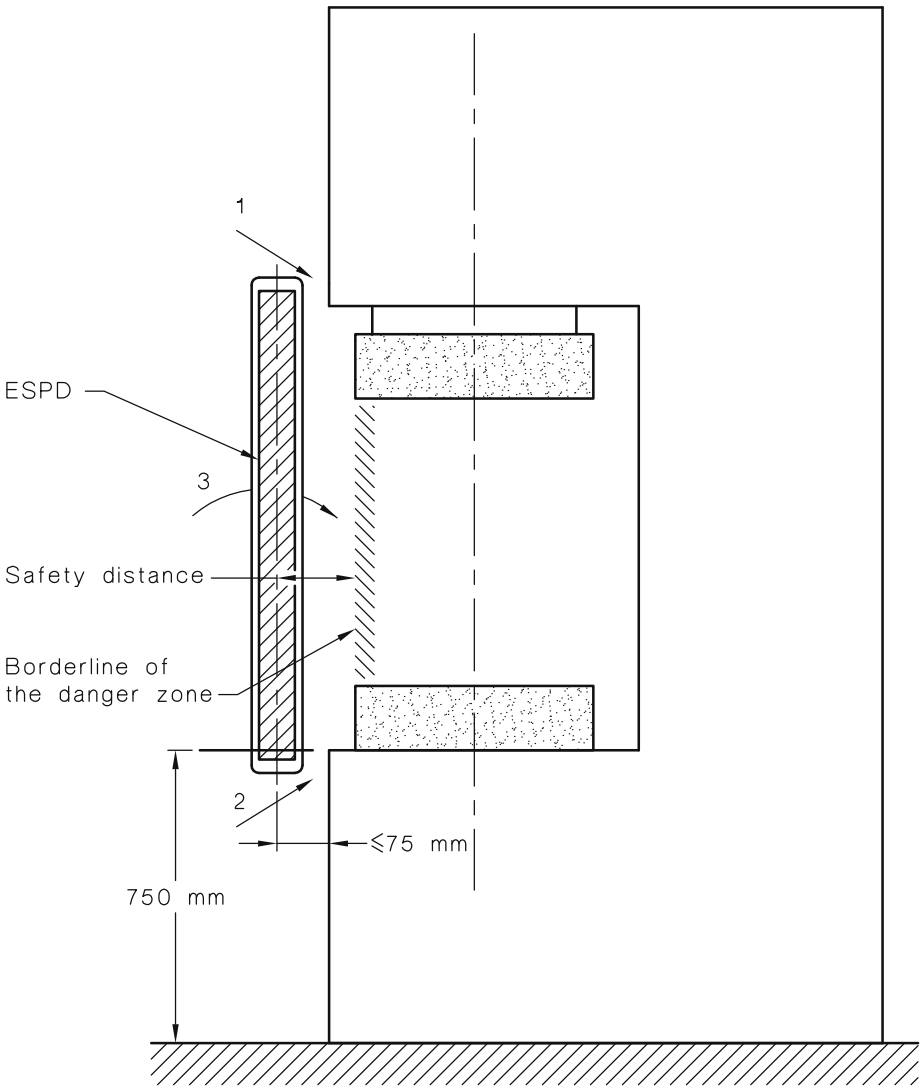
(g) Where the electro-sensitive protective equipment is also used for cycle initiation, either single or double break, the following applies:

(i) The height of the press table shall be equal to or greater than 750 mm above the standing level of the operator. If the table is less than 750 mm in height, this height shall be achieved by the use of an additional fixed guard kept in place permanently, or by the use of an interlocking guard fitted close to the press table. It shall not be possible to stand between the physical barrier and the table or tools, or beside the table or tools.

(ii) The opening stroke length shall be less than or equal to 600 mm, and/or the depth of the press table shall be less than or equal to 1000 mm.

(iii) The facility to initiate the press motion upon clearing of the curtain shall be limited to a period commensurate with a single normal cycle (the preset time).

(iv) If there is more than piece of electro-sensitive protective equipment safeguarding the press, only one shall be selected for cycle initiation at any one time (see Figure 3.1).



NOTES:

1 Values against reaching over (1), reaching under (2) and reaching around (3) in accordance with AS 4024.1801.

2 Side guards have been omitted for the purpose of this illustration.

FIGURE 3.1 APPLICATION OF ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT TO A MANUALLY FED PRESS USED FOR CYCLE INITIATION

3.3.13 Preset time

The pre set time shall not exceed 30 s, starting from the end of the previous operating cycle. The electro-sensitive protective equipment shall be required to be reset if the preset time has been exceeded. Normal means of initiating press motion shall be provided for occasions when it is not automatically initiated within that limited period.

3.3.14 Two-hand controls

Two-hand control devices shall comply with the following requirements:

(a) Two-hand control devices shall conform to the requirements of AS 4024.2601.

(b) The number of two-hand control devices in operation shall correspond to the number of operators indicated at the selection system on the press control console.

(c) Initiation of output signals shall not be possible using one hand, hand and elbow of the same arm, forearm(s) or elbow(s), hand and other parts of the body.

Reference should also be made to AS 60204.1.

3.3.15 Early opening guards

Early opening interlocking guards without guard locking, electro-sensitive protective equipment and two-hand control devices shall be placed in such positions that the operator does not have time to reach the danger zone before any dangerous movement in the tools area has ceased. Calculation of the safety distance shall be based on the overall response time of the press coming to a stop and on the speed of movement of the operator (see Appendix C).

3.3.16 Conditions of interlocking the motor and the clutch

Reverse running shall only be possible in the setting mode. It shall not be possible to start the motor if the press clutch is engaged or to engage it or leave it engaged if the motor is stopped, except under various setting conditions.

3.3.17 Single stroke devices

Where a press is to be used in single cycle mode, a single stroke device shall be fitted. This device shall prevent a subsequent stroke even if the control device is continuously actuated. A further stroke shall require the release of the control device and a new initiation.

3.3.18 Mechanical restraint devices

A mechanical restraint device shall be provided, to be inserted in the press for use during repair or any necessary intervention between the tools other than normal manual feeding. Where the device is not capable of absorbing the entire press force, it shall be interlocked to the press control so that a stroke cannot be performed while the device is in position, and the press slide is retained in the upper position.

On presses with an opening stroke length greater than 500 mm and a depth of table greater than 800 mm, the device shall be permanently fixed and integrated with the press. If an integrated device, when active, cannot be easily seen from the operator's position, an additional clear indication of the position of the device shall be provided.

3.3.19 Other requirements

3.3.19.1 *Tool fixing*

The press shall be designed and constructed so that tools can be secured to the press in such a way that no hazard can arise in the event of a single component fault or power failure.

3.3.19.2 *Fastening*

All fastenings on the press, e.g. screws, nuts or glued joints, shall be assembled in such a way that parts will not loosen and cause injury.

3.3.19.3 *Manual adjustment locking*

Where manual adjustment can create a hazard (e.g. due to the stroke or slide adjustment, or speed change), it shall have a reliable locking device that only allows adjustment by means such as a tool or an electronic password.

3.3.19.4 *Feedstock guides*

On automatically running presses with part revolution clutches and handling devices that are integral parts of the press, the leading edge of the coil shall be automatically guided into progression tools, where it is practicable.

If the leading edge of the coil cannot automatically be guided during loading through the handling device and the progression tools, the press shall be provided with either—

(a) an inching device (see Clause 3.5.11); or

(b) a hold-to-run control device with three positions and slow closing speed (less than 10 mm/s) consisting of a single button having the following positions:

(i) Position 1……..Stop.

(ii) Position 2……..Run.

(iii) Position 3……..Stop again.

After pushing the button over a pressure point in position 3, a restart shall only be possible after returning the button to position 1.

These devices shall be operational when any guard on the press is moved from its protective position, so that the leading edge can be manually guided by the use of ancillary handling devices (e.g. grips, tongs, magnetic holders).

3.4 CONTROL AND MONITORING SYSTEM

3.4.1 Control and monitoring functions

3.4.1.1 *Safety functions*

Control systems shall include safety functions designed so that controls have to be re-actuated in order for the press to perform a stroke—

(a) after changing the mode of control or operation;

(b) after an interlocking guard has been closed;

(c) after a manual reset of the safety system;

(d) after an operating power failure;

(e) after a primary pressure failure;

(f) following actuation of tool protective device or part detector;

(g) after removal of an interlocked mechanical restraint device; or

(h) following the detection of any fault in the clutch/brake valve.

3.4.1.2 *Safety system intervention*

In the event of an intervention of a safety system (interlocking guard or electro-sensitive protective equipment), separate manual reset functions shall be required to restore the normal intended operation—

(a) if a person can pass through an interlocking guard;

(b) if the electro-sensitive protective equipment used for cycle initiation is not interrupted in a pre-set time;

(c) if the electro-sensitive protective equipment is interrupted during any dangerous movement in the cycle; and

(d) if the electro-sensitive protective equipment protects sides of the press from which the press is not operated.

Reset controls shall be within viewing distance of the danger zone, but out of reach from within that zone. The reset functions shall fulfil the requirements for at least a single system with monitoring.

3.4.1.3 *Special requirements*

This Clause applies to presses fitted with any protective device of the following types:

(a) Electro-sensitive protective equipment using active opto-electronic protective devices.

(b) Early opening interlocking guards.

(c) Two-hand control devices used for normal operation.

If a fault occurs in the safety related parts of these protective devices or control systems, then—

(i) an unintended start-up shall not be possible;

(ii) the safe functioning of the protective device shall be maintained;

(iii) it shall be possible to stop the machine during the dangerous movement;

(iv) the control system shall immediately stop the machine during the dangerous phase of the closing stroke or, in other cases, no later than the end of the operating cycle (see Note); and

(v) the control system shall prevent any initiation of the next operating production cycle until the fault is eliminated.

In order to meet these requirements, the safety related parts of the control systems shall comply with AS 4024.1501.

NOTE: Examples of this are where a fault occurs in one channel of a two channel control system, so that the other channel remains operative and where a fault occurs during parts of the cycle other than the dangerous phase of the closing stroke.

3.4.1.4 *Vibration and shock*

Where a press is subject to considerable shock and vibration, the design of the control system shall take this into account.

3.4.2 Part revolution clutch presses: Redundancy and monitoring of clutch/brake control systems, and overrun monitoring for single cycle use

NOTE: See Tables 3.1, 3.2 and 3.3.

3.4.2.1 *General*

Redundancy and monitoring of clutch/brake control systems, and overrun monitoring shall be provided to protect an operator in all cases in which the safeguarding system does not prevent access to the danger zone before the slide has stopped (normally top dead centre), e.g. for—

(a) electro-sensitive protective equipment;

(b) early opening interlocking guards; and

(c) two-hand control devices.

3.4.2.2 *Provision of interlocking guard*

Interlocking guards fitted with a guard locking device shall be provided with redundancy and monitoring of the clutch/brake control system. An overrun monitoring device is not required.

3.4.2.3 *Provision of monitoring and redundancy*

Where provision for redundancy and monitoring of the clutch/brake control system is necessary, it shall conform to the following requirements:

(a) The press shall be fitted with a double-bodied solenoid-operated valve that directly controls the fluid to the operated clutch and brake, or the equivalent in the case of other forms of drive.

(b) The valve solenoids shall be connected to the control circuit by separate wiring so that a single fault in the wiring cannot activate both solenoids.

(c) It shall be established that a short circuit between connections of the safety valve (e.g. solenoid to solenoid, or solenoid to self-monitoring assembly) will be detected automatically and will not lead to additional or unexpected motion of the slide.

(d) Where there is a need for sensors monitoring the valve state, these sensors shall be integral parts of the valves. The valve may have an inherent monitoring system in which valve failure is self-revealing.

(e) Monitoring shall be continuous and able to detect a fault within the press cycle. In the event of a fault within the valve(s), the clutch shall be disengaged and the brake applied.

NOTE: The stopping time should not be adversely affected by the fault.

(f) It shall only be possible to restore further operation of the press by a restricted means, e.g. by a tool, key or electronic password.

(g) Valves shall retain their normal stopping functions in the event of one part of the double valve element developing a fault.

(h) Valves shall be designed to ensure that any leakage past the inlet when the valve is in the non-operated position escapes to atmosphere sufficiently freely to prevent a build up of pressure causing a stroke.

Valves shall be piped and sized to ensure sufficient exhaust capacity for prompt release of air from the clutch/brake. Exhaust mufflers should be rated to at least equal the valve manufacturer's specifications for flow capacity and maintained to ensure that this capacity is not reduced by any external influence.

3.4.2.4 *Provision of overrun monitoring*

Where overrun monitoring is necessary, it shall conform to the following requirements:

(a) Manually-fed presses fitted with protective devices for the type listed in Clause 3.4.1.3 shall include overrun monitoring devices to ensure that, if the crankshaft overruns its normal stopping position by an amount specified by the manufacturer (not exceeding 15° and preferably 10°), a stopping signal shall be immediately initiated and no new cycle initiation shall be possible.

(b) It shall only be possible to restore further operation of the press by a restricted means, e.g. a tool, key or electronic password.

(c) Where the cams to the overrun monitoring device are driven from a camshaft that is indirectly driven from a crankshaft (e.g. by a duplex chain drive between the camshaft and the camshaft), the indirect drive shall be monitored in such a way that, if it fails, a stopping signal shall be initiated and no new cycle initiation shall be possible until the fault is eliminated.

3.4.2.5 *Linking of overrun monitoring components*

The cams and relevant switches for overrun monitoring, single cycle stop and muting shall be linked one with another in a positive way so that the relative position between the cams and the relative position between the switches cannot be altered.

On presses fitted with a variable speed arrangement, the single cycle stop function switch may be capable of separate adjustment. All cams shall be positively secured to the shaft. All cams and relevant switches shall be in a locked enclosure.

3.4.2.6 *Adjustable stroke length*

Where the stroke length can be varied, the adjustment of cams or cam operated switches used for cycle control shall be linked in a positive way so that their relative position cannot be altered.

NOTE: This is to reduce the probability of mis-setting by the user, e.g. to compensate for deterioration in braking performance that should be remedied by maintenance of the brake.

3.4.2.7 *Camshaft clutches*

If the camshaft is connected to the crankshaft by a clutch, the clutch engagement shall be positive, e.g. by gearing.

3.4.2.8 *Cam adjustment*

The maximum adjustment of the rotary cam arrangement shall be mechanically limited to an angle of 60°, preferably 45°.

NOTE: Details of the rotary cam adjustments are given in Appendix D.

3.4.2.9 *Cam discs*

Cam discs shall be applied so that a wrong or unintended fitting cannot cause accidents, and—

(a) the limit switches and cam for control of the press shall be fixed to each other and adequately secured;

(b) unsecured nuts or bolts are not permissible;

(c) the position of the limit switches and cam plates in relation to each other shall be marked;

(d) the possibility of re-adjustment of limit switches or cam shall be limited by fixed end stops, so that the muting time during the closing movement of the press cannot exceed the press overall response time with any combination of speed and length of stroke; and

(e) the possibility of damage to the impulse device when the press is reversed shall be prevented.

3.4.3 Muting

Muting may be provided for electro-sensitive protective equipment and two-hand control devices. They shall only be muted at a point in the opening stroke, or when the dangerous phase of the closing stroke is passed and there is no risk of injury at the tools. Trapping points at ejectors and die cushions shall be taken into account. The safeguarding system shall become operative again at or before the start of the downstroke.

In addition—

(a) the muting position shall be secured against unauthorised adjustment by provision of special tools, e.g. key entry or electronic passwords;

(b) any additional hazard during the opening stroke shall be prevented, e.g. by fixed guards; and

(c) the signal for the initiation of muting shall be monitored.

Muting may also be provided for the gate of an interlocking guard fitted to a part revolution clutch press, where early opening of the gate is allowed when the dangerous phase of the closing stroke has passed (see Clause 3.4.2).

3.4.4 Programmable electronic systems (PES), programmable pneumatic systems (PPS) and safety related functions

The use of programmable electronic systems and programmable pneumatic systems shall not reduce any level of safety laid down in this Standard.

Where a press is controlled by programmable electronic systems or programmable pneumatic systems, the safety related functions shall not rely solely on the programmable electronic systems or programmable pneumatic systems.

AS 4024.1202 shall be consulted for requirements for safety functions implemented by programmable electronic control systems. AS 62061 shall also be consulted as it provides requirements and recommendations for the specification, design and validation of safety-related electrical control systems for machines that are not portable by hand.

3.4.5 Selector switches

3.4.5.1 *Provision of selector switches*

Where there is a choice of modes of operation, cycle initiation or safety system of the press (e.g. single stroke, inch or continuous, front or back, or front and back), selector switches shall be provided. The design shall ensure that, for each position not in use, circuits are completely isolated by positively operated contacts, or by redundant and monitored hardware. If the switch is set in an intermediate position, no operation shall be possible. The control system shall ensure that no start-up is initiated when the selector switch is operated.

3.4.5.2 *Use of single selector switch*

Where one selector switch is provided, it shall be used to select the appropriate mode of safeguarding, which can be two or more guards or protective devices (see Clause 3.3.3). Where two or more selector switches are provided and the mode of safeguarding is connected to the control system, the chosen mode of operation shall be automatically linked to the corresponding mode of safeguarding.

3.4.5.3 *Use of additional selector switch*

If a press is also intended to be used according to Clause 3.3.2(a) or (b) and at the same time operated, e.g. by foot switch, without any other safeguarding, this mode of production shall be chosen by an additional selector switch operated by a separate key or within a locked enclosure. The selection of this mode shall automatically give a clear indication at the press that only closed tools or fixed enclosing guards shall be used.

3.4.5.4 *Multiple operators*

If there is more than one operator at a machine, the level of protection shall be the same for each operator. Where a number of two-hand control devices can be used, the press shall only be operable if the combination selected corresponds exactly to the combination physically connected to the press.

3.4.5.5 *Safety related functions*

Selector switches for safety related functions shall be key-operated. The selection chosen shall be visible and clearly identifiable.

3.4.6 Isolation switch

An isolation switch, within reach of the operator, shall be provided to allow the safe disconnection of the clutch or direct drive control system; however, on presses with full revolution clutch, a mechanical blocking device shall prevent the engagement of the clutch.

3.4.7 Position switches

3.4.7.1 *General*

There are two important safety functions of position switches applied to presses:

(a) The cyclic position switch(es), e.g. muting, overrun and top dead centre limit switches.

(b) The interlocking guard gate switches.

3.4.7.2 *Design*

The switch and its means of operation shall be designed to maintain their correct relationship to one another, the operating cam and the stroke.

The mechanism associated with the switch, e.g. cam and follower, shall be designed so that reverse rotation is possible without damage.

3.4.7.3 *Manual feed*

On presses used for manual feed or removal, all shaft position switches controlling slide movement shall be the electro-mechanical type. Requirements for redundancy and monitoring of the function are specified in Clauses 3.4.1.3 and 3.4.2.

3.4.7.4 *Use of proximity switches*

Proximity switches are acceptable for the rotary cam arrangement of the crankshaft on solely automatically running presses. If redundancy and monitoring are required (see Table 3.3), the proximity switch units shall achieve redundancy and monitoring.

3.4.8 Control devices

3.4.8.1 *Shrouding*

Push button, foot switch and start control devices shall be shrouded to prevent accidental operation. Foot switches shall permit access from one direction only and by one foot only. Treadles shall not be used.

3.4.8.2 *Emergency stop*

Emergency stop devices shall, on actuation, stop all dangerous movement by immediate removal of power to the machine actuators (i.e. an uncontrolled stop, Category 0 of AS 60204.1).

There shall be at least one emergency stop control device within direct reach of each operator, including any operator(s) at the rear of the press. Any disconnectable control station shall not incorporate an emergency stop control device if the press can be operated while the control station is disconnected.

3.4.9 Valves

Manual override devices incorporated into valves shall be designed to include a captive lid or cover that requires the use of a tool or key to open it. Electrical override devices shall be key-operated and their operation shall only be possible with the slide in bottom dead centre position, motor off and flywheel stopped.

3.5 TOOLSETTING, TRIAL STROKES, MAINTENANCE AND LUBRICATION

3.5.1 General

The machine shall be designed so that toolsetting, maintenance and lubrication can be carried out safely. The need for access and manual intervention during setting and maintenance shall be minimized, e.g. an automatic system or remote application may be used for lubrication.

3.5.2 Guarding

Facilities shall be provided to allow the movement of the slide during toolsetting, maintenance and lubrication to be carried out with guards and protective devices in position and operational (see Clause 3.3.2).

Where this is not technically possible, at least one of the following facilities shall be provided:

(a) Rotation of the crankshaft by hand, with power isolated.

(b) Slow speed (less than 10 mm/s) and a hold-to-run control device.

(c) Two-hand control device with at least simultaneous operation (see Clause 3.5.8) and arranged so that it cannot be used for production, e.g. when the cycle stops at least three times during one revolution of the crankshaft.

(d) Using the limited movement control device (inching device).

For presses with full revolution clutches and for direct drive eccentric presses, only Item (a) above is permitted.

3.5.3 Trial strokes

All trial strokes (single operating cycle) after toolsetting or adjustment are considered as production strokes, and the safeguarding shall meet the requirements laid down in Clause 3.3.

3.5.4 Feeder devices

Manually adjustable feeder devices shall be capable of being set with the slide stationary.

3.5.5 Manual rotation of the crankshaft

If a bar or other device is used to rotate the crankshaft by hand, the following requirements apply:

(a) When the main motor is switched off, a device shall prevent re-engagement of the clutch before the flywheel has come to rest. This device, e.g. a timer that is not adjustable by the user or a motion detector, shall be monitored.

(b) It shall not be possible to inadvertently leave the bar in position during normal operation.

(c) It shall be possible to see at least part of the flywheel to ensure that it is stationary.

3.5.6 Additional control devices

Unless the protective devices used in normal production can be retained in use, control devices shall be provided on each accessible side of the press so that at least one person at each side, with a clear sight of the access zone and the tools area, is required to participate in initiation.

If it is foreseeable that there will be more than one person on a side, additional devices (e.g. enabling devices, selector switches, warning signals) shall be provided.

3.5.7 Opening movable guards

If a movable guard has to be opened for toolsetting, it shall be interlocked in accordance with AS 4024.1601.

The minimum requirement of interlocking at movable guards opened or removed only for toolsetting or maintenance is a switch of the positive opening operation type (see AS 4024.1602). The interface to the operative parts of the control system shall not rely solely on one relay.

3.5.8 Two-hand controls

Two-hand control devices shall comply with the following:

(a) Two-hand control devices shall at least comply with the requirements of type II AS 4024.2601.

(b) Initiation of output signals shall not be possible using one hand, or hand and elbow of the same arm.

3.5.9 Limited movement devices

Hold-to-run control devices and limited movement control devices (inching devices) shall be hardwired and the safety related parts of the control system shall conform to Category 2 of AS 4024.1501.

The movement produced by the limited movement control device (inching device) shall be so small as to prevent a hazardous situation and shall be limited by a time control or distance control. The slide movement shall not exceed 6 mm per inching step with the crankshaft at 90°.

3.5.10 Devices provided for toolsetting

Two-hand control devices or hold-to-run control devices provided only for toolsetting shall be arranged so that they are unsuitable for normal use.

3.5.11 Interfaces

The interfaces between hold-to-run control devices, two-hand control devices, limited movement control devices (inching devices) and the operative parts of the control system shall not rely solely on one relay.

3.6 OTHER MECHANICAL HAZARDS

3.6.1 Safeguarding drive and transmission machinery

The drive and transmission machinery and ancillary devices that are an integral parts of the press shall be safeguarded.

Where the safety distances given in AS 4024.1801 for reaching upward or over a barrier to a danger zone are not complied with, or where access is required for regular maintenance, safeguarding shall be provided as follows:

(a) Where access is required once per shift or less, by fixed or interlocked guards.

(b) Where access is required more than once per shift, by movable guards interlocked with the control system.

(c) Where the danger zone can be reached before the dangerous motion comes to a halt, by interlocking guards with guard locking and delayed unlocking.

The delayed unlocking shall be arranged so that a timer or a motion detector controls the guard locking.

3.6.2 Safeguarding ancillary devices

Ancillary devices that are not mechanically controlled by the press shall be additionally interlocked to the press control system so that, during any intervention, no hazardous situation will arise.

3.6.3 Ejection hazards

Ejection hazards created by machine components or their parts shall be eliminated by design or by additional shielding, both capable of withstanding the foreseeable forces.

3.7 SLIPS, TRIPS AND FALLS

Where raised work stations are provided with the machine, they shall be provided with adequate guard rails and toeboards. Safe means of access shall be provided to the work station (see AS 1657).

The press shall be designed, constructed and supplied to minimize the risk of slips, trips and falls in the press area (see AS/NZS 4586).

3.8 PROTECTION AGAINST OTHER HAZARDS

3.8.1 Electrical hazards

All electrical equipment shall be designed and constructed to prevent electrical hazards (e.g. shocks, burns).

3.8.2 Thermal hazards

Means such as shielding, or insulation shall be provided to prevent burns from accessible parts of the press, e.g. brakes, clutches and part of the hydraulic system.

3.8.3 High pressure fluid ejection hazards

Additional shielding, e.g. screens, shall be provided to flexible piping installed adjacent to an operator's working position to reduce the risk resulting from a failure in the flexible piping system.

3.8.4 Hazards generated by noise

The press shall be designed and constructed so that risks resulting from the emission of airborne noise are reduced to the lowest level, taking account of technical progress and the availability of means of reducing noise, in particular at its source.

The design shall take into account noise from each source. Appropriate technical measures for reducing noise at the main sound sources of the press are listed below:

(a) Transmission noise .....flywheel and gearwheel damping facilities.

(b) Pneumatic exhaust ..... silencers.

(c) Power generation source ..... acoustic panels (partial or total).

(d) Noise at the tools..... damping facilities on the press.

(e) Workpiece ejection.....silenced nozzles.

(f) Feeding and transfer systems ..... acoustic enclosures, damping facilities.

(g) Structurally transmitted noise..... anti-vibration machine mounts.

Additional or alternative measures giving identical or higher reduction efficiency may be used. In any case, declared noise emission values are the decisive criteria for the noise emission of a given machine. The manufacturer shall be able to supply the necessary information concerning the measures incorporated in order to reduce noise at source.

3.8.5 Hazards generated by vibration

The design of the press shall be such that vibration that can cause injury shall be avoided, e.g. by isolation of the press from the floor foundations.

3.8.6 Hazards generated by materials and substances

3.8.6.1 *Hazardous substances*

Hazardous substances shall not be used wherever possible in the construction of the press, and the use of materials that can cause injury or damage to health shall be eliminated.

Adequate means shall be provided to prevent the formation of aerosols and respirable oil mists in unhealthy concentration, e.g. from oil used to lubricate pneumatic systems.

3.8.6.2 *Use of asbestos*

Asbestos linings for clutches and brakes shall not be used.

3.8.6.3 *Processing hazardous substances*

If it is known that hazardous substances are intended to be processed by the user (e.g. hard metal powder), safeguarding systems shall be designed to minimize operator exposure and to accept, if necessary, exhaust ventilation.

3.8.6.4 *Exhaust ventilation design*

Design measures for exhaust ventilation and dust collection equipment shall include features to minimize the risk from fire and explosion.

3.8.7 Hazards generated by neglecting ergonomic principles

3.8.7.1 *Posture*

The press and its controls shall be designed to provide a good work posture that does not cause fatigue.

3.8.7.2 *Controls*

The positioning, labelling and illumination, if necessary, of control devices, and facilities for materials and tool set handling shall be in accordance with ergonomic principles.

3.8.7.3 *Lighting*

Where necessary on the press, work stations and the zones in which control devices, guards and protective devices are located shall be lit sufficiently to ensure that all work equipment and materials can be properly seen, and eye strain is avoided.

3.8.7.4 *Manual handling*

Parts of the press that need to be lifted with a lifting device shall include necessary attachments to accommodate the fitting of a lifting device.

Tanks containing hydraulic fluid shall be placed or oriented in such a way that the filler and drain pipes can be easily reached.

SECTION 4 INFORMATION FOR USE

4.1 MARKING

The press shall be marked with the following:

(a) Name and address of the manufacturer and, where applicable, of the supplier.

(b) Designation of series or type.

(c) Serial number.

(d) Year of construction.

(e) Mass of the press, without tools or ancillary devices.

(f) Lifting points for transportation and installation purposes.

(g) Nominal force and nominal force travel.

(h) Normal stop position of the crankshaft, e.g. top dead centre.

(i) Maximum tool dimensions and mass.

(j) Maximum permissible flywheel speed in revolutions per minute, and direction of rotation.

(k) Continuous stroking rate, in strokes per minute.

(l) Minimum and maximum if variable speed range.

(m) Maximum permissible number of clutch engagements per minute.

(n) Minimum and maximum stroke length.

(o) Slide adjustment and shut height.

(p) Supply data for electrical, hydraulic and pneumatic systems (e.g. minimum pneumatic pressure).

(q) Minimum and maximum fluid pressure in the clutch/brake system.

(r) A chart indicating the appropriate air pressure in the counterbalance cylinders for the mass of the tool.

(s) Overall response time and corresponding safety distance(s) (see Appendix C).

(t) Any limitation on the type of protective device(s) and mode of operation, e.g. closed tools, for which the press is suitable.

Protective devices supplied with the press shall also be marked with identification data.

4.2 INSTRUCTION HANDBOOK

An instruction handbook shall be provided with the machine and shall include the following information:

(a) A repeat of the information with which the press is marked (see Clause 4.1).

(b) A reference to any Standard used in the design of the press.

(c) Instructions for safe installation e.g. floor conditions, services, anti-vibration mountings.

(d) Instructions for how the initial test and examination of the press and guarding system are to be carried out before first use and being taken into service.

(e) Instructions on control systems, including circuit diagrams for electrical, hydraulic and pneumatic systems. Where a programmable electronic system or programmable pneumatic system is provided, the circuit diagrams shall show the clear relationship at the interface between any hardwired part and the programmable electronic system or programmable pneumatic system.

(f) Information on noise levels likely to be generated during use.

(g) Details or any further protection for the operator which may be necessary to deal with residual risks, e.g. hearing protection, eye protection or foot protection.

(h) Instructions for safe use, including—

  (i) setting and trial strokes;

  (ii) maintenance;

  (iii) cleaning;

  (iv) programming (where required);

  (v) avoidance of danger from all hazards, including ejection hazards created by workpieces, tools or parts of them, fluids, linings etc.

(i) Particular training needed by persons who are appointed to prepare mechanical presses for use, including suitable and sufficient instruction in—

  (i) press mechanisms;

  (ii) protective devices;

  (iii) accident causation and prevention;

  (iv) the work of the toolsetter;

  (v) tool design; and

  (vi) replacement parts.

(j) Details of any pre-production inspection of the guard or protective device required after toolsetting or adjustment of the tools.

(k) Specification of any fluid to be used in hydraulic systems and for lubrication, braking or transmission system.

(l) Specifications for consumables and components, taking account compatibility and continued safe operation of the press.

(m) Descriptions of foreseeable failure modes and advice on detection, prevention and correction by periodic maintenance.

(n) Requirements for any test or examination necessary after changes or modifications to the press that affect the safety functions.

(o) Requirements for periodic maintenance, test and examination of the press, guards and protective devices, including maintenance, testing and examination intervals. Periodic examinations shall be capable of being carried out with equipment or tools that are generally available or such tools or equipment shall be provided with the press.

It is recommended that check lists be prepared for the operations covered by Items (d), (j) and (o). In particular, safety examinations shall contain a specific check list that can be signed by the examiner.

APPENDIX A

PRESSES WITH FULL REVOLUTION CLUTCHES—DESIGN REQUIREMENTS

(Normative)

A1 EXTRACTOR DESIGN

A1.1 Clutch engagement

The extractor shall be designed so that, after being moved to the position where the clutch is released for engagement, it cannot return to the clutch disengaging position until the crankshaft has rotated at least 20° from its normal stopping position.

A1.2 Movement limitation

The extractor shall be prevented by mechanical stops from moving beyond the designed limits necessary for engagement and disengagement of the clutch. The stops shall be in direct contact with the extractor unit, and not with associated linkages or levers.

A1.3 Mechanical interlocking

The design of the extractor shall allow mechanical interlocking with a protective device.

Where the extractor embodies a cushioning device, it shall not be possible for the interlock to apply pressure to the device.

A1.4 Rolling key clutch

For presses of a capacity of 400 kN with rolling key clutches, the clutch shall be designed so that, when engaged, the crankshaft is reliably connected to the flywheel in both directions of relative rotation.

A2 PREVENTION OF OVERRUN AND FALL-BACK

A2.1 General

In addition to and independent of the normal cyclical working of the friction brake on the press, mechanical means shall be provided to prevent the unintended descent of the slide by overrun or fall-back of the crankshaft, or gravity fall.

A2.2 Interlocking guards

Particular requirements for interlocking guards at full revolution clutch presses are given in Paragraph B1.

APPENDIX B

INTERLOCKING GUARDS

(Normative)

B1 PRESSES WITH FULL REVOLUTION CLUTCHES

B1.1 Guard gate

For manually operated guards with a horizontally pivoted gate or shutter and a mechanical interlocking system, the guard gate shall be arranged so that movement of the clutch mechanism for clutch engagement is not possible until the gate or shutter has moved to a position beyond the fully closed position by an amount equal to at least 10% of its total movement.

The design of the guard shall be such that there is no possibility of re-exposure to the danger zone while the guard is traversing the overlap area.

B1.2 Guard performance

On variable stroke presses, stroke variation shall not affect the performance of the guard and associated mechanical interlocking arrangements.

The arrangements shall be such that examination and testing of the interlocking devices can be effectively carried out. Independent testing of the interlocking devices will generally involve some disengagement of the guard and press-operating mechanism.

B1.3 Extractor interlocking device

The principal components of the clutch are the key and the extractor. The extractor shall be fitted with a positive interlocking device to fulfil the following conditions:

(a) When the gate is in any position other than the closed position, the interlocking device shall lock the extractor with the clutch key in the disengaged position.

(b) When the extractor is in any position other than that specified in Item (a), it shall not be possible to move the interlocking device or open the guard gate.

(c) When it is necessary to disconnect the interlocking device from the guard (e.g. to enable the press to be turned by hand) or when fixed guards or closed tools are to be used, a manual adjustment of the interlocking device may be made to permit clutch engagement.

(d) The interlocking device shall move to the safe locked position as described in Item (a) if disconnected from the guard. This shall be achieved by gravity or, where this is impracticable, by a compression spring incorporated in the device. On inclinable presses, this shall be achieved for all positions of the press body.

B1.4 Guard to extractor linkage

If the linking between guard and extractor is not mechanical, then the movement and position of the interlocking guard, the crankshaft and the extractor shall be monitored by their own control system in the following way:

(a) The control system shall not depend on the control system of the press. The connection shall be made directly to the extractor.

(b) The control system shall be automatically monitored so that any failure of the components in this control system cannot lead to an unintended cycle.

(c) After any failure of a component in the control system, it shall not be possible to open the guard or to initiate a cycle.

(d) The extractor movement shall be integrated into the control system.

(e) Any significant deviation of the extractor stop position shall actuate the automatically monitored control system to prevent any further cycle.

B2 PRESSES WITH PART REVOLUTION CLUTCHES

B2.1 Hand fed press

Where the press is hand fed, the guard shall fulfil the following requirements:

(a) Electrical interlocking shall comprise two mechanically actuated position switches operating in opposite modes.

(b) The switches shall not be operated until the guard shutter has reached a closed position preventing access to the danger zone.

(c) Redundancy and monitoring shall be provided (see Figure B1).

Each of the two interlocking switches above are connected in series with a solenoid that operates a valve element. This arrangement ensures that the press clutch system will exhaust correctly provided that one valve element is operational. The movement of each valve shall be monitored.

Monitoring can be fulfilled either by—

(i) switches being connected into fail-safe monitoring circuits so that failure of either valve element to return to the off position at the end of a cycle will prevent initiation of another cycle; or

(ii) an inherent monitoring system.

NOTE: Any fault detected should also prevent initiation of another cycle.

B2.2 Early opening guard

Where the guard is early opening (so that the guard gate can be opened before top dead centre), the press shall have the type of control and braking system specified in Clause 2.4.2. The guard gate shall not open before bottom dead centre. Where the press is hand fed and the guard gate can be opened before top dead centre, the guard shall conform to Paragraph B2.1 above, except that the switches need not be connected in series to the solenoid.

B2.3 Automatic feed

Safety integrity of the guard should be achieved either—

(a) as determined from the category of control system recommended in AS 4024.1501; or

(b) by use of interlocks as shown in Figure B1.

NOTE: In Figure B1, the guard should be interlocked with the press control devices by means of two independent electrical circuits.

The two limit switches are—

(i) actuated by the guard and installed in opposite modes; and

(ii) connected in separate circuits to a double-monitored solenoid-operated air valve that controls the air supply to clutch/brake combination.

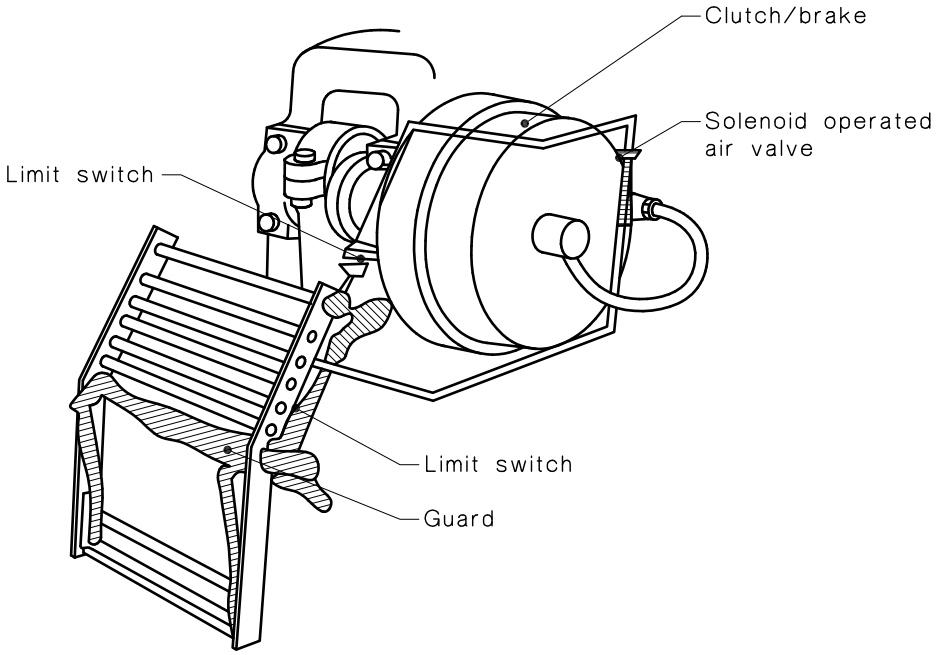


FIGURE B1 EXAMPLE OF AN INTERLOCKING GUARD WITH REDUNDANCY AND MONITORING

APPENDIX C

CALCULATION OF MINIMUM SAFETY DISTANCES

(Normative)

C1 SAFETY DISTANCE

The minimum distance at which early opening interlocking guards without guard locking, electro-sensitive protective systems using active opto-electronic protective devices, or two-hand control devices are placed from the danger zone shall be calculated in accordance with the general formula given in AS 4024.2601.

The equation is as follows:

$$S = (K \times T) + C \quad \ldots C1$$

where

S = the minimum distance from the danger zone to the detection point, line or plane in mm

K = parameter derived from data on approach speeds of the body or parts of the body in mm/s

T = the overall system stopping performance (overall response time), in s

C = the additional distance based on the intrusion towards the danger zone prior to actuation of the protective device in mm

C2 DETERMINATION OF *K*

In order to determine K, an approach speed of 1600 mm/s shall be used for horizontally arranged electro-sensitive protective equipment and for two-hand control devices. For vertically arranged active electro-sensitive protective equipment, an approach speed of 2000 mm/s shall be used if the minimum distance is equal to or less than 500 mm. An approach speed of 1600 mm/s can be used if the minimum distance is greater than 500 mm.

C3 DETERMINATION OF *C*

In order to determine C for electro-sensitive protective equipment, see Paragraph C6. For unshrouded two-hand control devices, C shall be at least 250 mm. For shrouded two-hand control devices and early opening interlocking guards without guard locking, C can be zero.

C4 SYSTEM STOPPING PERFORMANCE

When calculating the overall system stopping performance, the following features shall be taken into account under the most severe normal conditions:

(a) The maximum stroke length.

(b) The maximum slide speed during the closing stroke (e.g. half-stroke range for eccentric presses).

(c) The maximum number of strokes per minute.

(d) The influencing temperature of the relevant parts of the system.

(e) The maximum tool mass, in accordance with the intended use of the press.

(f) The maximum fluid pressure in the clutch/brake system.

(g) The minimum air pressure allowed by the low pressure cut-off arrangement of the counter-balance cylinders.

(h) The wear of the relevant parts of the stopping function.

(i) The effect of any rapid exhaust valve and its silencers.

NOTE: A means of determining the overall response time is given in Appendix E.

C5 POSITION OF PROTECTIVE DEVICES

When the position of the protective devices that are mechanically linked to the press can be altered, the devices shall, in order to maintain the minimum distance, be interlocked or capable of being locked in position, so that they can only be moved with the use of tools or keys.

C6 DETERMINATION OF *C*

With regard to the detection capability of the active opto-electronic protective device, the additional distance *C* in Table C1 shall at least be used when calculating the minimum distance *S*.

TABLE C1

ADDITIONAL DISTANCE *C*

Detection capability mm	Additional distance *C* mm	Cycle initiation by the electro-sensitive protective equipment
≤14	0	Allowed
>14 ≤20	80	
>20 ≤30	130	
>30 ≤40	240	Not allowed
>40	850	

APPENDIX D

SETTING OF THE ROTARY CAM ARRANGEMENT

(Informative)

D1 BASIC FEATURES OF THE ECCENTRIC ADJUSTMENT AND ROTARY CAM ARRANGEMENT

Fix the angle during adjustment of different lengths of stroke. Figure D1 shows the eccentric adjustment.

Assuming starting from the maximum stroke length and the slide in top dead centre, e_1 and e_2 are then in line, and the rotary cam arrangement indicates that the slide is positioned in top dead centre (see Figure D2(a)).

By turning the eccentric bush e_2, a new and shorter stroke length equal to $2e$ is achieved (see Figure D2(a)).

To reposition the slide to top dead centre, the crankshaft (and thus the rotary cam arrangement) is turned by an angle α in the opposite direction to the turning of the eccentric bush. The stroke length is now reduced to $2y$ (see Figure D2(c)). The rotary cam arrangement indicates a slide position deviating at an angle α from top dead centre. This is the reason why the rotary cam arrangement needs to be adjusted.

The angle α can thus achieve values between 0° and a value of α, which is dependent on the ratio between e_1 and e_2.

α_{max} is achieved if e_2 is turned in such a way that the angle between e_2 and e is 90° (see Figure D3).

α_{max} is obtained from $\sin \alpha_{max} = e_2/e_1$.

Where $e_1 \geq e_2$, α_{max} cannot be greater than 90° ($\alpha_{max} = 90°$ can occur for $e_1 \leq e_2$). If the eccentric bush is adjustable 180°, α_{max} can also be calculated by using the maximum and minimum stroke lengths S_{max} and S_{min} in—

$$\alpha_{max} = \frac{S_{max} - S_{min}}{S_{max} + S_{min}} \quad \ldots D1$$

If the press stopping position coincides with top dead centre at maximum and minimum stroke length ($\alpha = 0°$), the stopping position is displaced according to the angle from top dead centre at every other set stroke length.

To compensate for this and to maintain the stopping position at top dead centre, it should be possible to adjust the rotary cam arrangement to a corresponding angle. This adjustment can be made by rotating the limit switches, or cams, in relation to the crankshaft.

The largest angle by which the rotary cam arrangement can be rotated between mechanical stops is designated α_p, which is the maximum permissible adjustment of the rotary cam arrangement.

It is not permissible for the average stopping position of the slide to exceed the top dead centre by more than 60° (it should not be exceeded by more than 45°) at any combination of speed, stroke length and/or adjustment of the rotary cam arrangement. Therefore, the angle α_p should be limited between the mechanical stops.

The margin of the angle brake monitor (overrun) ε_2 shall also be included in the permissible overrun (60° or preferably 45°).

NOTE: ε_2 is defined in Appendix E.

Therefore, the sum of α_p and ε_2 shall not exceed 60° (preferably 45°) at the maximum stroke rate of the press (see Figure D4).

α_p is normally equal to α_{max}, so that the stopping position of the slide will always be at the top dead centre at different stroke lengths.

If the angle α_{max} is large, however, α_p should be limited so that the permissible overrun is not exceeded.

Consequently, the stopping performance of the slide at certain stroke lengths (these are dealt with below) cannot be nearer to top dead centre than within the angle λ (see Figure D5).

Figure D5 shows $\alpha_p = \alpha_{max} - \lambda$

The size of α_{max} is dependent on the maximum or minimum stroke length of the press. The minimum stroke length is the factor which has most effect on the size of the angle. For this reason, maximum and minimum stroke lengths should be used as shown in Table D1.

If α_p cannot equal α_{max}, then a stop of top dead centre cannot be achieved ($\lambda > 0$). This can arise at—

(a) maximum and minimum stroke length; and

(b) the stroke length created at $\alpha = \alpha_{max}$

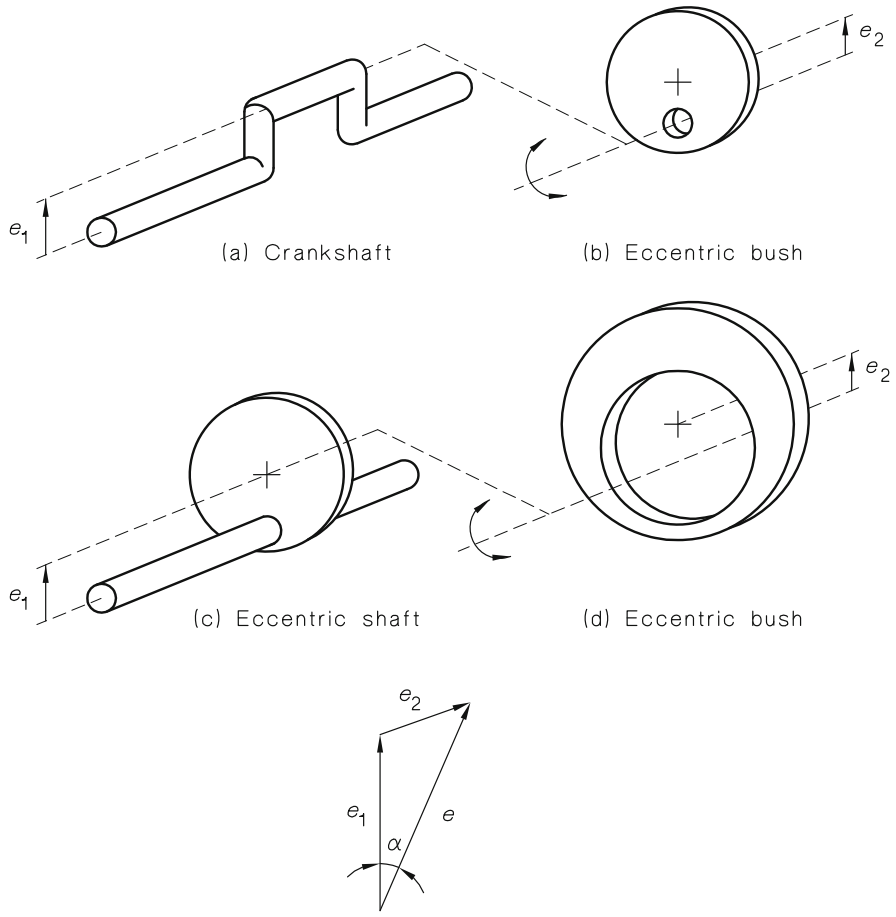
The limits for adjustment of the rotary cam arrangement are determined—

(i) with crankshaft direction of rotation, by the maximum overrun $\alpha_p + \varepsilon_2$; and

(ii) against crankshaft direction of rotation, the maximum permissible part of the mute angle before bottom dead centre, which is designated φ_{max} (see Figure D6).

One of the rotary cam arrangement end stops shall, in order not to exceed the maximum permissible overrun, be fixed in relation to the eccentric shaft when the slide is in top dead centre by either (a) or (b) in Figure D2, i.e. $\alpha = 0$ or $\alpha = \alpha_{max}$

The eccentric bush (ε_2) can be turned clockwise or anti-clockwise by ε_1 (see Figure D7). However, the necessary limitation of the adjustability of the rotary cam arrangement allows only one half of a full revolution of the eccentric bush to be used. For this reason, the stroke adjustment shall be designed so that only the correct half can be used.



LEGEND:

e_1 = eccentric distance of the crankshaft or eccentric shaft
e_2 = eccentric distance of the eccentric bush
e = (half stroke length) vectoral sum of e_1 and e_2
α = angle between e_1 and e (i.e. change in angle between e_1 and e on the basis of the change in stroke length). This is the angle the crankshaft is turned in order to reposition the slide to the same angle position as before the stroke adjustment.

FIGURE D1 ECCENTRIC ADJUSTMENT

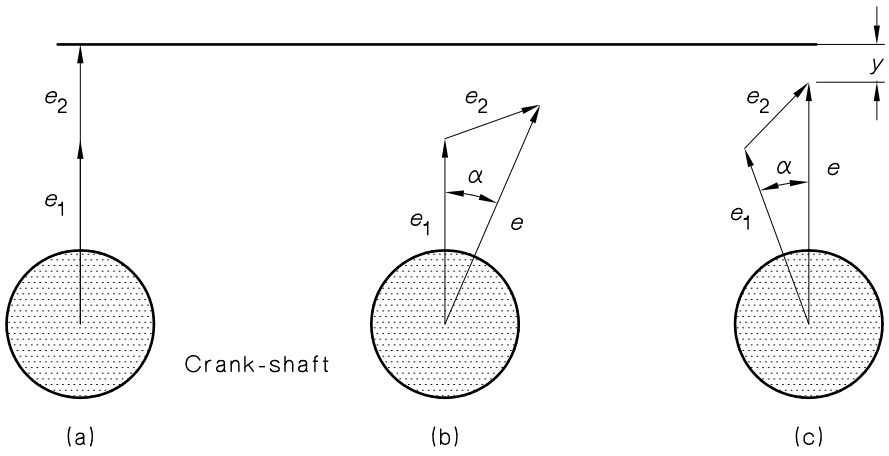


FIGURE D2 EFFECTS OF ADJUSTING ECCENTRIC BUSH

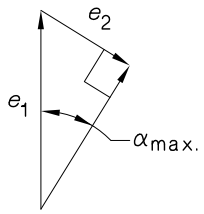


FIGURE D3 MAXIMUM CRANKSHAFT OFFSET

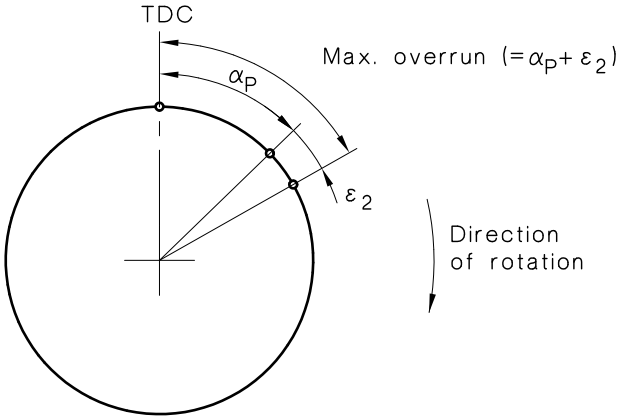


FIGURE D4 MAXIMUM OVERRUN

λ = displacement of the stopping position

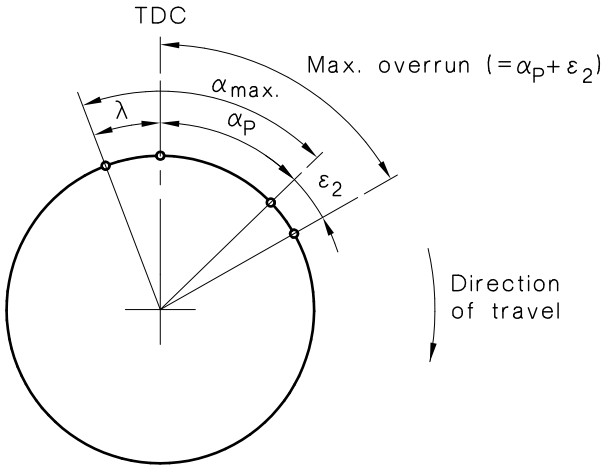


FIGURE D5 STOPPING POSITION DISPLACEMENT

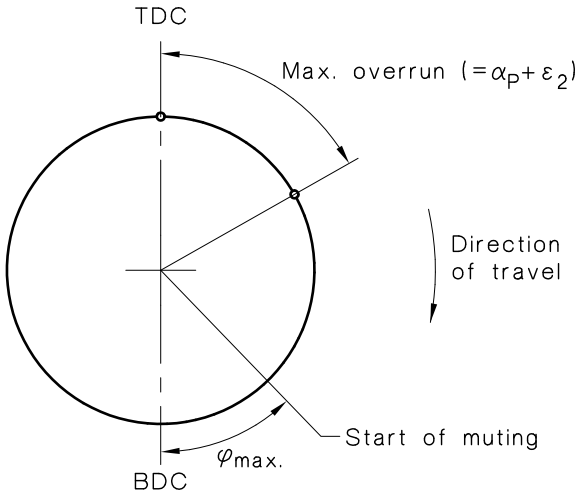
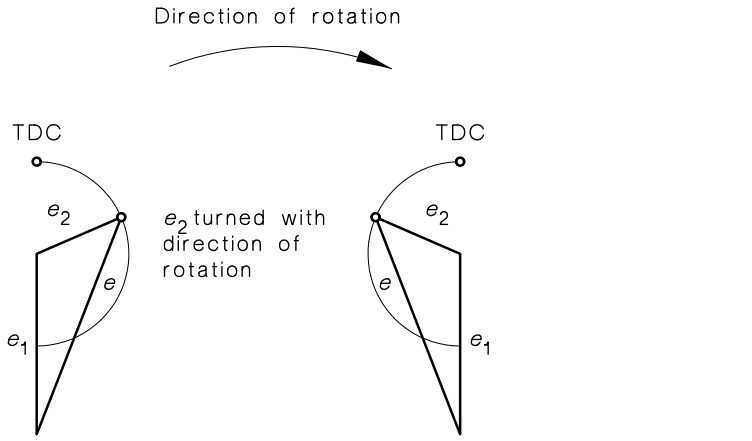


FIGURE D6 MAXIMUM MUTE ANGLE BEFORE BOTTOM DEAD CENTRE



(a) Clockwise rotation of bush (b) Anti-clockwise rotation of bush

FIGURE D7 BUSH ROTATION

TABLE D1

RECOMMENDED STROKE LENGTHS ENLARGED WITH ANGLE α_{max}

Stroke length mm		$\frac{S_{max} - S_{min}}{S_{max} + S_{min}}$	sin α_{max}	α_{max}	Pressing force
Max.	Min.			degrees	kN
63	12	51/75	0.68	42.9	100
71	12	59/83	0.711	45.4	160
80	12	68/92	0.739	47.7	250
90	16	74/106	0.698	44.4	400
100	16	84/116	0.724	46.5	630
112	20	92/132	0.697	44.3	(800)
125	20	105/145	0.724	46.5	1000
140	20	120/160	0.75	48.7	(1250)
160	25	135/185	0.73	47.0	1600
180	25	155/205	0.756	49.3	(2000)
200	25	175/225	0.778	51.2.0	2500

NOTES:

1 $\sin \alpha_{max} = \frac{S_{max} - S_{min}}{S_{max} + S_{min}} = \frac{\varepsilon_2}{\varepsilon_1}$

2 This table is based on the European Power Press Manufacturers' Panel (EPPMP) recommendation on stroke lengths enlarged with angle α_{max} and a stopping displacement λ = overrun monitoring margin ε_2.

D2 DETERMINATION OF THE POSITION WHERE MUTING BEGINS

The movement of the press is shown schematically in Figure D8.

The time from the moment the press receives the muting signal until bottom dead centre is traversed (corresponds to angle φ_{max}) shall not exceed the overall response time of the press with any combination of speed and stroke lengths and/or setting of the rotary cam arrangement.

Figure D9 shows $\varphi_{max} \geq \varphi + \alpha_{max}$, so that the muting cannot occur before the angle resulting from the above formula.

This means that it is not permissible for φ to exceed a specific value.

φ may be calculated as follows:

$$\varphi = \omega \times T \quad \text{. . . D2}$$

where

ω = angular velocity, in degrees per second;

T = overall response time, in seconds (see Appendix E)

The maximum permissible value φ_{max}, in degrees, is:

$$\varphi_{max} = 6Tn \quad \text{. . . D3}$$

where

n = number of strokes per minute

φ_{max} is calculated at the minimum number of strokes n_{min} of the press, if adjustable.

The value obtained for φ_{max} from the above equation applies basically to presses with a fixed stroke length and fixed rotary cam arrangement. Hence the point where muting begins cannot occur earlier than angle φ_{max} before bottom dead centre as a result of a change in the stroke length and/or setting of the rotary cam arrangement (see Figure D9).

This means that the rotary cam arrangement has a fixed (mechanical) stop in one end position, so that $\varphi + \alpha_{max}$ (or α_p) does not exceed φ_{max} when the stroke length (or rotary cam arrangement) is adjusted.

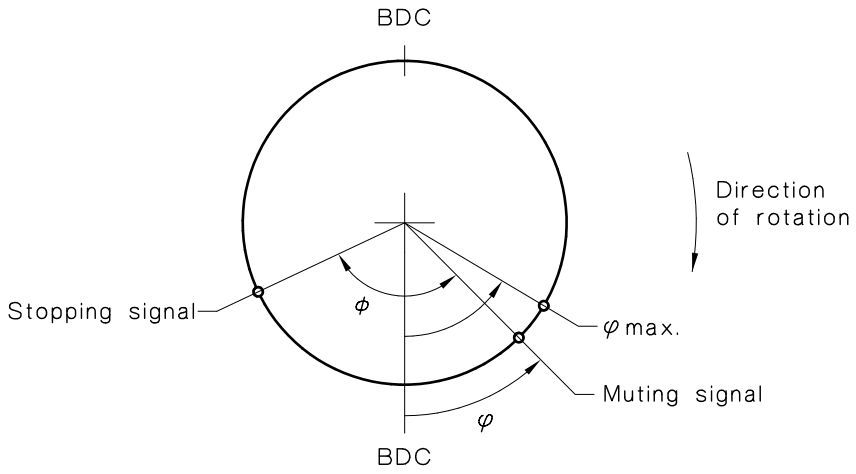
NOTE: The angle φ can be negative at a certain setting.

The following settings then give the two end positions of the rotary cam arrangement (between which the angle is α_p):

(a) With crankshaft direction of rotation:
the end position is determined from α_p (or α_{max}) + $\varepsilon_2 \leq 60°$ (preferably 45°) after top dead centre (see Figure D1).

(b) Against crankshaft direction of rotation:
the end position is determined by $\varphi + \alpha_{max}$ (or α_p) $\leq \varphi_{max}$ before bottom dead centre.

This applies to the least favourable setting.



LEGEND:
ϕ = muting angle (angle between the muting signal and the stopping signal).
φ = part of the muting angle before BDC, which varies with stroke length. and rotary cam arrangement and is calculated negative after BDC.
$\varphi_{max.}$ = maximum permissible part of the muting angle before BDC, in degrees which is calculated from the overall response time and the speed as described below.

FIGURE D8 PRESS MOVEMENTS

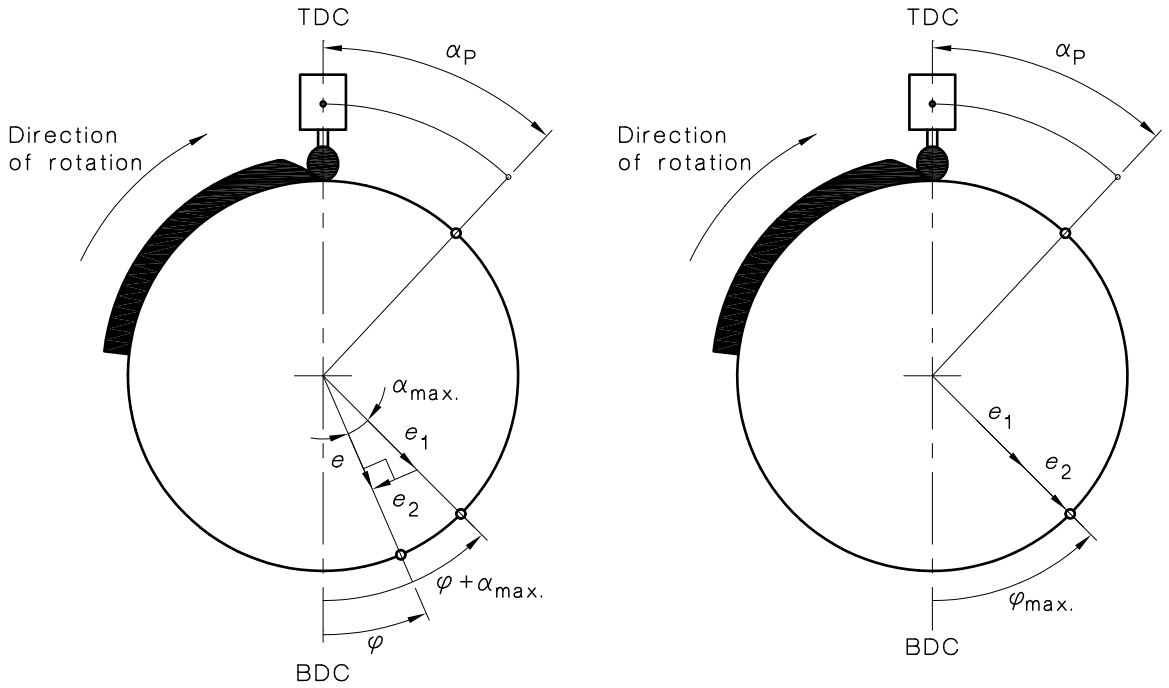


FIGURE D9 TIME FROM MUTE SIGNAL RECEPTION TO BOTTOM DEAD CENTRE

APPENDIX E

DETERMINATION OF OVERALL RESPONSE TIME

(Informative)

E1 SCOPE

This Appendix provides one means of determining the overall response time (T), used in the calculation of safety distances.

E2 RESPONSE TIME

The overall response time (T) may be determined from the following equation:

$$T = t_1 + t_2 + t_3 + \Delta t \quad \ldots \text{E1}$$

where

T = overall response time, in seconds

t_1 = response time measured at normal operating pressure, in seconds

t_2 = brake monitor safety margin (overrun monitoring margin), in seconds

t_3 = pressure differential response time, in seconds

Δt = uncertainty in the time measuring method, in seconds

The relationship between t_1 and t_2 is depicted in Figure E1 and Figure E2.

E3 DETERMINATION OF t_1

The time (t_1) should be measured under the conditions given at Appendix C, Paragraph C4 Items (a) to (i) (see also Figures E1 and E2).

E4 DETERMINATION OF t_2

The brake monitor safety margin (t_2) may be determined from the following equation:

$$t_2 = \frac{2\varepsilon_2}{\omega} = \frac{\varepsilon_2}{3n_{\max}} \quad \ldots \text{E2}$$

where

t_2 = brake monitor safety margin, in seconds

ε_2 = brake monitor safety margin (overrun monitoring margin), in degrees

ω = angular velocity, in degrees per second

$n_{\max}$ = maximum stroke rate, in strokes per minute

Term ε_2 (the effect of brake wear on the stopping angle) is depicted in Figure E3 and Figure E4. Time (t_2) assumes rotation of the crankshaft under braking.

E5 DETERMINATION OF t_3

The pressure differential response time (t_3) may be determined from the following equation:

$$t_3 = \frac{\varepsilon_3}{\omega} = \frac{\varepsilon_3}{6n_{max}} \quad \text{. . . E3}$$

where

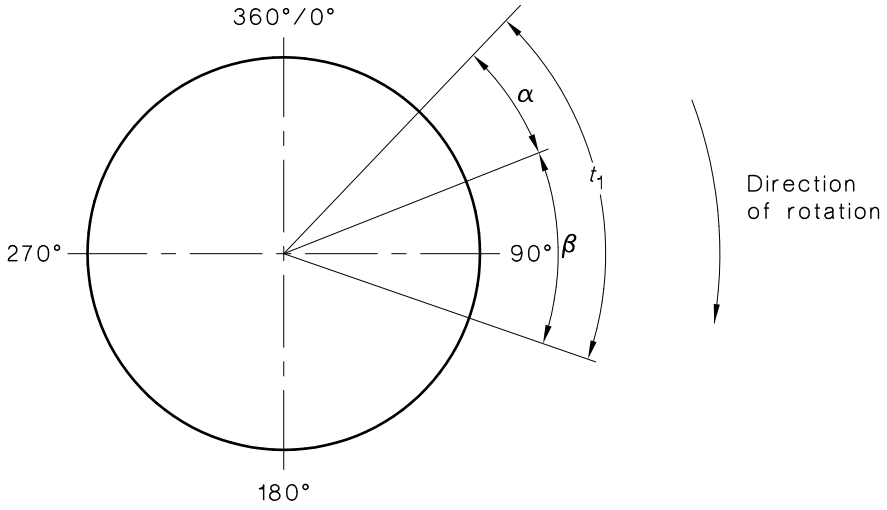
t_3 = pressure differential response time, in seconds

ε_3 = pressure differential stopping angle, in degrees

n_{max} = $E - F$

= maximum stroke rate, in strokes per minute

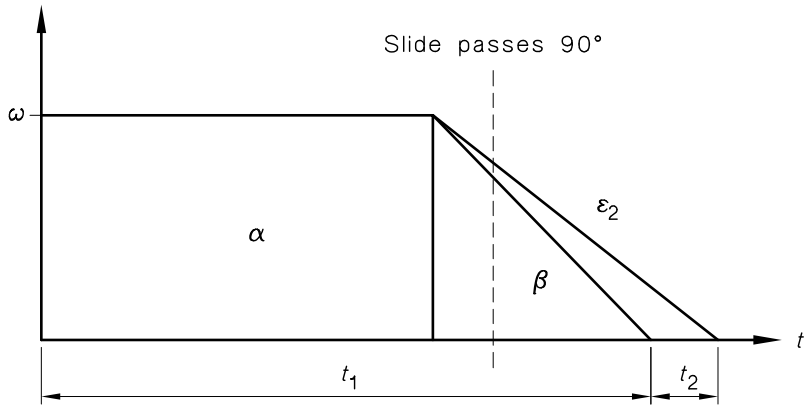
The relationship between E, F, and ε_3 is shown in Figure E3 and Figure E4. Time (t_3) assumes free rotation of the crankshaft.



LEGEND:

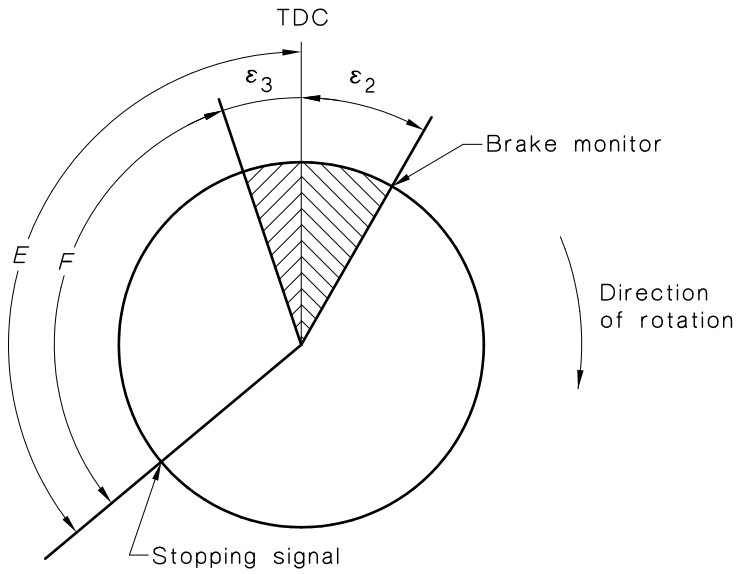
t_1 = Response time at working pressure, in seconds
= $\alpha + \beta$
α = Angle of free rotation, in degrees
β = Braking angle (assumed to be linear), in degrees

FIGURE E1 RELATIONSHIP BETWEEN α, β AND t_1



LEGEND:
t_1 = Response time at working pressure, in seconds
t_2 = Brake monitor safety margin, in seconds

FIGURE E2 RELATIONSHIP BETWEEN t_1 and t_2



LEGEND:
E = Stopping angle at working pressure
F = Stopping angle at min. pressure
ε_3 = $E - F$

FIGURE E3 RELATIONSHIP BETWEEN E, F and ε_3

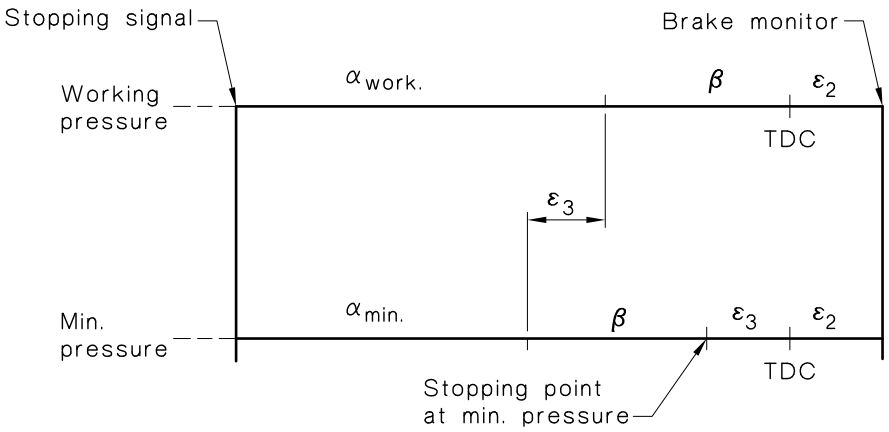


FIGURE E4 RELATIONSHIP BETWEEN RESPONSES AT NORMAL WORKING PRESSURE AND MINIMUM PRESSURE

E6 COMMENTARY ON FIGURES E3 AND E4

Figures E3 and E4 both show that, when the stopping signal and the position of the brake monitor are fixed, the angles between the two points are constant, although the size of the partial angles can vary.

In Figure E3, *E* is the stopping angle that occurs at normal working pressure when the cam arrangement is adjusted so that the average stop position is as close to top dead centre as possible. *F* is the new stopping angle that occurs at the same setting of the rotary cam arrangement, but at the minimum pneumatic pressure determined by the pressure monitor switch setting.

Figure E4 shows that a smaller braking angle occurs with minimum pressure in the clutch/brake than with normal working pressure. This is because air at the lower pressure exhausts more rapidly. If the brake deteriorates while working at minimum pressure, the overall response time (T) can be exceeded although the brake monitor angle has not been exceeded. This occurs because the crankshaft rotates at full speed while traversing angle α (the system response angle), but at an average of half speed, while traversing angle β (the mechanical braking angle).

Theoretically, t_3 (the pressure differential response time) can be measured directly since t_3 is the difference between t_1 at normal working pressure and t_1 at the minimum working pressure. However, a more practical way is to measure ε_3 manually and convert it to t_3 using Equation E3.

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