SAFed

SAFETY ASSESSMENT FEDERATION

Guidance

Power Presses

Guidance for the Competent Person - Press Brakes

REFERENCE: PPC 04
ISSUE: 01
DATE: 01/10/2018

DOCUMENT INFORMATION:	
REFERENCE:	PCC 04
ISSUE:	01
DATE:	01/10/2018
PREPARED BY:	Power Press Committee (TC7)
APPROVED BY:	TC 7 and TSC

DOCUMENT HISTORY RECORD:		
ISSUE:	DATE:	CHANGE DETAIL:
01	01/10/2018	Initial document

Reviewed, updated and re-published by SAFed 2017/18

The Health and Safety Executive (HSE) was involved with Safety Assessment Federation (SAFED) in producing this guidance. HSE endorses the guidance, as it follows a sensible and proportionate approach to managing health and safety

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INTRODUCTION

1. This publication, is based on the original work of the Press Brake Sub-Committee of the Joint Standing Committee (JSC) on Safety in the Use of Power Presses. It has been reviewed and updated by the Safety Assessment Federation (SAFed), The guidance contains practical advice on the safe use and maintenance of press brakes. The types of press brakes covered is predominately friction clutch press brakes and older mechanical and hydraulic press brakes. The guidance does not cover conventional mechanical key clutch presses.

2. A press brake can be defined as an open frame, single action press with the bed designed for holding long narrow forming edges or dies. Currently the most common type is those in which the tools are closed by hydraulic pressure. Less common types of machine are those in which the tools are closed by mechanical power transmitted through a flywheel and clutch mechanism, and the direct drive servo press brake, which does not incorporate a flywheel and clutch mechanism.

3. The work for which press brakes are primarily designed is the bending, folding and punching of sheet metal. These machines are occasionally used in other industries to perform similar work on non-metallic sheet material.

4. The size and variety of components worked, the need for individual alignment when working to a line and the characteristic upward deflection of the work piece during bending can present difficulties when determining what the most appropriate safe guarding measures are in order to comply with the law. Press brakes generally require the application of specialised guarding techniques, including a combination of fixed guarding and light guards, for example. The reliability and effectiveness of which is dependent upon the standard of design, maintenance and adjustment of the machine as a whole. Many accidents have occurred at press brakes: the injuries inflicted are almost invariably severe and frequently involve amputation. The causes of accidents generally include inadequate guarding arrangements, poor maintenance of the press, and failure of control systems.

LEGAL REQUIREMENTS

Provision and Use of Work Equipment Regulations 1998 (PUWER 98)

5. The Provision and Use of Work Equipment Regulations (PUWER) place duties on employers, the self-employed and people who have control of work equipment in order to ensure that work equipment is used safely to prevent injury and maintained in a safe condition

Guarding

6. Effective measures must be taken to prevent access to dangerous parts of machinery or to stop their movement before any part of a person enters the danger zone.

Maintenance

7. work equipment, which includes press brakes, must be maintained in an efficient state, in efficient working order and in good repair, Your arrangements for maintenance should be adequate to meet this requirement. This will include ensuring that your employees or those who maintain your press brakes have the necessary knowledge, skills, training and facilities to do what is needed to meet this requirement.

8. This guidance contains information and advice on how to ensure that your press brake is effectively guarded and adequately maintained in order to prevent injury.

9. It is a common misconception that only mechanical press brakes driven through a flywheel and clutch mechanism need be guarded. This is incorrect; Regulation 11 of PUWER98 requires the dangerous parts of any machinery to be guarded, regardless of the power source.

10. Metal working press brakes which are driven through a flywheel and clutch mechanism are subject to the Regulations 31-35 of PUWER 98 (as applied to power presses). These Regulations require the press, guards and protection devices are thoroughly examined by a competent person at specified intervals, at least every 12 months, where it has fixed guards only or at least every 6 months, in other cases; and each time that exceptional circumstances have occurred which are liable to jeopardise the safety of the press or its guards or protection devices and any defect is remedied before press is used again. All safety devices on these machines must be inspected and tested on each day of use by a person who has been trained and appointed for this purpose. Only trained and appointed persons may be employed as tool setters on this type of machine.

11. The Regulations 31-35 of PUWER 98 (as applied to power presses) do not apply to hydraulic and direct driven mechanical press brakes. However, users of these machines should note the general requirements of Section 2 of the Health and Safety at Work etc. Act 1974 (HSW Act); this includes the duty to ensure, so far as is reasonably practicable, that machinery is maintained in a safe condition and that employees receive such instruction, training and supervision as is necessary for their safety (paragraphs 156 to 167) and PUWER 98.

12. The terms `competent person', `appointed person', 'authorised person' are used in the text; they can be defined as follows.

13. Competent person is a person who carries out the thorough examinations and tests as required by Regulation 32 of the Provision and Use of Work Equipment Regulations 1998 (PUWER 98) as applied to power presses', or a person who carries out similar activities on machines which are not subject to the Regulations.

14. Appointed person is a person who has been appointed by the duty-holder/employer/person under Regulation 33 of PUWER 98 (as applied to power presses) to carry out inspections and tests and to prepare press brakes for use, or a person appointed by the occupier or employer to carry out similar activities on machines which are not subject to the Regulations.

15. Authorised person is a person who has been appointed by the duty-holder/employer/person to carry out maintenance and similar activities on machines.

16. You should ensure that people who determine the nature of the inspections required and who carry out inspections are competent to do so and the competent persons should have the necessary practical and theoretical knowledge and experience. Appointed persons are suitable with sufficient training and knowledge.

17. Users of hydraulic and direct driven mechanical press brakes are advised to institute a system of daily inspection and periodic thorough examination, for which it is suggested that the requirements of the Regulations 31-35 of PUWER 98 (as applied to power presses) could be used as a guide. Paragraphs 156 to 167 contain further advice about machinery maintenance and the training of operators and tool setters.

18. Section 6 of the HSW Act imposes general duties on persons who design, manufacture, import or supply machinery for use at work. Since 1992 the Supply of Machinery (Safety) Regulations have applied to new (and old machines where they have been substantially modified). These Regulations were replaced in 2008 to implement the new EU Machinery Directive. The Supply of Machinery (Safety) Regulations 2008 require new or substantially modified machines to be designed, and constructed to be safe, to be CE Marked, and to be supplied with instructions for their use and maintenance, and with a Declaration of Conformity. Further information on the supply of machinery for use at work can be found on the HSE website at http://www.hse.gov.uk

MECHANICAL PRESS BRAKES: GENERAL REQUIREMENTS

19. There are two types of mechanical press brake in use. These are direct driven machines and clutch driven machines. The following recommendations refer specifically to clutch driven machines however, where relevant, the recommendations should be applied equally to direct driven machines.

Clutch

20. Owing to the type of work which mechanical press brakes are designed to undertake the clutch fitted is invariably of the friction type. The design of the clutch, together with its associated linkage or connection to the brake is of vital importance to the safe use of the mechanical press brake. The specialised guarding systems developed for use on press brakes, which are described in later sections are generally dependent upon the reliable performance of these components.

21. The types of clutches fitted to press brakes can be divided into two categories: mechanically -operated friction clutches, usually by a series of rods and linkages, and air-operated friction clutches. Friction clutches operated by a system of mechanical linkages, generally operated by a treadle, enable the clutch to slip to permit the tools to close at a controlled low speed. Air operated clutches are generally not designed to slip, but can provide a slow approach in a series of short increments by the rapid engagement and disengagement of the clutch. Air operated friction clutches are now the type most commonly found on mechanical press brakes, they are often used with a two speed gearbox to permit a fast approach and return of the beam with a slow pressing speed.

22. The types of friction clutch encountered on press brakes are:

A. Air operated clutch with integral brake unit. The clutch may be of multiple or single plate type mounted co-axially with a brake of similar construction, the two being directly coupled to give simultaneous clutch disengagement and brake application.

B. Air operated clutch with independent air -controlled spring-applied brake. This type of system is generally used with two-speed machines where a common brake operates in conjunction with the two clutches required to control the two-speed gear system. The clutch and brake units are electrically and pneumatically interlocked, normally using a common valve of the double-bodied monitored type, to disengage the clutch and operate the brake.

C. Air operated multi-plate clutch with independent rod operated brake. This type of clutch is generally associated with larger machines and is sometimes connected to the brake by a substantial rod passing through the centre of the flywheel shaft. The direct co-axial connection between the clutch and brake gives good fail-safe characteristics. Problems can arise through the accumulation of dust from the clutch friction surfaces.

D. Multi-plate clutch with yoke lever engagement. This type of clutch is generally associated with smaller machines and is now seldom fitted to new machinery. Problems sometimes arise with this type of clutch due to dust from the friction surfaces restricting the movement of the clutch.

E. Single-plate clutch with toggle engagement. This type of clutch is was seldom fitted to later machines. A potential danger associated with this type of clutch is the development of excessive travel in the operating toggles which may arise from lack of maintenance. This situation can eventually prevent clutch disengagement.

23. Clutches should following general requirements.

A. Clutches should be capable of starting and driving the machine without excessive heat generation under conditions of maximum sustained production.

B. Where the clutch and/or brake unit has a maximum number of single-stroke engagements per minute which can be obtained without excessive heat generation, then this should be clearly marked on a plate attached to the machine.

C. Sufficient working clearances should be provided so as to ensure that, under the severest conditions of operation, friction drag leading to undesired movement of the driven members will not take place.

D. The clutch should be designed so that failure of any one component does not stress other components so that rapid consequential failure is possible.

E. The design should be such that the accumulation of dust, or debris produced from frictional surfaces, is minimised in areas likely to give rise to clutch drag or seizure and that broken components are not likely to cause clutch failure.

F. All practicable steps should be taken to avoid corrosion of the working parts of the clutches which may affect their efficiency.

G. The connection between the clutch and brake should be robustly constructed and be as short and direct as possible.

H. The clutch and brake should be designed so that in the event of pneumatic, hydraulic or electrical failure the clutch is disengaged immediately, and the brake applied.

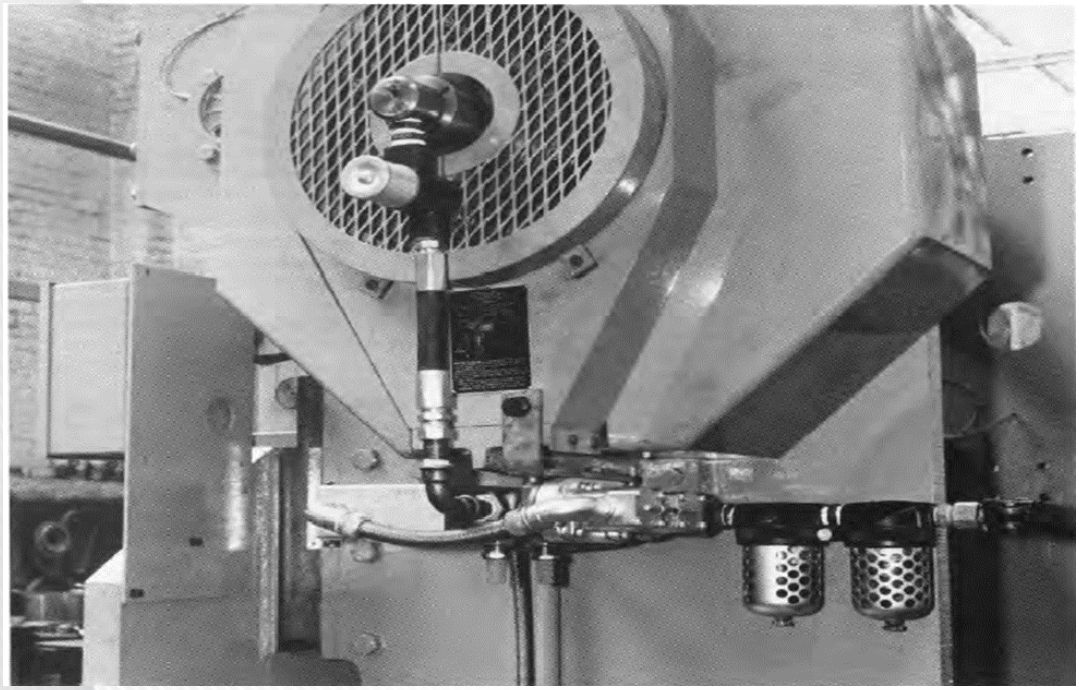
I. Where springs are used for disengaging the clutch, they should be of the compression type and safely rated. Care should be taken to ensure that all the springs are closely uniform in dimensions, quality and rating. A single spring should not be relied upon for this duty, unless equivalent safety is assured by other means. The means of loading the springs should be such that, when appropriately adjusted, the spring anchorages can be locked to prevent risk of slackening back. The arrangements for spring housing and guiding, and of guide pins, should be such as to minimise binding.

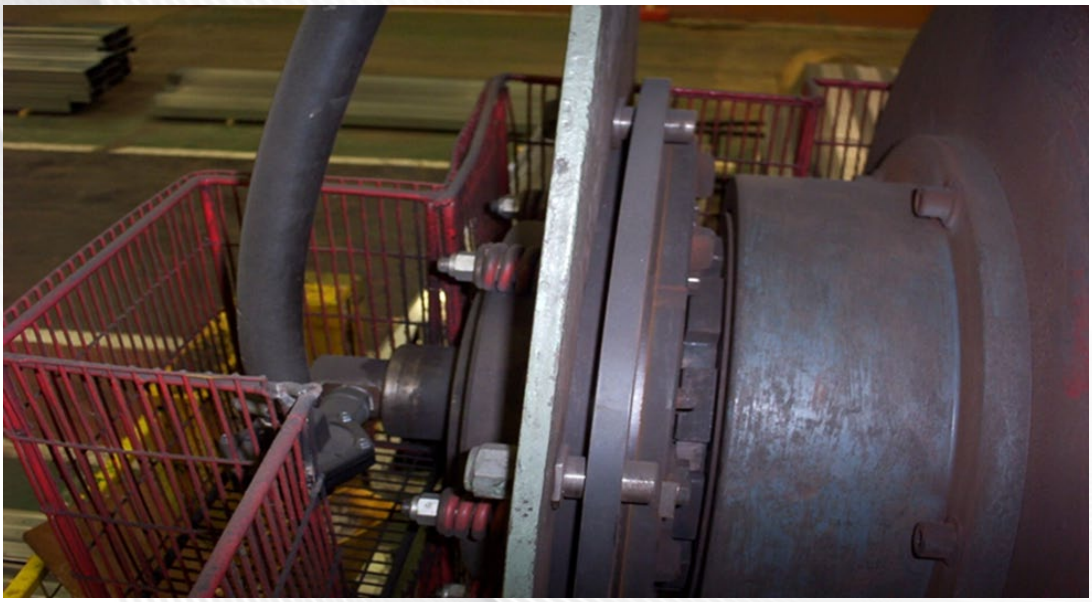
J. If diaphragms are used they should be designed and installed so as to minimise the possibility of failure, e.g. through overstressing or fatigue, and care should be taken to avoid damage by the cutting effect of sharp edges.

K. See paragraph 34 under 'Pneumatic supply'.

Brake

24. The brake is possibly the single most important item affecting the safe performance of any mechanical press brake. Many types of brake have been fitted to these machines although the use of air clutches has led to the widespread adoption of the combined clutch-brake unit. (Figs 1 and 2).





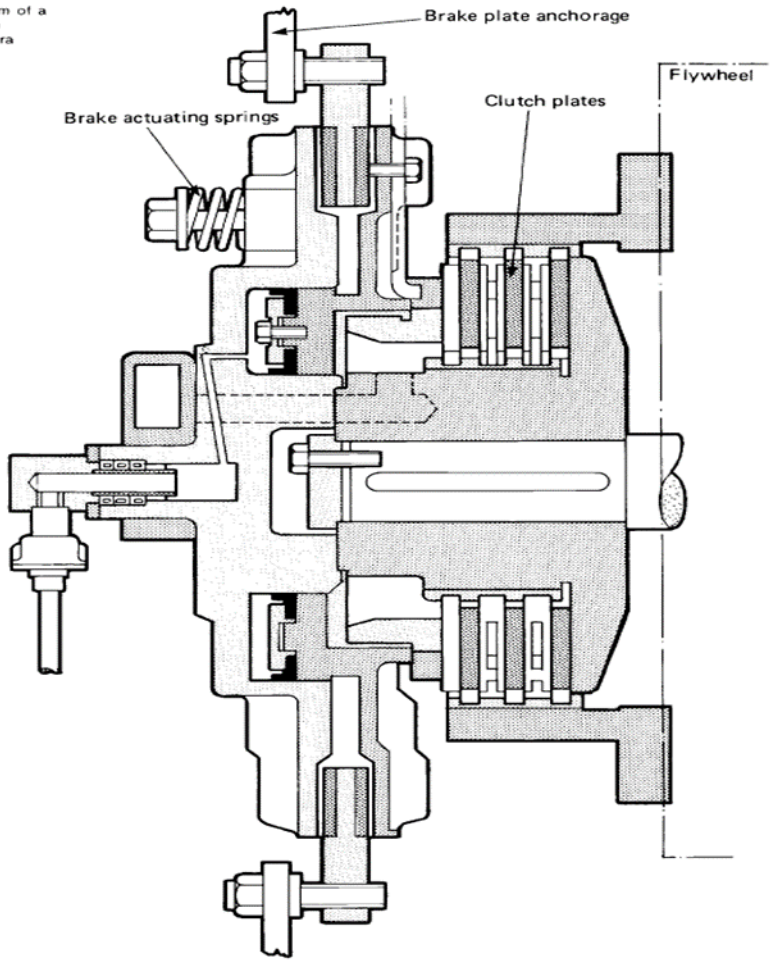


Fig 2 Schematic diagram of a typical combination plate clutch and brake unit (para 47(a))

25. The use of air operated combined clutch -brake units have made a valuable contribution to the safety of mechanical press brakes. Given the correct air supply pressure the correct synchronisation of the brake and clutch is virtually assured. This type of combined unit provides the shortest and most direct linkage between the clutch and the brake, and maintenance requirements are reduced to the minimum.

26. Earlier mechanical press brakes were frequently fitted with band brakes. Band brakes are unreliable and can ultimately fail without warning. Over-tightening can lead to fracture of the band brake with a consequent total loss of braking. Paragraph 44 to 47 give advice upon the replacement of band brakes on existing machines. New mechanical press brakes should not be fitted with band brakes.

27. The following recommendations for brake design and performance are applicable to all types of brake fitted to mechanical press brakes.

28. In general, it is essential that if the press brake should fail as a result of any electrical malfunction or failure of the electrical supply, then the press brake (in conjunction with its associated safety device) should maintain a safe condition.

29. In the event of disconnection of the power supply to the motor on mechanical machines resulting in run-down of the flywheel, provision should be made to prevent stroke initiation, e.g. by isolation of the switch or pedal.

A. The clutch and brake should be designed so that in the event of pneumatic, hydraulic or electrical failure the clutch is disengaged, and the brake immediately applied.

B. In general, fluid pressure should not be used to apply a brake unless means are provided to ensure that, in the event of loss of fluid pressure, the integrity of the brake is maintained.

C. Under conditions of maximum sustained production, brakes should not generate excessive heat.

D. The brake should be designed so that failure of any one component does not stress other components so that rapid consequential failure is possible.

E. The design should be such that the accumulation of dust, or debris produced from frictional surfaces, is minimised in areas likely to give rise to clutch drag or seizure, and that broken components are not likely to cause brake failure.

F. All practicable steps should be taken to avoid corrosion of the working parts of brakes which may affect their efficiency.

G. The connection between the brake and clutch should be robustly constructed and be as short and direct as possible; integral clutch-brake units may offer the ideal in this respect.

H. Where springs are used for applying the brake, they should be of the compression type and sufficient in power to secure effective brake application. A common arrangement is to use multiple spring pressure for this purpose. A single spring should not be relied upon for this duty, unless equivalent safety is assured by other means. Care should be taken to ensure that all the springs are closely uniform in dimension, quality and rating. The means of loading the springs should be such that when appropriately adjusted, the spring anchorages can be locked to prevent

risk of slackening back. The arrangements for spring housing and guiding, and of guide pins, should be such as to minimise binding.

I. The presence of oil on brake friction surfaces may adversely affect the performance of the brake; therefore, effective arrangements should be made to prevent penetration of oil to the brake friction surfaces.

Pneumatic supply

30. Every press brake should bear a plate stating the maximum and minimum designed working pressure for the clutch operation.

31. There should be provided at each press brake a supply of compressed air sufficient in quantity and pressure to feed the press brake and all other machines on the same header main without causing a pressure drop which will affect the efficient working of the press brake.

A. The drop leg supply line to the press brake should be taken from the top of the header main.

B. A pressure gauge should be fitted in the supply line to the press brake. To ensure that the press brake cannot be operated at below the makers designed minimum operating pressure, a low-pressure cut-off device should be provided.

C. The supply line to the press brake should not be smaller than the inlet port provided by the manufacturer.

32. The supply of compressed air should be clean, dry and free from rust, scale or other impurities. To this end, a strainer or similar device should be provided to remove moisture. A drain tap should be provided in an appropriate and accessible position to remove the moisture accumulated after any period of standing and immediately before use. Any piping beyond the point where moisture and solid foreign matter are removed should not form a trap into which further moisture can accumulate.

33. Where valves or other working parts of the press brake control system require lubrication, visible automatic means of lubrication should be provided to introduce the oil into the air line in suitable form. The arrangements should be of such a nature that they will only operate when air is flowing. The lubricator and the equipment referred to in paragraph 28, should be placed as close as possible to the main clutch control valve, but should be readily accessible and visible.

34. All piping, piping fittings, passages, surge or storage tanks, and cored holes or drilled holes, should be free from burrs or foreign matter which might cause damage to valves or clutch operating parts. Sharp edges should be removed wherever they may adversely affect the flow of air.

35. Each run of piping should where practicable be continuous from one piece of apparatus to another. Equipment or components should be removable without disturbing the piping runs and without bending or springing the piping in a manner likely to damage it. Rigid piping should be securely supported at frequent intervals to avoid vibration or movement. Care must be taken to avoid kinking of flexible pipes

used to carry fluids for clutch and brake operation. Such kinking can cause traps which prevent the fluid exhausting. This applies particularly to piping feeding the running joint of the clutch.

36. Operating valves should not depend on connected piping for support. This is to avoid undesirable effects from vibration which might affect both valves and piping.

37. Operating valves should be so designed as to ensure that, when in the idling or non -operating position, leakage of air past the inlet valve will escape to atmosphere sufficiently freely to prevent build-up of pressure in the clutch -operating cylinder.

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

39. Exhaust ports and piping between clutch -operating cylinders and valves should be of sufficient capacity to ensure prompt release of air from clutch-operating cylinders. Precautions should be taken to ensure that exhaust ports of operating valves are of adequate size to prevent back pressure on the valve. Where silencing systems are fitted, they should be provided and installed in accordance with the valve manufacturer's recommendations and maintained to prevent back pressure through the valve exhaust port.

40. Control valves should be mounted in positions which provide adequate accessibility.

41. 41. 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 should be positive in character.

Operating start controls

42. Accidents have occurred when press brake operators or their helpers have accidentally stepped on clutch operating pedals or treadles, or these controls have been depressed through tools or materials falling on them. Treadles should not be fitted to new machines; they should be replaced on existing machines where it is reasonably practicable to do so. In addition, all operating start controls should be adequately shrouded or otherwise arranged to prevent, as far as possible, accidental operation from any cause. (An example of a suitable shroud is shown in Figure 7(a)).

Crankshaft position indication

43. All press brakes should be provided with a visible means of indicating the position of the crankshaft in relation to top dead centre.

MECHANICAL PRESS BRAKES: FAIL-SAFE STOPPING CAPABILITY, OVERRUN DETECTION AND STOPPING PERFORMANCE MONITORING

44. Fail-safe stopping capability and overrun detection should be provided in all cases in which the guarding system does not prevent access to the trapping area before the crankshaft has stopped. Certain types of safety system require a stopping performance monitor to be fitted to the machine. These requirements can be summarised as follows.

A. Fail-safe stopping capability and overrun detection should be provided on machines having the following types of guarding system.

B. Electro-sensitive safety systems of all types

C. Early rising guards

D. Distance bar trip guard with early opening feature

E. Any other guarding system which does not prevent access to the trapping area before the crankshaft has stopped.

Fail-safe stopping capability and overrun detection need not be provided if the machine has one of the following types of guarding system.

1) Fixed guards

2) Fully-interlocking guards with guard control

Distance bar trip guards with guard control, which do not have the early opening feature

Stopping performance monitoring should be provided on machines fitted with electro -sensitive safety systems of all types.

Note: Guard control is defined as a means of maintaining the guard in the closed position until the machine has stopped at its normal stopping position.

45. Where the provision of fail-safe stopping capability, overrun detection and stopping performance monitoring is necessary, these should conform to the following standards.

A. Fail-safe stopping capability. Every press brake should be fitted with a double bodied solenoid operated monitored valve which should directly control the pneumatic supply to the air operated clutch and brake, or the equivalent in the case of other forms of drive. The monitoring should ensure that in the case of a failure within the valve, (or equivalent); the electrical power to the main drive is removed from the machine in such a way that it can be restored only by an authorised person.

B. Overrun detection. Machines fitted with safety devices of the type listed in paragraph 41(a) should include overrun detection to ensure that if the crankshaft overruns the top of the stroke

by 10° the power is removed from the machine in such a manner that it can be restored only by an authorised person. The means of overrun detection should be in a lockable enclosure.

C. (c) Stopping performance monitoring. For machines fitted with an electro-sensitive safety system a stopping performance monitor should be provided which ensures that as soon as the overall system stopping performance used for the calculation of the minimum curtain distance (Appendix 1) is exceeded, the electrical power to the main drive is removed from the machine in such a way that it can be restored only by an authorised person. Where the stopping performance monitoring is carried out towards the end of each cycle the actuating element of the stopping performance monitor may incorporate the overrun detection facility.

D. (d) The stopping performance monitor provides a check on brake performance preventing the machine being operated before the brake deterioration assumes dangerous proportions. The intention is that the cause of any deterioration should be investigated and corrected. After initial setting no further adjustments should be made. This should be achieved by placing the stopping performance monitor in a lockable enclosure.

Note: Failure of transmission of motion to the stopping performance monitor or the means of overrun detection should result in removal of power from the machine in such a way that it can be restored only by an authorised person. One way of achieving this is to use multiple independent mechanical means to provide signals to the stopping performance monitor, or the means of overrun detection, which will detect a failure in one of the drives.

E. Means of removal of power from the machine where electro-sensitive safety systems are used this should be achieved using two machine secondary control elements, each controlled by a secondary switching device. (See BS 6491/BS EN 61496). The position of the operating part of each machine secondary control element should be monitored so that in the event of failure within either control element, it will not be possible to restore power to the machine until the failure has been corrected.

Use of an arrestor brake

46. An arrestor brake is a brake having the capacity to bring to rest within a safe distance all the moving parts of the press brake, including the flywheel. The use of an arrestor brake on a press brake is no longer recommended as an alternative to fail-safe stopping capability, overrun detection and stopping performance monitoring. Two factors in particular have influenced this view,

A. development in the technology of braking systems and stopping performance monitoring now ensure fail-safe stopping capability and early detection of brake deterioration. This is considered to be greatly preferable to arresting movement mechanically when a repeat stroke has already commenced;

B. the stopping forces involved in arresting all the moving parts in mid-stroke are so great that there is widespread reluctance to test these devices for fear of causing damage to the machine. Hence the percentage of arrestor brakes in service that are maintained in correct working order is unknown.

MECHANICAL PRESS BRAKES: BRAKE CONVERSION OF EXISTING MACHINES

47. Dangers may arise through the continued use of press brakes fitted with band brakes since modern guarding techniques and production methods impose great demands on brake performance, and there is evidence that attempts are frequently made to attain this performance by over-tightening the band brake. While this may provide a limited short term improvement, it increases immeasurably the risk of total brake failure caused by eventual fracture of the band brake.

48. The HSE issued guidance on the actions to be taken where existing presses are found to be fitted with a band brake only and having guarding that does not prevent access to the tools and this is shown below.

49. The Health & Safety Executive have advised that for those who use and examine Mechanical Press Brakes that any existing band brakes and supplementary or back up braking arrangements shall be replaced when these devices are used in conjunction with Electro Sensitive Safety Systems or Early Opening Interlocking Guards where access to the dangerous parts is possible before the machine has stopped at top dead centre.

Brake conversion methods

50. A range of proprietary brake conversions is available for the modification of press brakes fitted with band brakes. A summary of the techniques most commonly used is given below, together with comment upon the principal characteristics of each. Only full clutch-brake conversion and the replacement brake are recommended.

C. A full clutch brake may be defined as the replacement of both the existing brake and clutch. In most cases this is by far the most satisfactory conversion and is strongly recommended (see paragraph 25(g)). Brake performance, fail-safe stopping capability, overrun detection and stopping performance monitoring should be as for new machines (see paragraphs 17 to 42). This method has the great advantage that by replacing both clutch and brake, problems of clutch synchronisation and accelerated wear are avoided. (Fig 2).

D. A replacement brake replaces the existing band brake whilst utilising the existing clutch mechanism. The replacement brake should be capable of achieving the desired stopping performance (paragraph 42).

HYDRAULIC PRESS BRAKES: DESIGN CONSIDERATIONS

General requirements

51. All hydraulic components should be of adequate strength and suitable for the purpose for which they are to be used. Hydraulic system components and the fluid used should be compatible. Hydraulic systems should be designed to avoid unnecessary generation of heat; under conditions of continuous operation it is recommended that the pump inlet temperature should not exceed 60°C (140°F). Heat exchangers should be protected against excessive pressures, pressure surges and corrosion.

52. To minimise the possibility of creating turbulent flow the fluid velocity should not exceed 1 m/s for suction lines, 5 m/s for pressure lines and 6.5 m/s for exhaust lines.

Control circuits and valves

53. Spool valves are more likely to jam than seated valves when affected by dirt in the hydraulic system. Seated valves should be used to support the beam.

Fail-safe stopping capability

54. The hydraulic system should be designed so that the press brake can be stopped at any part of the stroke. Two control valves should be provided and so arranged that if one valve fails when called upon to stop the machine; the second valve will bring the dangerous motion to a halt. It should not be possible to initiate further closing movement upon failure of either of these two valves.

55. The position of the operating parts of these valves should be automatically monitored, such that the safety system will detect the failure of either valve. The monitoring system should detect and register the position of the valve piston or spool. However, if the hydraulic circuit is such that failure of either valve is self-revealing, i.e. the machine can no longer be operated, the requirement for monitoring is waived. Monitoring the electrical supply to the solenoid or the position of the piston or spool actuating mechanism is unlikely to give an adequate level of integrity to the system.

56. Rapid approach protection will vary as given below.

A. On up-stroking press brakes where the beam has to be raised against the action of gravity various methods are used to obtain rapid closing of the beam. All methods require a large volume of oil to be supplied to the press brake cylinder(s). If this is fed directly into the cylinder(s), for instance via non -return valves, there is a danger that due to back pressures the beam may make an uncovenanted stroke. Whatever method is chosen for rapid approach all the oil capable of causing the beam to move should be passed through the main control valve(s) or through auxiliary valve(s) the operation of which is totally dependent on the supply of pilot oil from the main control valve(s).

B. On down-stroking press brakes all the oil from the return area of the cylinders should be passed through the main control valve(s) or if this is not possible through auxiliary valve(s) the operation of which is totally dependent upon the supply of pilot oil from the main control valve(s). This applies even though the press brake is fitted with seated `hold-up' valves since it provides back up security.

57. Monitored solenoid operated valves should be designed to ensure that the monitor device always registers the actual spool position.

58. Solenoid operated valves may be provided with a method of manual operation. However, manually operated devices should be designed to prevent, as far as is practicable, their accidental or careless operation.

59. Failure of pilot pressure should cause the beam movement in any direction to stop.

60. Pressure control valves should not be adjustable above the maximum design pressure of the system. Hydraulic systems should be so designed and constructed that harmful transient pressures are not generated. Over-pressure and under-pressure protection should be provided where damage to the system or to personnel may result from either excessive or inadequate hydraulic pressure. Provision should be made to ensure that intensification of hydraulic pressure cannot take place between the pistons and the annular areas of the cylinders.

61. Safety valves, where not used as operating pressure control valves, should be so designed and constructed that they cannot readily be adjusted by unauthorised persons. There should be no means of isolation between a safety valve and the hydraulic circuit.

62. Where gasket or manifold mounted valves are used these should incorporate locators to prevent incorrect assembly between the valve and its mounting surface.

Stopping performance monitoring

63. Inadequate maintenance may lead to long -term deterioration of the stopping performance and it is therefore recommended that, where hydraulic press brakes are fitted with electro-sensitive safety systems, the stopping performance should be assessed in accordance with manufacturers recommendations.

64. This may be done by the use of a portable stop-time measuring instrument which directly, measures stopping time or by incorporating an ‘on demand' test into the safety system. The 'on demand' test should indicate when the overall system stopping performance used for the calculation of the minimum curtain distance, or the corresponding amount of linear displacement of the beam, is exceeded. Each measurement/test should be recorded by the person carrying out the test and the record should be kept available for inspection.

65. An automatic stopping performance monitor incorporated into the machine and the safety system may be used instead of stop-time measurement or an `on demand' test. In such cases the stopping performance monitor should comply with either BS 6491: Specification for Electro-Sensitive Safety

Systems for Industrial Machines or BS EN 61496 Safety of machinery — Electro-sensitive protective equipment (or current associated standards) and should be specified for use with the machine and electro-sensitive safety system to which it is applied.

Emergency operation

66. Means should be provided to ensure that in an emergency situation it is possible to override any operation of the machine so that an opening movement of the beam can be obtained.

Fault diagnosis

67. The provision of gauges or gauge connection points for diagnostic tests of both the primary and secondary (pilot) pressure is recommended.

Systems using accumulators

68. Hydraulic accumulators should be charged with an inert gas, e.g. nitrogen. Accumulator systems should be provided with a safety relief and discharge block, which should be so designed that they cannot be rendered ineffective (see paragraph 160).

69. A non-return valve should be provided between the pump and the accumulator, and a stop valve should be provided between the accumulator and any other part of the hydraulic circuit.

70. It is recommended that accumulators on new machines be fitted with automatic discharge equipment.

Filtration of hydraulic fluids

71. Filtration of the hydraulic fluid is of great importance - the majority of hydraulic control system faults can be attributed to contamination of the hydraulic fluid.

72. Effective means of oil filtration should be incorporated in all new hydraulic press brakes, although no hard and fast rules can be laid down on how to achieve this since the hydraulic system varies from manufacturer to manufacturer.

73. In general, it should be regarded as good practice to protect the pump inlet with a filter, or at least a strainer. The finest level of filtration which it is practicable to achieve by this method will be limited to about 40 microns (micrometres), below which the elements will become costly and are difficult to clean. If this filter element becomes blocked cavitation damage may occur to the pump; to avoid this, it may be necessary to fit a bypass to the filter and the suction line. If the bypass comes into use unfiltered oil will be passed through the pump and into the control system and the reliability of the control system will be at risk. It is recommended that an audible or visual warning signal should be incorporated to indicate when the bypass system comes into operation.

74. To achieve finer levels of filtration it is necessary to introduce one of the systems described below.

A. Pressure line filtration. This has the advantage of providing very fine levels of filtration and protects all the valves in the system. The filter elements can be located so as to filter all the oil all the time or they may, in order to prolong element life, be situated so that they are effective only during the actual machine operation.

B. Return line filtration. This system also enables fine levels of filtration to be achieved, and the filter elements are generally situated on the main return line. Dependent upon the type of machine, i.e. up-stroking or down-stroking (pre-filling type) they may or may not accept return oil from the main cylinder. Where it is possible for them to do so they are effective in removing dirt introduced into the system of the hydraulic cylinder or cylinders.

C. Off line filtration. This takes the form of either an inbuilt separate small unit or a tee off some existing line, e.g. a pilot line. Fine levels of filtration can be achieved, and the size of the filter is small. When using this type of system some of the oil is filtered all the time. There are a number of proprietary units now available containing a small motor and pump unit combined with a pair of filter elements; this type of filtration system can also be fitted to existing machinery.

75. It is important that the air filter to the main hydraulic reservoir should be of suitable size and specification. This is particularly applicable to down-stroking pre-filling hydraulic press brakes since an undersized air filter will quickly block, causing unfiltered air to be drawn into the reservoir via joints in the tank lid, etc.

Fluid reservoirs and pipework systems

76. The fluid reservoir should be large enough to hold all the fluid necessary for safe operation of the press brake. Maximum and minimum filling levels should be shown clearly.

77. All pipes leading to and from the hydraulic reservoir should terminate below the minimum fluid level to avoid aeration of the fluid, which may cause erratic and unsafe operation of the press. The reservoir should be vented, all breather holes being protected by adequately sized air filters.

78. All piping, and fittings should be of adequate strength to withstand the pressure to which they are subjected. Allowance should be made for the maximum rate and frequency of any transient pressure rises developed in the system.

79. Rigid piping should be used where practicable, which should be adequately supported to minimise vibration or movement. The intervals between supports for horizontal piping should not exceed 50 x the outside diameter of the pipe, and the intervals between supports for vertical piping should not exceed 100 x the outside diameter of the pipe. Pipework mountings should be designed to permit movement through thermal expansion.

80. Flexible hoses should be arranged so that they cannot become kinked, nipped or chafed. Hoses should be properly supported and of adequate length to avoid torsional stress or sharp flexing and straining at the end fittings.

81. Where the rupture of any pipe or flexible hose is likely to cause injury to the operator, the piping or hose should be suitably covered or located in a safe position.

82. It is preferable that the seated valves supporting the beam should be mounted directly on the cylinder(s). If this is not possible then flanged and/or welded fittings should be the minimum requirement for all connections from the cylinders to the supporting or main directional valves.

Hydraulic cylinders

83. Piston rods and seals should be adequately protected from the ingress of foreign matter. Non-metallic sealing elements should not pass across edges or bores during the operation; edges which have to be crossed during assembly should be chamfered.

84. Pistons should be secured to the piston rod in such a manner as to prevent unintended loosening.

85. Consideration should be given to the provision of adjustable cushioning at each end of the stroke.

Identification of hydraulic and pneumatic circuit components

86. 86. All circuit components should be clearly marked or identified in a manner which corresponds to the identification of that component in the circuit diagram.

87. All components should be sufficiently identified, in conjunction with the circuit diagram and accompanying documents (see paragraph 85(b)) to enable a correct replacement part to be specified if necessary.

Provision of technical data

88. The following technical data should be supplied with all new machinery.

A. The maximum safe working load of the machine for the following operations should be specified.

1) Pressing and bending operations;

2) Punching and piercing operations.

B. Information necessary for the safe use and maintenance of the machine, which should generally include:

C. Hydraulic, pneumatic and electrical circuit diagram. Where modifications are made to the circuit they should be clearly recorded in the circuit diagram. Where more than one manufacturer is involved in the supply of a machine - e.g. press brake and guard manufacturer - they should co-operate to ensure that all necessary technical data, including any modification to the original machine circuits, is included in the information supplied to the customer.

D. Maximum and minimum system working pressures.

E. Pressures to which any relief or reducing valves are set.

F. Description of function of actuators and valves.

G. Pump delivery, volume and pressure.

H. Accumulator capacity and initial gas pressure setting.

I. Types of filters required, showing degree of filtration in microns.

J. Electric motors kW, rpm and direction of rotation.

K. Maintenance data supplied with the machine should include advice on potential system hazards and safe working procedures.

Operating start controls

89. It is recommended that adequate shrouds, or other means, should be provided to prevent accidental operation from any cause (see paragraph 38).

ELECTRICAL CONTROLS: ALL TYPES OF PRESS BRAKE

90. Generally, for existing machines, safeguarding systems will include a combination of mechanical guarding, electro-sensitive protective equipment (ESPE), pressure mats, limit gap between tools and slow movement via hold to run control.

91. Also principles of electrical safety and the integrity of electrical control systems are discussed in the 'Electrical Equipment' section of a report Power Press Safety, published by the Joint Standing Committee on Safety in the Use of Power Presses for existing older presses and the relevant standards BS EN 692 Machine tools – Mechanical presses - Safety, BS EN 693 Machine tools – Safety – Hydraulic presses & BS EN 12622 Safety of machine tools – Hydraulic press brakes for current machines. The recommendations in the report apply no less to press brakes than to mechanical power presses.

92. The following additional recommendations apply to the control functions of press brakes.

A. In general, it is essential that if the press brake should fail as a result of any electrical malfunction or failure of the electrical supply, then the press brake (in conjunction with its associated safety device) should maintain a safe condition.

B. In the event of disconnection of the power supply to the motor on mechanical machines resulting in run-down of the flywheel, provision should be made to prevent stroke initiation, e.g. by isolation of the foot switch or pedal.

HSG 236 also gives guidance on the requirements for testing, circuit diagrams etc. (for press PUWER 98 (as applied to power presses)

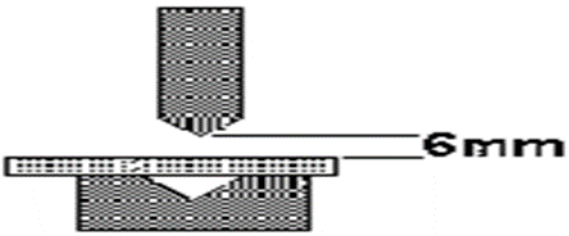
METHODS OF SAFEGUARDING

Introduction

93. Guarding is required for the dangerous parts of all press brakes. Whichever guarding method is selected for any machine it is important to remember that protection must not only be provided from the operating position; guarding must be provided to prevent access to the trapping area from any direction.

94. For comparatively thin workpiece sections, if the arrangements controlling the length of stroke are so set or adjusted and secured against adjustment by the operator, that the maximum daylight (which is the gap seen when looking straight through the tools between workpiece and top tool) does not exceed 6 mm, the tools may no longer be dangerous and the necessity for guarding may be obviated. When such a stroke restriction is being used it is important that users ensure by all practicable means, e.g. by locking or removing the control mechanism (including ensuring an equivalent level of security is achieved if the gap is set via the control system software, e.g. via a program modification that cannot be overridden by the operator), that the stroke setting cannot be disturbed by the operator. The use of this stroke restriction substantially limits the range of work which can be done on a machine and, if used as the sole safeguard on a machine, the user should ensure its suitability for all their work. If a safe tool gap cannot be ensured then additional effective safeguarding, e.g. ESPE must be provided.

Fig. 1



95. Speed alone should not be taken as the criterion for determining whether a machine should be guarded at the front or not. Even if a hydraulic press brake operates extremely slowly, account should still be taken of all other factors affecting the operation of the machine, e.g. number of operators, necessity for holding the material during bending, width of work piece (from front to back), these factors should be considered as part of your risk assessment. However, in general older (non CE Marked) machines running at 12mm/sec or less and newer machines at 10mm/sec or less may well not require guarding when used with a hold-to-run shrouded foot pedal. The foot pedal should be a three-position device with the upper and lower most positions acting as a position stop, and the middle position acting as the run position. If the lower most position stop has been activated, then a restart should only be possible after returning the pedal to the upper most position.

96. Where access to the trapping area is not normally required from the sides and rear, then fixed guarding preventing access to these areas should be provided. The guarding should be fixed in position with fasteners requiring a tool for their removal (see Figs 3 and 4).

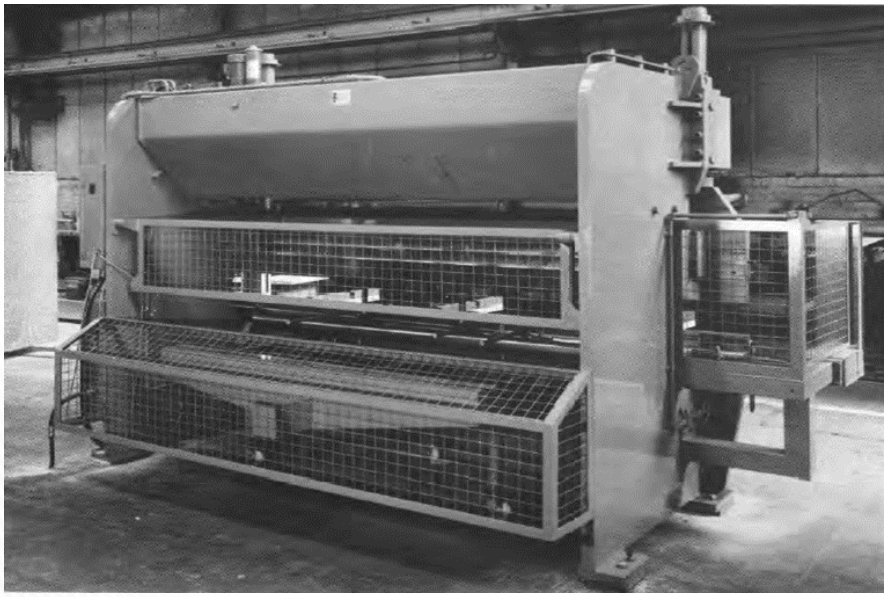


Fig 3 Read guards with fixed top and bottom panels. The top panel has been fitted with an electrical limit switch as an additional safeguard (paragraph 92).

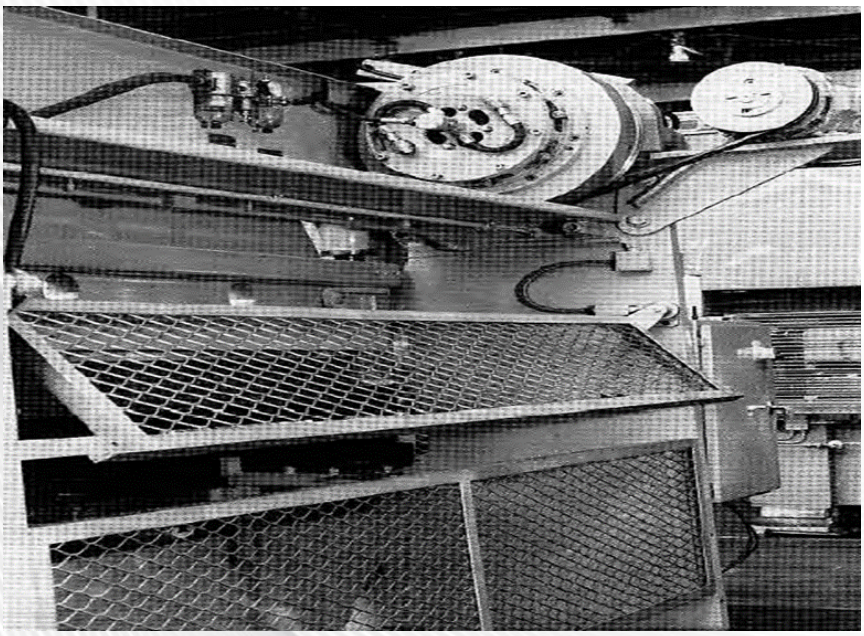


Fig 4 Further example of fixed rear guards showing the electrical interlocking switch on the top panel as an additional safeguard (paragraph 92)

97. Where occasional access to the trapping area is required from the sides and rear, e.g. for tool setting or tool changing, it may be advantageous for the guards to be capable of sliding, swinging or being otherwise easily displaced. In such cases the guards should:

A. be secured as a fixed guard when in position and have the addition of a positively operated limit switch or other interlocking device connected into the machine's control circuit so as to ensure that the machine cannot operate whilst the guard is open;

B. an electro-sensitive safety system as described in paragraphs 95 to 116 and Appendix 1.

98. Where frequent access to the trapping area is required from either the sides or rear (e.g. -where the working method requires the component to be removed by sliding off the end of the beam) then the guards should contain all the features of an interlocking guard or electro -sensitive safety system as described in paragraphs 95 to 130 (see Fig 5).

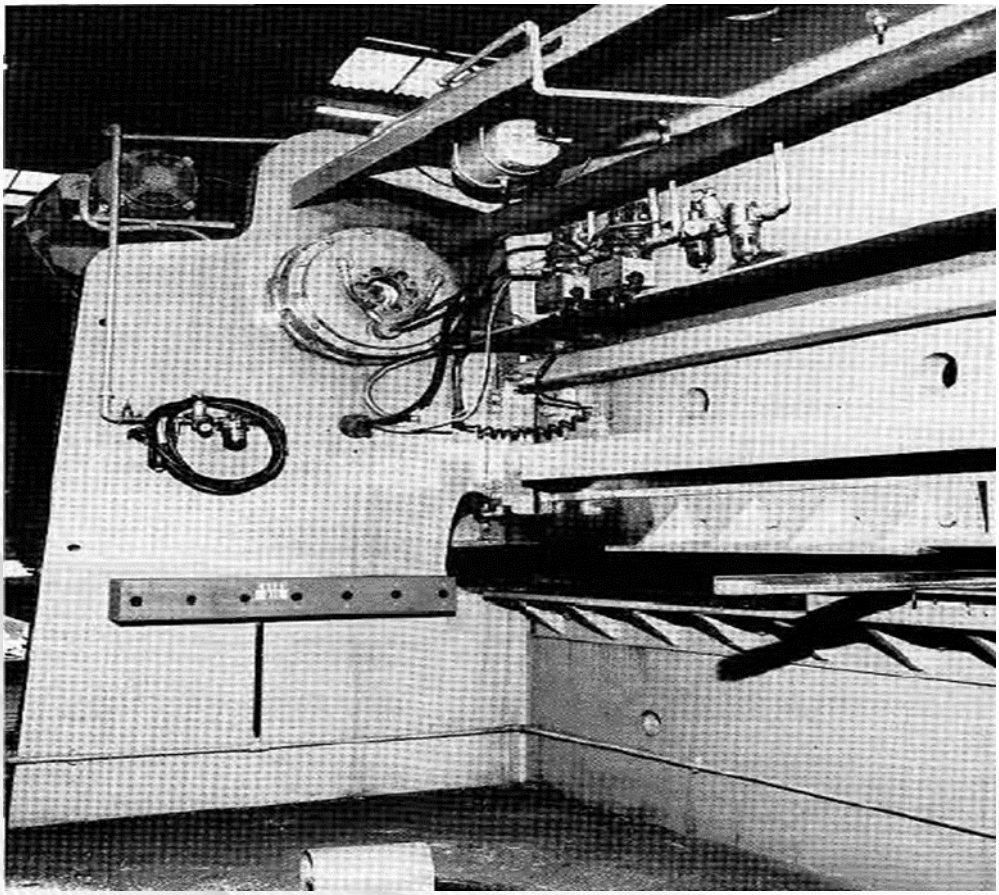


Fig 5 Horizontal format photo-electric safety device at the rear of a press brake (paragraphs 93 and 94)

Electro-sensitive protective equipment (ESPE)

General

99. Electro-sensitive protective equipment does not place a tangible barrier between the operator and the dangerous machinery. They operate by actuating the machine's braking system to bring to rest the parts of the machine which can form a trap before they can constitute a danger. They therefore rely on the efficiency of the machine's braking system or hydraulic system in arresting the movement of such parts within the required time. They should comply with the general standard of performance outlined in Appendix 1.

100. The most commonly available type of electro-sensitive protective equipment applied to press brakes is the photo-electric safety system or AOPD (active opto-electronic protection device) and this section will therefore deal solely with these. However, other types of electro-sensitive protective equipment have been developed, laser, camera etc and if these systems are to be used on press brakes then they should provide a degree of safety at least equivalent to that provided by photo-electric safety systems. See Appendix 1.

101. On many presses, safety at the tools depends on the integrity of electrical control circuits. Where this is the case, the circuits should be included in the thorough examination and test. The likelihood of a fault occurring and leading to injury at the tools will determine the extent and depth of the examination.

102. An operator working at machinery equipped with an electro-sensitive safety system relies not only on that system for his safety but also on the ability of the machinery to respond correctly and efficiently to output signals. High standards for construction and performance of the safety system are given in BS 6491. Specification for Electro-Sensitive Safety systems for Industrial Machines and BS EN 61496 Safety of machinery — Electro-sensitive protective equipment. Unless the control system of the machinery is constructed and performs to a similar high standard the level of protection afforded by the electro-sensitive safety system will be lowered.

103. The main aim should be to ensure that the control system as a whole is designed so that in the event of a single component failure the overall system will not fail to danger.

104. It is essential that the suppliers of the machine and the suppliers of the safety system(s) co-operate (where possible, at the design stage) to ensure safety at the machine.

105. If you buy an older press (made before about 1995) the photoelectric device may have been made earlier standard (BS 6491:1984) and installed according to earlier HSE guidance (PM41 instead of HSG180). There is no need to modify the press and photoelectric device to conform with HSG180 unless the risk assessment at the press indicates otherwise. You can get advice about presses with old photoelectric guards from your competent person.

106. The purpose of the thorough examination and test is to determine if, at the time of thorough examination, the press and its safeguards are installed safely and are safe to operate and if there are any defects that could make the press unsafe in the future. It cannot tell you everything about the press, and there may be things that happen between examinations that you need to do something about. The

thorough examination is not a substitute for maintenance but the information from the thorough examination can help you check your maintenance systems are working properly.

Photo-electric safety systems

107. This electro-sensitive safety system projects a 'Curtain' of radiation (either visible or infra-red) across the area to be guarded. An interruption of this curtain results in a signal to arrest the dangerous parts of the machine. The photo-electric safety system should not be used in place of fixed guards but only where access is needed very frequently to parts within the guarded area. In practice this means that a photo-electric safety system is used to guard the front of a press brake (where the operator normally works) and occasionally the rear and sides of the machine.

108. In order that a daily inspection and test can be carried out (see paragraph 159) there should be provided the facility for a visual indicator to show when the appropriately sized test piece (see Appendix 1) has resulted in the correct response from the photo-electric curtain.

109. For large and awkwardly shaped work pieces, the photo-electric safety system is often the most effective means of safeguarding. When such safety systems are used on press brakes they should conform to the requirements of Appendix 1.

110. The values specified in pares 3 to 10 of Appendix 1 are based on currently available knowledge and may be subject to amendment as a result of future development.

111. Guard format The format of the photo. electric curtain should be chosen to suit the type of work being undertaken. There are two basic formats; the vertical where a number of individual light beams (or a single beam scanning the same area) are mounted in a vertical plane to farm, in effect, a sensitive curtain across the front of the machine, (Fig 6), and the horizontal format where the individual light beams (or single beam scanning the same area) are mounted in a horizontal plane.

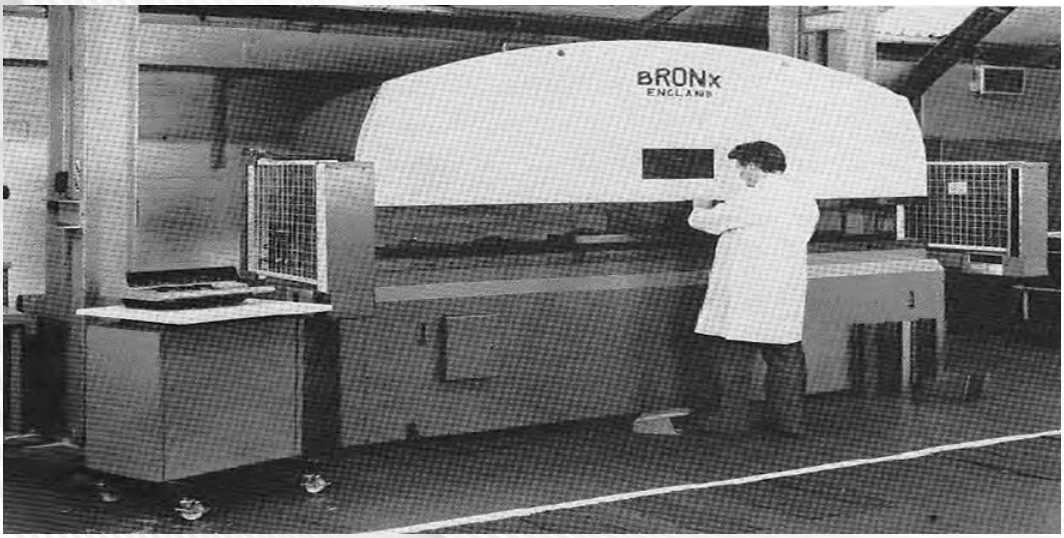


Fig 6 Photo-electronic safety device fixed in the vertical format. Note the limit switch on the side guard (paragraph 104)

112. Vertical format light curtains may be inclined towards or away from the machine provided that they are inclined less than 30° from the vertical and the minimum curtain distance is not less than that given in paragraph 3 of Appendix 1.

113. Photo-electric safety systems are available which provide a curtain in a single plane (either vertical or horizontal) or a choice of either curtain plane in the one unit. Selection of the format may be:

A. by physical rotation of the arms containing the optical devices (Rotating arm dual format systems. Fig 7), or

B. by manually initiated, or automatically actuated, electrical selection of one pair of the twin arms containing the optical devices. (Fixed arm dual format systems. Fig 8).

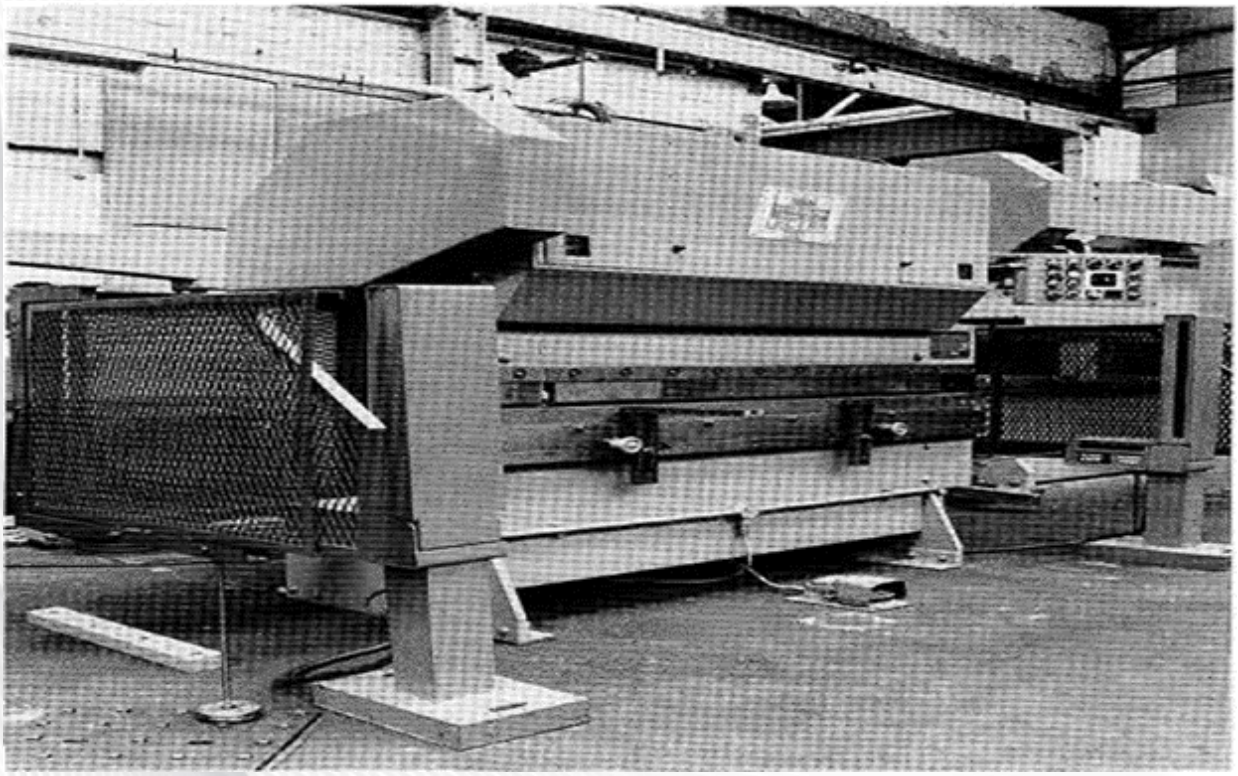


Fig 7(a) Rotating arm dual formal photo-electric safety device in the vertical position, with side guards (paragraph 106)

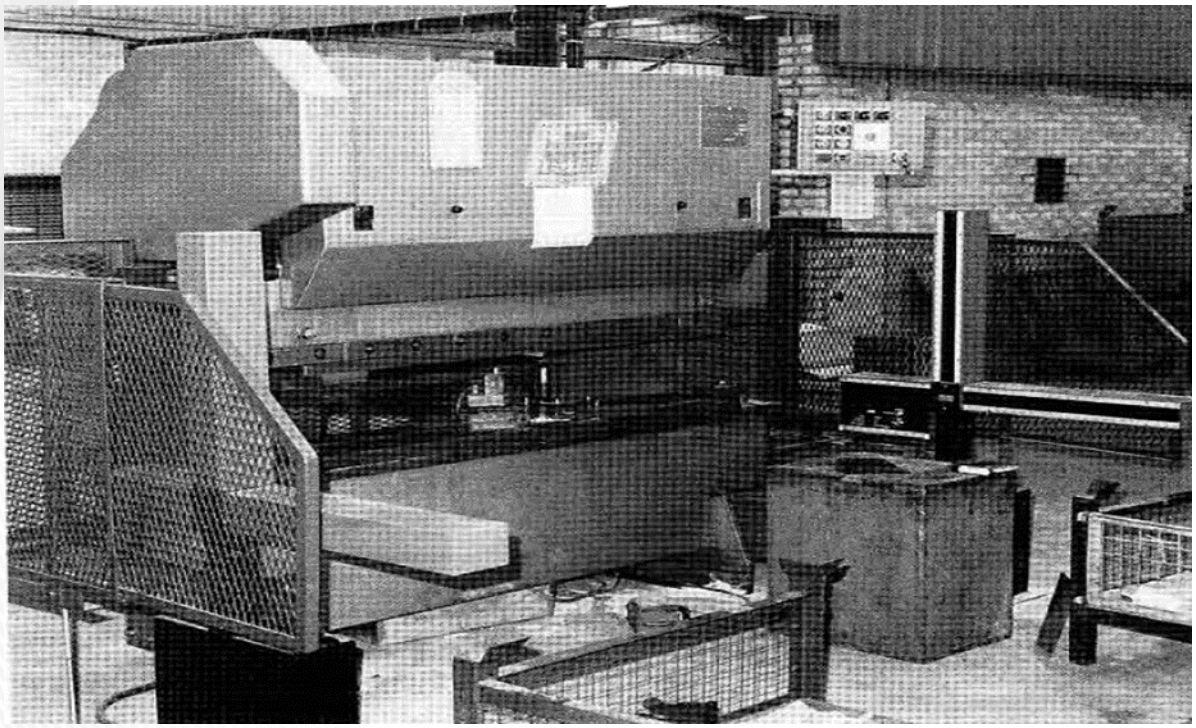


Fig 8 Fixed arm dual format photo-electric safety device (paragraph . The left hand side guard has been moved towards the machine for clarity. The machine will not operate with the curtain in the horizontal mode until the guard is in the 'fully out' position

114. Where selection is by physical rotation of the arms as in paragraph 106(a), it should not be possible to rotate the arms from the vertical position towards the trapping parts such that the minimum curtain distances as stated in paragraph 3 of Appendix 1 are reduced, Particular care should be taken to ensure that the side guarding is adequate to prevent access to the dangerous parts when the photoelectric safety system is in any operative position (see pages 89 to 94).

115. Where the photo-electric safety system operates by reflecting the transmitted light beam back along its own path and additional reflector(s) are placed within the area of detection then under no circumstances should the configuration of additional reflector(s) allow an item of thickness equal to or greater than the specified test piece size to be undetected by the photo-electric curtain anywhere within the whole of the area of detection as specified in Appendix 1.

116. Muting Provision is usually made to render the photo-electric curtain inoperative or muted at a point in the approach stroke where the bending or other operation is just about to begin. If muting is to be used then it is essential for the safe operation of the press brake that the muting point is correctly set. Muting should not occur until the top tool is nearly in contact with the work piece (see paragraph 153). A greater gap than this allows a portion of the closing stroke of the press brake to be unnecessarily unguarded and constitutes an avoidable hazard. The machine should be provided with an illuminated means of indicating when the photo-electric curtain has been muted.

117. It should be emphasised that muting is intended only during final stage of closure ie the residual gap has been minimised to prevent finger entry. Also, upon return stroke the ESPE is also muted, therefore

entry into the danger zone at this time is possible – hence reliance on other safeguards to prevent the tool from dropping if a partial stroke (or double stroke) were to occur.

118. The muting device is vulnerable to maladjustment, and should therefore not be used if more effective measures can be adapted.

119. To allow the tool setters to adjust the point at which muting takes place, the safety system should contain a 'stroke-stop' facility, which may be subsequently switched out if not required. This is an automatic stop command and its position will be associated with the mute point.

120. When the machine is given a command to stop the beam there will be a delay before it comes to rest. When it comes to rest the beam should be just within the muted portion of the stroke. Depending upon the approach stroke speed the distance travelled before the beam comes to rest will vary. It should not be possible, by any operation of the press brake, to obtain muting at a gap larger than that which has been set for the operation in question. (See paragraphs 109 to 112) Where closing speeds are selectable the selector mechanism should be lockable. Similarly, the stroke stop/mute positions should only be adjustable by means of a key or other tool kept under the control of an authorised person.

121. Use of a photo-electric curtain for machine initiation Some photo-electric safety systems have the facility to initiate a stroke on removal of an obstruction (e.g. the operator's hands) from the curtain. Two modes of operation are sometimes available, one requiring the curtain to be interrupted and restored once (single break), the other requiring the curtain to be interrupted and restored twice (double break).

122. Where there is the possibility of unintentional initiation due, for example, to the shape of the work piece or particular working method, this type of initiation system is unlikely to be suitable. However, where such machine initiation systems are considered suitable all of the following conditions should be fulfilled,

A. the system should fully comply with the 'General Standard of Performance' as set out in Appendix 1

B. the single or double break methods should not be the exclusive means for initiating machine motion. A conventional control should also be provided.

C. setting, maintenance and similar non -production operations should only be carried out with the photo-electric safety system selected in the `guard only' mode;

D. effective provision should be made and maintained to ensure that it is impossible for persons to pass completely through the photo-electric curtain towards dangerous parts and so allow the curtain to clear behind them; The safeguarding provisions should prevent the possibility for two persons to be involved in the work activity in such a way as to allow one person to be able to exit the area and initiate a stroke, whilst the second person remains within the danger zone;

E. the photoelectric safety function should be effective at all times during dangerous motion;

F. the facility for automatic initiation of machinery motion upon clearing of the curtain must be limited to a period commensurate with the normal cycle time. Normal means of initiating

machinery motion is therefore required for occasions when machinery motion is not automatically initiated within that limited period

123. Marking. BS 6491 requires the photo -electric safety system manufacturer to give relevant information which should be marked on a label or plate on the outside of the equipment. In addition, the supplier of the machine should provide clearly visible and permanent tables giving relevant information relating to the machine. This should include:

A. year of manufacture;

B. model or type;

C. name and address of manufacturer:

D. serial number:

E. supply voltage and frequency;

F. stopping performance;

G. a stipulation that components should only be replaced by components known to be compatible with the remainder of the safeguarding system;

H. where appropriate, the standard to which the equipment was constructed and tested.

124. A further visible and permanent label should be fitted to the machine which states;

A. the overall system stopping performance used for the calculation of separation distance in milliseconds;

B. the appropriate test piece diameter in millimetres;

C. the minimum separation distance in millimetres.

BS EN 61496 requires

A. identification of the product, including name and address of the supplier, designation of series or type, serial number and year of construction;

B. parameters, for example dimensions, of the detection zone;

C. detection capability;

D. response time;

E. rated voltage(s) including number of phases and frequency where relevant;

F. rated input power (if greater than 25 W) or rated current;

G. designation of IP code;

H. for class II equipment only, symbol for classification for protection against electric shock;

I. warning sign of hazards arising from dangerous voltages;

J. type of ESPE according to 4.1.3.

Please see HSG180 Application of electro-sensitive protective equipment using light curtains and light beam devices to machinery for further information

Interlocking guards and safety devices General

125. An interlocking guard consists of a physical barrier connected mechanically. electrically, hydraulically or pneumatically to the operating controls of the press brake to ensure that except when the barrier prevents access to the danger area, the brake cannot be released, and the clutch cannot be engaged. It should not be possible to gain access to the tools during dangerous closing motion. With the press brake beam in motion it should not be possible to open (or remove) the barrier on the opening stroke unless fail-safe stopping capability and overrun detection are provided (see paragraphs 40 to 42)

126. Guards of this type presently fitted to press brakes are the distance bar trip guard, the early rising guard, and the interlocking screen guard.

127. In all cases appropriate guarding should be fitted which will prevent access to the trapping area from any direction not covered by the main guard. All guard interlocking arrangements should be so arranged that they are fail-safe so far as is reasonably practicable.

128. Detailed consideration has not been given to guard design relating specifically to hydraulically operated press brakes. However, interlocking guards may be used on such machines provided that sound principles of design are adopted giving a standard of safeguarding at least equal to that provided for mechanical machines as set out in paragraphs 117 to 130. The recommendations concerning the provision of overrun detection are not applicable to hydraulic press brakes since the danger of overrun is not present with this type of machine.

Distance bar trip guard

129. A bar, incorporating a screen to prevent access from below is located across the front of the press brake and mounted so that it is lightly balanced to move outwards to a distance at which the operator is beyond arm's reach of the tools. (Fig 9). Interlocks prevent the clutch being engaged unless the bar is In this position. As soon as the clutch is engaged, locks operate to prevent the bar from being pushed inwards. A small amount of bar movement is allowed so that the interlocks will immediately disengage the clutch and apply the brake in the event of an operator pressing against or upon the bar in an attempt to reach into the trapping area.

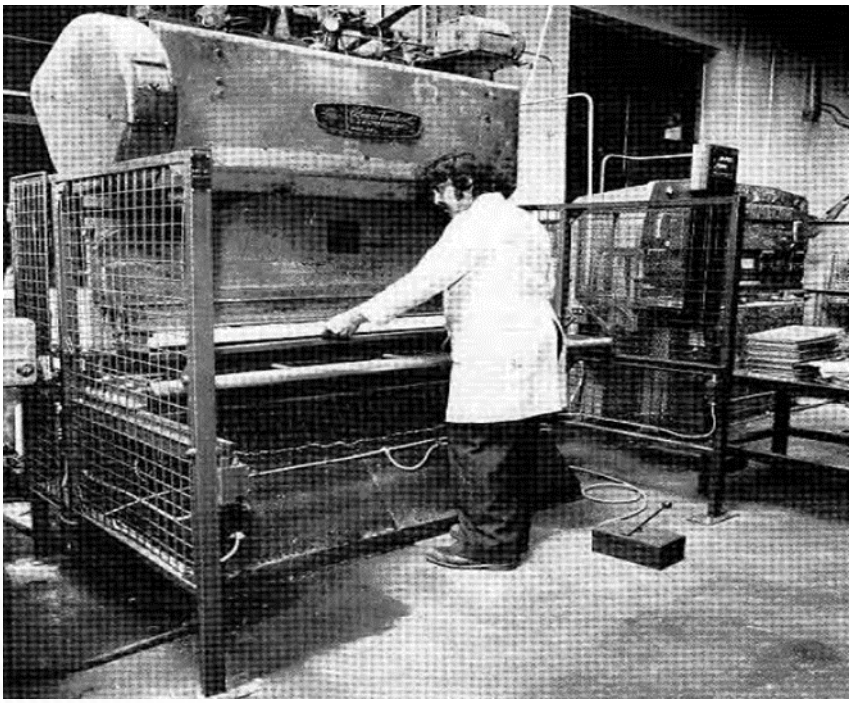


Fig 9(a) Distance bar trip guard with the guard in the 'In' position, i.e. machine not capable of operating

Fig 9(b) Guard in the 'out' position, i.e. machine capable of operating (paragraph 121)

130. The position of the barrier when the machine may be operated should be such as to prevent any person from reaching the nearest trapping point.

131. The positioning of the barrier should be such that the distance from the bar to the nearest trapping point, when measured horizontally, is at least 1050 mm before it is possible to engage the clutch.

132. Some of these guards have been made to be `early opening'. In this form the locks are released at the `muting' point, i.e. when the tools are so close together that there is no further trapping danger. (See pages 109 to 112). The operator can then push the bar inwards and continue the stroke. To protect the operator against the dangers of repeat strokes and overrun. this early opening feature should only be used when fail-safe stopping capability and overrun detection are provided (see paragraphs 40 to 42).

Early rising guard

133. This guard consists of a moving screen which extends along the full length of the tool bed and which, when in its lowest position. prevents access to the trapping area from the front of the machine. Where such a guard is fitted, additional fencing, which prevents access from any direction other than from the front, will be required. The screen is arranged so that it rises as the work is bent in order that the work piece does not foul the screen (Fig 10).

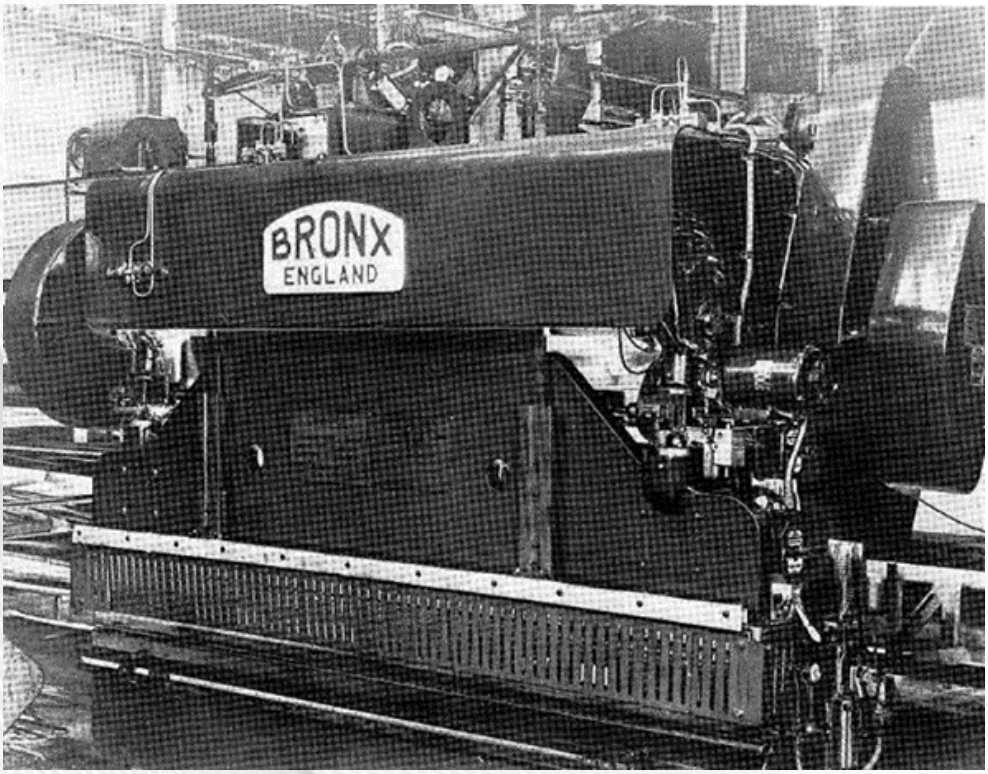


Fig 10 Early rising guard (paragraph 125)

134. It should not be possible to engage the clutch until the screen is at Its lowest level, at which point access to the trapping area should be prevented. At its lowest point the screen should be locked or held in that position until the gap between the descending tool and work piece is so small that there is no risk of trapping. At such a point the screen can be allowed to rise.

135. It is important that the guard is correctly adjusted, set and maintained at all times so as to ensure its correct operation and to ensure that the movement of the screen does not result in injury. To protect the operator against the dangers of repeat strokes and overrun, this early opening feature should only be used when fail -safe stopping capability and overrun detection are provided (see paragraphs 40 to 42).

Interlocking screen guard

136. This guard consists of an enclosure around the tools with a movable screen. which is interlocked with the clutch and brake mechanism in such a manner that when the guard screen is in any position other than fully closed, the brake cannot be released, and the clutch cannot be engaged. It should also be interlocked so as to ensure that when the clutch is engaged, and the brake is released, the guard screen cannot be opened.

137. Effective means should be provided for preventing non-powered overrun past top dead centre and an effective single stroke device should be provided which will ensure that the crankshaft comes to rest at top dead centre after each stroke,

138. The guard screen may take the form in which, when it is closed, it is sufficiently close to the surface of the bottom tool to prevent a person from reaching into the trapping area. Alternatively, the screen may. when in the closed position, entirely enclose the front of the tools. This would be appropriate when work pieces do not have to be supported by hand during the bending operation.

Fixed guards

139. Fixed guards consist of enclosures firmly secured in position, requiring a tool for removal, which prevent access to the trapping area from any direction. A fixed guard should be of strong construction sufficient to withstand the stresses of the process and environmental conditions. A fixed guard should be secured in position whenever the press brake is in motion, or is likely to be in motion, and it should not be possible to remove or open the guard at any time without the aid of a tool. Where an opening is necessary in a fixed guard for the purpose of feeding material, it should not allow the operator access to the dangerous parts. (General advice on this matter is contained in PD 5304).

140. Hanging screen fixed guard. To facilitate removal of the work piece, some `fixed' guards have a limited movement of the front screen. This type of guard is often referred to as a hanging screen fixed guard. The front screen of such a guard extends across the full length of the tool bed. The screen hangs on hinges or on trunnion-type fixings and has a limited amount of free movement so as to permit the screen to approach closely the front of the top tool so that bending can take place outside the screen. It also allows the screen to move away from the tools for removal of the work piece. The movement of the screen in conjunction with its position in relation to the trapping area should be so restricted as to prevent persons

from gaining access to the trapping area, where variations in height of the bottom tools are likely to be encountered, facilities for vertical adjustment of the screen should be provided.

Pressure sensitive mats

141. These devices operate by means of a number of suitably spaced electrical or fluid switches/valves contained within a mat connected to a control unit and covering the approaches to the danger area. Pressure on a mat operates one or more of these switches.

142. These devices should not be used as the primary safeguard for a press brake unless the device incorporates self-checking and provision for monitoring to the same standard as electro• sensitive safety system. (See paragraphs 95 to 116).

143. Where a press brake is fed from the front, and a suitable safeguard is provided at the front, a pressure sensitive mat may be useful at the sides and rear where the principal aim is to detect the presence of any person. Pressure sensitive mats should not be used as the sole safeguard at the sides and rear, but they may be used inside a side or rear fence to prevent persons standing between the fence and the machine. Where these mats are used they should not be fitted such that removal of pressure from a mat will. of Itself, initiate a stroke of the press brake.

GUARDING: SPECIAL CONSIDERATIONS

Self-contained unit tools

144. Proprietary individual unit tools are often used for punching, piercing and notching operations. Trapping parts may be created at the punching area, at the upper stripper plate, and between the underside of the press brake beam and the punch at the top of the unit tool. Safeguarding should be provided in all cases where the gaps between the trapping parts are greater than 6 mm. A number of safeguarding methods have been used and these include:

A. Individual guards at each tool or a single guard for all tools (care should be taken to ensure that finger access is not possible from any direction, including the back of the machine). Such guards should not be attached to any moving part of the machine;

B. Electro-sensitive safety systems (see paragraphs 95 to 116). These systems may include `muting' provided that the gap between the punch and die is not greater than 6 mm and that muting does not occur until the blow plate on the beam of the machine is nearly in contact with the top of the punch of the unit tool (see paragraph 153);

C. Interlocking guards (see paragraphs 117 to 130).

Power press tools

145. Press brakes are sometimes used with conventional 'power press' tools for operations such as punching, forming and cropping etc. In such cases the press brakes carry tools between which components are located by methods usual in press tool techniques. Fixed, interlocking or electro-sensitive safeguarding systems may be used. However, interlocking guards should have `guard control' (paragraph 41), and should not incorporate an `early rising' or `early opening' feature. Where electro-sensitive safety systems are used, it is important that the system is operative throughout the working cycle of the machine (i.e. 360^0 in the case of mechanical press brakes or the closing stroke in the case of hydraulic press brakes) and that the dimensions and stopping performance in Appendix 1 and all other requirements of this document are followed.

Use of machine with numerical control (NC)

146. When the use of NC machines is being considered the following points should be taken into account.

A. It is essential that there is full compatibility between the machine control system and the guard control system. The design of the NC or CNC machine should allow for the action of the electro-sensitive or other safety system on the machine controls. It is essential that information regarding the condition (i.e. guard interrupted and guard clear) of the electro-sensitive safety system is fed into the programmable electronic system because the signal to stop (and subsequently to allow a restart) could occur at any point in the machine cycle when the system is active. Unless the programmable electronic system is fully informed of the machine state there could be aberrant effects on subsequent operations. It should be noted however that stop signals from the electro-sensitive safety system or any other emergency stop, interlocking guard or trip device should be applied directly to the machine control elements. This should be done in such a way as to ensure that no other control signal under any circumstances can allow the machine to restart until the electro-sensitive safety system or any other emergency stop, interlocking guard or trip device has been reset.

B. Where powered back gauges are used they may have a separate power supply from the supply to the press brake. If access is gained to the rear of a machine via an interlocked rear guard, it may still be possible to have power to the gauges. In such cases care should be taken to ensure that rear guards are also interlocked with the power supply to the back gauges to prevent the possibility of a person being injured by their movement.

C. It is particularly important that the NC system provides for the tools to be opened by manual means in the event of an emergency.

Using worktables with horizontal format photo-electric systems

147. The worktable may provide a physical support and thereby enable the operator to reach further towards the tools without interrupting the light curtain than would otherwise be possible. In such circumstances it may be necessary to install the curtain at a distance greater than that given in Appendix 1 to ensure that the operator cannot reach a trapping point without obstructing the light curtain. Similar arrangements may be necessary where such a worktable is introduced to an existing press brake. When the safety system is so installed it is important that the operator should not be able to stand undetected between the light curtain and the trapping parts during dangerous closing motion.

End of bed working

148. Where it is necessary for an operator to work at the end of the press brake bed, e.g. for bending on horn extensions, provision should be made for the safeguarding system to include this area. This may be achieved by extending the electro-sensitive safety system or by the provision of interlocked guards. The interlocked portion of the guard should be electrically interlocked so that, with the guard in its open position, a closing movement is only permitted when the safety system is operating in mute (see paragraphs 109 to 112).

TOOL DESIGN AND USE

Safe design in use

149. A major consideration in tool design should be to obviate the necessity for the operator's hand to be placed between the tools. This is particularly the case where narrow work is being done. It is strongly recommended that tool designers (and persons who prepare press brakes for use) provide some form of device for placing and locating the work piece in position.

Operations using gauges

150. Press brake work is often carried out against adjustable back stops which are usually supplied as standard equipment with machines. The current practice of using front operated back gauges is commended. Gauges should be designed to permit adjustment from the front without the need for access between the tools of the machine (Fig 11).

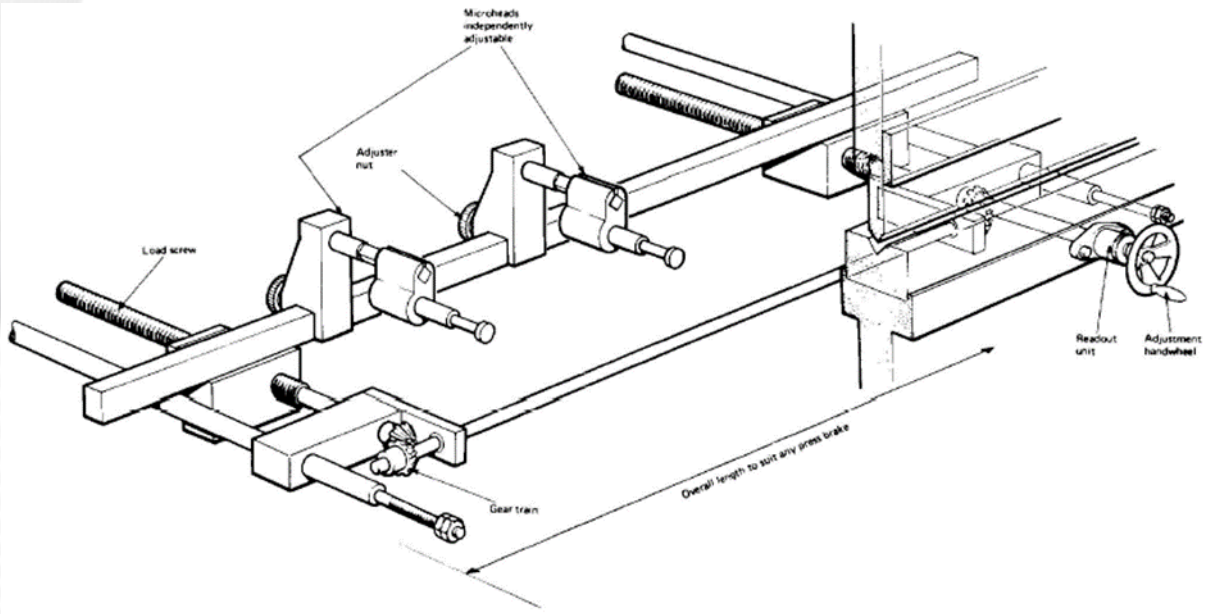


Fig 11 Backstop capable of adjustment from the front of the machine (paragraph 142)

Tool handling and changing

151. For ease of handling the weight of press brake tools should be as low as possible. Tools are often long and heavy and accidents can be a direct result of attempting to insert or remove such cumbersome tools solely by human effort.

A. To overcome this hazard mechanical handling equipment can be of use, e.g. portable cranes, hoists fitted over each machine, tool trolleys, overhead cranes and fork lift trucks. For convenience of handling it may be desirable to strap the top and bottom tools together, provided that care is taken to ensure stability. The beam can then be moved to its fully open position at which point the power to the machine should be switched off. A lifting device can then be used to remove the tools from the machine. The procedure for setting tools is given in paragraphs 148 to 152.

B. Tool changing can be made easier by the use of sectionalised tools. Alternatively, a standard punch holder with interchangeable nose pieces can be used. The standard holder can remain in the machine almost permanently, the nose pieces only being changed. Manual handling during tool changing can be further reduced for 'vee' bending by the use of single 'vee' bottom tools located in a fixed filler block. This has the added advantage of reducing tool setting times by avoiding the need to relocate the 'vee'.

152. Where possible a safety lip or tang should be provided on all tools (and a matching recess on the `nipping strip') so as to minimise inadvertent fall of tools during tool changing. The tool designer should take account of the fact that loading/unloading from the side is generally safer than from the front.

153. Information which is relevant to the safe handling of press brake tools should be clearly marked on all tool sets preferably in the form of a uniform information plate. It is suggested that the following items of information may be given where relevant.

A. Tool number or identification

B. Weight of tools

C. Metric/Imperial eyebolts required

D. Front of tool

154. To ensure that the tool is compatible with the press brake, the following items should be considered.

A. Tool shut height

B. Required stroke of the press brake

C. Press brake capacity

D. Type of guarding required

SAFE WORKING METHODS

Tool handling

155. The tool handling methods provided should be used (paragraphs 141 to 146) and ad hoc arrangements should not be used.

Tool setting

156. The press brake should be fully prepared before tools are inserted and the setter should check to ensure that the tools, the machine and the job to be carried out are compatible. Safe systems of work should be provided for the insertion of tools in a press brake.

157. Accidents can occur to persons while changing or setting tools at press brakes, and where these operations cannot be performed with the tools securely fenced, they should not be carried out unless the power to the machine is switched off. The safest position to stop the machine for tool changing is with the tools closed; any necessary movement of the beam can be obtained by inching, jogging, or by using the beam height adjustment mechanism. The danger of oversetting or uneven setting should also be stressed.

158. It is important that the guard is placed back into its operational condition before any trial stroke is made. After tool setting the machine and guarding system should be inspected and tested and if satisfactory the records should be completed. The machine can then be handed over to production.

159. It is also important that setters be instructed in the function of the essential parts of the machine mechanisms, with the importance of adjusting the guard correctly after each tool set-up and of reporting immediately any damage to or malfunction of any part of the guard.

160. For hydraulic machines care should be taken to ensure that the pressure is adjusted to be within the capacity of the tooling in relation to the length and thickness of material being formed.

Use of muting, stroke-stop or early opening

161. The muting device is vulnerable to maladjustment and it should only be used where the nature of the work piece makes it necessary. Where it is necessary to apply the mute condition or where early-opening safety devices are used it is imperative that the adjustment of the mute, stroke-stop and early opening positions are carried out only by appointed persons. The guard should be muted only when the gap between the top and bottom tools is just greater than the material thickness. Great care should be taken to ensure that muting devices are correctly adjusted after tools have been changed (see paragraphs 109 to 112).

Secondary trapping points

162. When material is being formed on a press brake a secondary trap may be created between the work piece and the front of the machine or tooling, e.g. when forming channels or when holding material such as trays which have side flanges. Secondary traps may also be created between the work piece and work supports when beam pressure is first applied. Where such situations could occur safe systems of work piece manipulation should be adopted.

Fault conditions

163. Although electro-sensitive safety systems are designed to maintain safety under single fault conditions it should be borne in mind that some faults may not render the machine completely unusable. It is important, therefore, that all malfunctions are reported immediately. Failure to do so may result in a second fault developing later, causing a serious reduction in the protection provided.

MAINTENANCE AND INSPECTION

General

164. The law requires that work equipment, which includes press brakes, is maintained in an efficient state, in efficient working order and in good repair. Your arrangements for maintenance should be adequate to meet this requirement. This will include ensuring that your employees or those who maintain your press brakes have the necessary knowledge, skills and facilities to do what is needed.

Your duties as an employer under PUWER 98

165. You must ensure that:

- Your press brakes and all their guards, the control systems and ancillary equipment (eg automatic feed systems) are maintained so that they do not put people at risk;
- Maintenance work on press brakes is carried out safely, ie machinery is shut down and isolated, and done by people who have the right skills and knowledge;
- Training is provided for the 'appointed person to help them fulfil their role;
- Adequate health and safety information and, where appropriate, written instructions are made available to everyone using press brakes or supervising and managing their use;
- An inspection and test is done by the appointed person and certificate is signed to confirm the press is safe to use for those presses for PUWER 98 (as applied to power presses). However, it is considered good practice that daily inspection is completed on press brakes in accordance with HSG180 Application of electro-sensitive protective equipment using light curtains and light beam devices to machinery.
- Any existing maintenance log * is kept up to date;

* You are advised to keep a log of the maintenance activities performed on the press brake – it provides evidence that the press has been properly maintained.

Preventive maintenance

166. Preventive maintenance is needed to identify potential failures before employees are put at risk of injury. Worn or defective parts need to be repaired or replaced and adjustments need to be made at set intervals to ensure the press will continue to work safely.

What to maintain

167. Target your maintenance at those parts of the press that could cause danger if they failed or deteriorated (e.g. brakes, clutches, guards, safety- related parts of the control system).

When to maintain

168. This will vary according to press design and the way the press is used but take into account:

- The instructions on maintenance from the machine manufacturer;

- Your own experience of the way the press behaves, eg based on maintenance records and examination reports;
- The usage and other service conditions, eg two shifts a day, heavy duty and
- Discussing the frequency of your maintenance programme with your competent person or your maintenance contractor.

Thorough Examination and Test

169. It is a requirement of the Regulations 31-35 of PUWER 98 (as applied to power presses) that mechanical press brakes and safety devices should be thoroughly examined and tested by a competent person at specified intervals; six months in the case of most press brakes. It is recommended that similar arrangements be made for hydraulic press brakes and their safety devices to be thoroughly examined and tested by a competent person at intervals not exceeding six months. The competent person should prepare and sign a report of his examination and test, which should include comment on the general condition of the machine and its associated safety devices.

Information

170. You should make available any guidance provided by Manufacturers and suppliers of press brakes and safety devices. the examination and testing of their products for use by the competent person when performing his examination

Daily inspection

171. Regulation 33 of PUWER 98 (as applied to power presses) require the safety devices of mechanical press brakes to be inspected by a suitably trained and appointed person within the first four hours of any working period and also after the setting, resetting or adjustment of the tools[1]. It is recommended that a similar system of daily inspection should be introduced for hydraulic and other types of press brake. The inspections should be carried out by a suitably trained and appointed person (see paragraphs 161 to 167) and a record of all tests should be kept, bearing the date and time of the inspection, and signed by the person making the test. The press brake should not be returned to service unless it is verified that the safety devices remain in efficient working order. (See paragraphs 11 and 12).

[1] Recommended minimum tests for photo-electric safety devices are set out in HSE leaflet INDG316 which is obtainable from the offices of the Health and Safety Executive

Accumulators

172. Where a hydraulic accumulator is fitted, and it does not have automatic discharge equipment as described in paragraph 67, a suitable warning notice should be attached to the machine stating that the accumulator should be discharged or isolated before work commences on the hydraulic system.

TRAINING

General

173. Every employer should provide such information, instruction, training and supervision as is necessary to ensure so far as is reasonably practicable the health and safety at work of his employees. Such training and supervision is of vital importance for all aspects of press brake use, and all persons whether operators, setters, supervisors, competent persons or managers, should be fully aware of the dangers associated with the use of press brakes and of the necessary precautions to be observed.

Operators

174. Press brake operators should be informed of the basic hazards of press brakes and instructed in the precautions which need to be observed. They should be warned of the principal danger of hands being trapped between the tools and against interfering with the setting or adjustment of safety devices. All operators have a duty to take reasonable care of themselves, and others and to ensure that they co-operate in all health and safety matters with their employer.

Toolsetters

175. Regulation 33 of PUWER98 (as applied to power presses) requires that no person should set, re-set, adjust or try out the tools on a mechanical press brake, or install or adjust any safety device on such a press brake unless he has been trained in accordance with the ACOP to the Regulations, paragraph 118. The ACOP to the Regulations states that suitable and sufficient practical instruction should be given in the following matters with respect to press brakes:

A. (The mechanisms of press brakes with particular reference to their bearing on safety. The nature and function of clutch mechanisms, flywheels, brakes and ancillary equipment.

B. Safety systems. The types of system and their functions. The methods of installing, inspecting and testing the safety systems, including the detection of defects.

C. Accident causation and prevention. The causes and prevention of accidents with special reference to press brakes.

D. The work of the tool setter. Safe methods of working. Lubrication. Co-operation with the press brake operator.

E. Tool design in relation to safe methods of working.

176. Only press brakes of the mechanical type and which embody flywheel and clutch mechanisms are covered by the Regulations, however it is considered that similar instruction and training be given to toolsetters of all press brakes, including machines which are driven by hydraulic or direct means.

Management and supervisors

177. All managers, supervisors and any other persons in positions of authority in premises where press brakes are used should be fully instructed and informed of the hazards associated with the use of press brakes and of the necessary precautions to be observed.

Emergency procedures

178. All persons whether operators, toolsetters, supervisors or managers, should be fully instructed and trained as to the necessary action they have to take in the event of an emergency. This is particularly important if the situation should arise where a person is trapped in a press brake.

APPENDIX 1: ELECTRO-SENSITIVE PROTECTIVE EQUIPMENT

Definitions

179. Definitions applicable to all electro-sensitive safety systems are given in BS 6491: Specification for Electro-Sensitive Safety Systems for Industrial Machines and BS EN 61496 Safety of machinery — Electro-sensitive protective equipment, the following definitions are relevant to the terms used in this publication for electro-sensitive safety systems, of the photo -electric type, when applied to press brakes..

180. Area of detection the area within which a response to the specified test piece (see paragraph 3) will take place.

181. Curtain object detection capability. The minimum size of test piece (see paragraph 3) which when placed anywhere at right angles into the photo-electric curtain will be detected, thereby causing the final switching devices to actuate.

182. Muting. A facility for automatically switching the photo-electric safety system into a condition where the final switching devices do not respond to an interruption of the photo-electric curtain.

183. Overall system stopping performance. The time, or travel, occurring from the actuation of the photo-electric curtain to the cessation of dangerous motion.

184. Photo-electric curtain. An electro-sensitive means whereby an arrangement of photo-electric emitter and receiver devices can detect the presence of a specified object entering, or in, a defined area.

185. Photo-electric safety system. An electro-sensitive safety system comprising a photo-electric curtain, safety monitoring means, a safety system control unit, final switching devices and a secondary switching device.

186. Test piece. An opaque cylindrical object of low reflectivity which is capable of being used to check the curtain object detection capability.

General standards of performance

187. Where a photo-electric safety system is used it should comply with the following standards.

A. It must not be possible for the trapping parts of the machine to be set in dangerous motion while any part of a person is in such a position as to actuate the photo-electric safety system.

B. When the trapping parts are in motion, actuation of the photo-electric safety system during a dangerous part of the operating cycle must result in the trapping parts being brought to rest before they can constitute a danger. It must not be possible for the trapping parts to be set in motion again until the safety system has been completely restored to its normal condition and the machine controls re-operated.

C. It is important that the photo-electric safety system complies in all respects with BS 6491, Specification for Electro-Sensitive Safety Systems for Industrial Machines or EN 61496 Safety of machinery — Electro-sensitive protective equipment.

D. There should be no means of rendering the photo-electric safety system ineffective, except as described in paragraphs 109 to 112.

Curtain object detection capability, distance from the trapping point and overall system stopping performance

188. For each type of photo-electric safety system the detecting curtain should be fixed in position and should not be easily adjustable. The distance of the curtain from the nearest trapping point, the curtain object detection capability of the photo-electric curtain and the overall system stopping performance should be calculated as follows:

For PM41 Systems

(Note: PM41 withdrawn in 1999 replaced by HSG180)

189. For horizontal format curtains

A. The curtain object detection capability should be 177 mm or better. The positioning of the outermost point at which the appropriate test piece will just be detected will depend upon the overall system stopping performance. Where the overall system stopping performance is 200 ms or better, a minimum distance of 1050 mm between this point and the nearest trapping point should be maintained.

B. Where the overall system stopping performance exceeds 200 ms, 18 mm should be added to the figure of 1050 mm for every additional 10 ms. Thus where the overall system stopping performance equals 400 ms the outermost point of the horizontal curtain should be positioned at least 1050 + (20 x 18) = 1410 mm, from the nearest trapping parts.

190. For vertical format curtains

A. It is anticipated that most press brakes will fall into Category 1 as defined in Guidance Note PM 41, The application of photo-electric safety systems to machinery. Where this is the case the following guidelines may be followed. Where Category 1 is not appropriate then the guidelines in Guidance Note PM 41 for Category 3 machinery should be followed.

B. For Category 1 machinery the minimum distance from the area of detection of the photo-electric curtain to the nearest trapping point of the machine, (D), can be calculated by adding the appropriate curtain penetration figure (P) to the product of the overall system stopping performance (RT) and a derived hand speed of 1.8 m/s. This figure is based on experience of curtain distances which have been successfully adopted in earlier photo-electric safeguarding standards for press brakes and similar types of machinery without giving rise to accidents.

C. Where D is in millimetres and RT is in milliseconds:

D = P + (RT x 1.8)

or P + 150mm, whichever is the greater.

The curtain penetration figure (P) is a function of the curtain object detection capability (S). Where S is in millimetres: P = 3.4 (S - 7), where S is greater than 7mm. If S is less than, or equal to 7mm, then P = 0

Examples:

Example 1: Where S = 38mm and RT = 200 milliseconds

P = 3.4 (38 - 7) = 105.4 and D=105.4+360= 465.4mm

Example 2: Where S = 38mm and RT = 350 milliseconds

P = 105.4

and D = 105.4 + 630 = 735.4mm

Example 3: Where S = 17mm and RT = 300 milliseconds

P = 3.4 (17-7) = 34 and D=34+540= 574mm

191. In order to accommodate different heights of the trapping point and to make adjustment of the curtain position unnecessary, photo-electric curtains should be positioned in relation to a fixed point. It is considered that the most appropriate point is the bed of the machine. For up stroking machines the machine bed should be taken at the lowest position of the moving beam. Curtains should be installed as follows.

Size and positioning of photo-electric curtain

Horizontal format curtain (Fig 12)

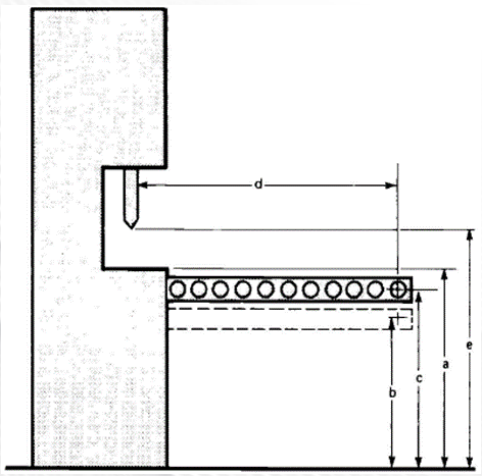


Fig 12 Horizontal format curtain

192. Height of machine bed (A) Vertical height of the machine bed as measured from the standing position of the operator.

193. Minimum curtain height (B) As measured from the standing position of the operator. (750 mm)

194. Maximum curtain height (C) As measured from the standing position of the operator. (25mm less than the 'height of the machine bed').

195. Minimum curtain distance (D) The outermost position at which the appropriate test piece will just be detected as measured horizontally from the nearest trapping point. (1050 mm).

196. The minimum curtain height, as measured from the standing position of the operator, should be 750 mm and the maximum curtain height should be 25 mm less than the height of the machine bed, e.g. if the machine bed is 900 mm above the standing position of the operator then the curtain should be installed between 750mm and 875mm above the standing position of the operator. The minimum curtain distance should be 1050mm and the curtain object detection capability should be maintained at all positions of the curtain. Where the distance from the innermost point at which the test piece is just detected to the machine frame is greater than 177mm additional means should be provided to prevent a person from standing between this innermost point and the machine.

197. Where the height of the machine bed is less than 800mm or the height of the highest possible trapping position of the operator (E)) is greater than 1200mm special considerations apply and in such 198. Cases the safety system should be installed so as to prevent an undetected person from reaching into the trapping area. This may require an increase in the minimum curtain distance (D).

Vertical format curtain (Fig 13)

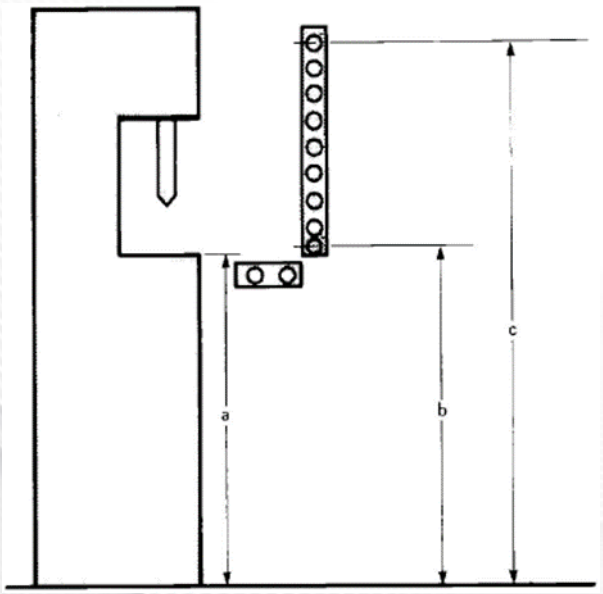


Fig 13 Vertical format curtain

Height of machine bed (a) Vertical height of the machine bed as measured from the standing position of the operator.

198. Lowest point of curtain (b) The maximum height at which the appropriate test piece will just be detected at the lower extremity of the curtain as measured from the standing position of the operator to the top of the test piece.

199. Highest point of curtain (c) The minimum height at which the appropriate test piece will just be detected at the upper extremity of the curtain as measured from the standing position of the operator to the bottom of the test piece.

200. Minimum vertical depth of curtain The minimum effective height of the light curtain as found by subtracting (b) from (c). (600mm).

201. The vertical positioning of the photo-electric curtain should be in accordance with Table 1 and the minimum vertical depth of the curtain should be 600mm. The curtain object detection capability should be maintained at all positions of the curtain.

202. Where the height of the machine bed is less than 800mm or the difference between the machine bed and the highest possible trapping point (as measured from the standing point is greater than 200mm special considerations apply and in such cases the safety system should be installed so as to prevent an undetected person from reaching into the trapping area. This may require an increase in the minimum vertical depth of curtain.

Table 1 Positioning of vertical format light curtain

Height of machine bed (a) mm	Lowest point of curtain (b) mm	Highest point of curtain (c) mm
800	750	1350
801-900	800	1400
901-1000	850	1450
1001-1100	900	1500

Positioning of AOPDs with respect to machinery

Alternative formats for AOPDs

203. An AOPD consisting of one light beam device should be used only if the ESPE meets the requirements of IEC 61496: 1997 (or an equivalent standard of performance) and is installed according to the advice given in this guidance.

204. However, to give the required level of protection most applications will require a light curtain or an AOPD consisting of more than one light beam device.

205. There are five main formats of AOPDs:

A. *normal approach* - where the detection zone is NORMAL to the direction of approach. This may be achieved by vertical or horizontal light curtains or arrangements of light beam devices (Figure 1a);

B. *parallel approach* - where the detection zone is PARALLEL to the direction of approach (Figure lb);

C. *angled approach* - where the detection zone is at some other angle to the direction of approach (Figure lc);

D. *combination* - where the detection zone combines two or more of the above;

and

E. *fixed or rotating dual format* - where the detection zone can be readily converted to a position either normal or parallel to the direction of approach. If the conversion is carried out by rotation of the AOPD assembly, it should not be possible to rotate the assembly towards the dangerous parts if the minimum separation distance, calculated in accordance with paragraphs 14 to 28, cannot be maintained.

Combined vertical and horizontal light curtain applied to a hydraulic press brake

Light curtain which can have its assembly rotated to alter the angle of approach

HSG 180 Systems

AOPD positioning

206. For the purposes of this section, the term 'light curtain' includes a light curtain as defined, or an arrangement of light beam devices having the same detection capability as the light curtain.

207. When an ESPE is used as a trip device it should ensure that it is not possible for a person to reach through the AOPD to any dangerous parts, before they have been brought to a safe condition. The position of AOPDs with respect to the danger zone need not normally be capable of adjustment.

However, adjustment of separation distance is found to be necessary, means should be provided to ensure the correct separation distance can be maintained and that the adjustment does not expose persons to risk of injury. For calculating the separation distance, danger zone should be interpreted as nearest dangerous part (see Figures 1(a)-(c).

Normal approach light curtains (Figure 1a)

208. For machinery with variable characteristics, a single position based on the parameters requiring the greatest separation distance will be used. Calculation of the separation distance should be based on the methodology contained in EN999:1998 Safety of machinery – the positioning of protective equipment in respect of approach speeds of parts of the human body, as set out below. It should be noted that in EN 999:1998 the term 'minimum distance' is used.

NOTE: EN999 has been replaced by BS EN ISO 13855:2010 Safety of machinery – Positioning of safeguards with respect to the approach speeds of parts of the human body. This standard includes guidance for: -

A. electro-sensitive protective equipment [see IEC 61496 (all parts)], including

   - light curtains and light grids (AOPDs)

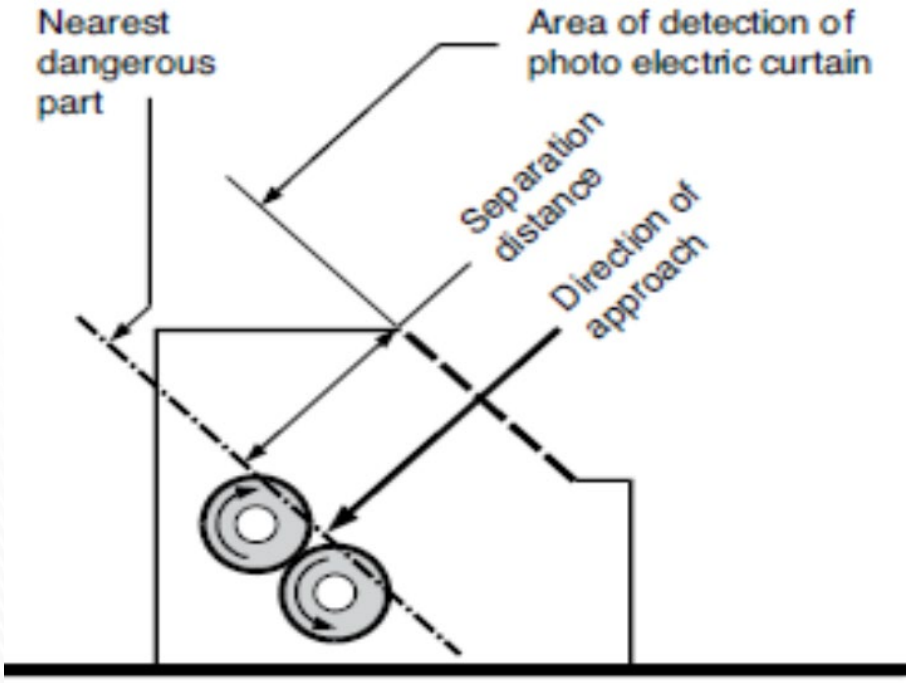
   - laser scanners (AOPDDRs) and two-dimensional vision systems

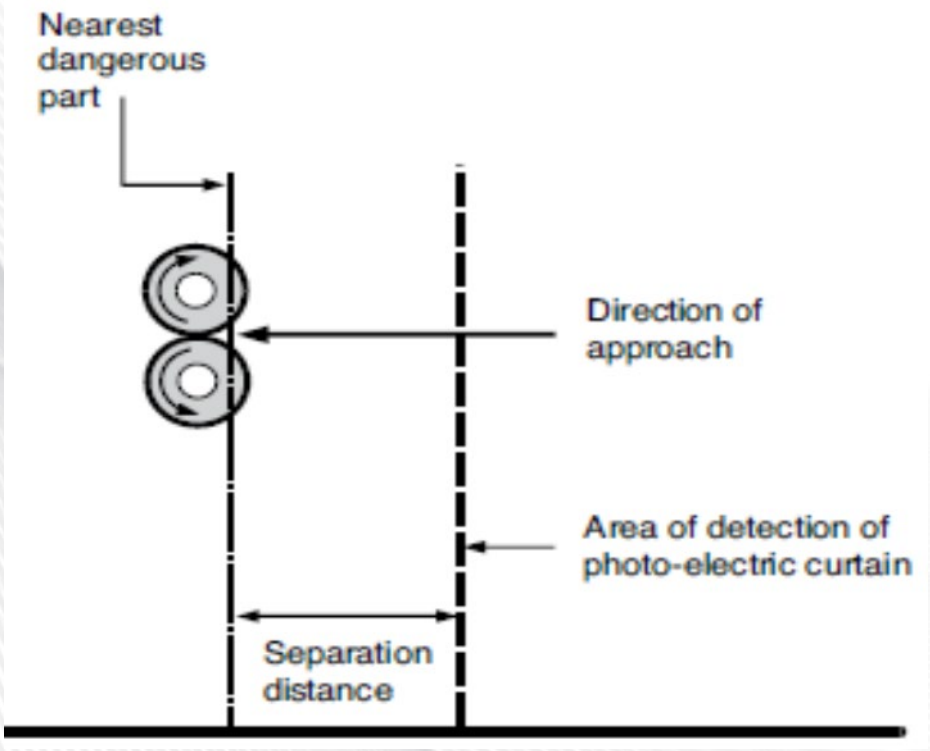
B. pressure-sensitive protective equipment (see ISO 13856-1, ISO 13856-2 & ISO 13856-3, especially pressure sensitive mats;

C. two-hand control devices (see ISO 13851)

D. interlocking guards without guard locking (see ISO 14119).

209. This International Standard specifies minimum distances from the detection zone, plane, line, point or interlocking guard access point to the hazard zone for hazards caused by the machine (e.g. crushing, shearing, drawing in).


Nearest dangerous part
Area of detection of photo electric curtain
Separation distance
Direction of approach


Nearest dangerous part
Direction of approach
Area of detection of photo-electric curtain
Separation distance

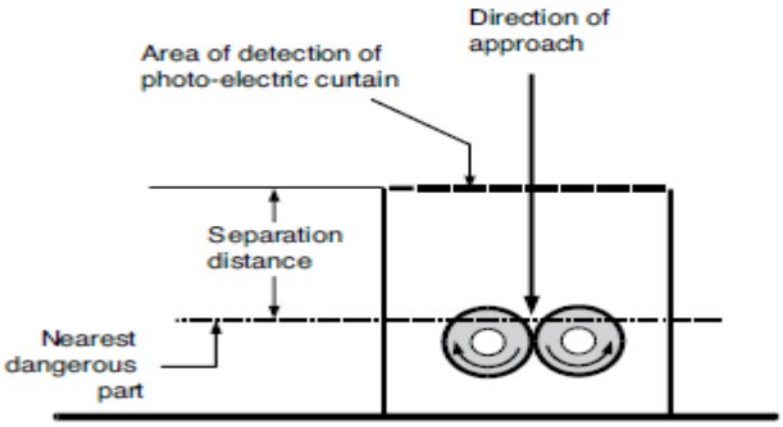


Figure 1a Normal approach curtain: three theoretical applications

210. The separation distance from the danger zone should be calculated by using the formula:

S = (K x T) + C

where:

S is the separation distance, in millimetres, from the danger zone to the detection point, line, plane or zone;

K is a parameter, in millimetres per second, derived from data on approach speeds of the body or parts of the body;

T is the overall system stopping performance in seconds;

C is an additional distance, in millimetres, based on intrusion towards the danger zone prior to actuation of the AOPD.

211. For light curtains with a maximum object detection capability of 40 mm diameter, the separation distance (S) from the detection zone to the danger zone should not be less than that calculated by using the formula given in paragraph 17 where:

K = 2000 mm/s;

C = 8(d-14) but not less than 0; and

d = the detection capability of the light curtain in millimetres and subject to a minimum allowable value of S of 100 mm.

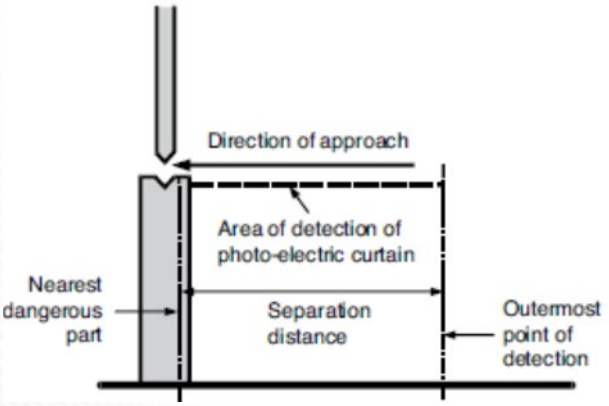
212. If S is found to be greater than 500 mm when using a value of 2000 mm/s for K, then a value of 1600 mm/s for K may be used. However, if the results of the calculation give a value less than 500 mm, the separation distance used should be 500 mm. The formula becomes:

S = (1600 mm/s x T) + 8(d-14 mm).

See EN 999 or BS EN ISO 13855 for the calculation of the separation distance for AOPDs having a detection capability larger than 40 mm.

213. Access to the danger zone from any direction not protected by the light curtain needs to be prevented by fixed or interlocking guards or other equally effective means. Similar steps should be taken to prevent or detect anyone remaining between the light curtain and the danger zone. These could also include the use of light beam devices.

Parallel approach light curtains (Figure 1b)



214. The separation distance should be calculated by using the formula given in paragraph17 where:

K = 1600 mm/s;

C = (1200 mm-0.4 H), but not less than 850 mm; and

H = the height of the detection zone above the reference plane (e.g. floor) in millimetres.

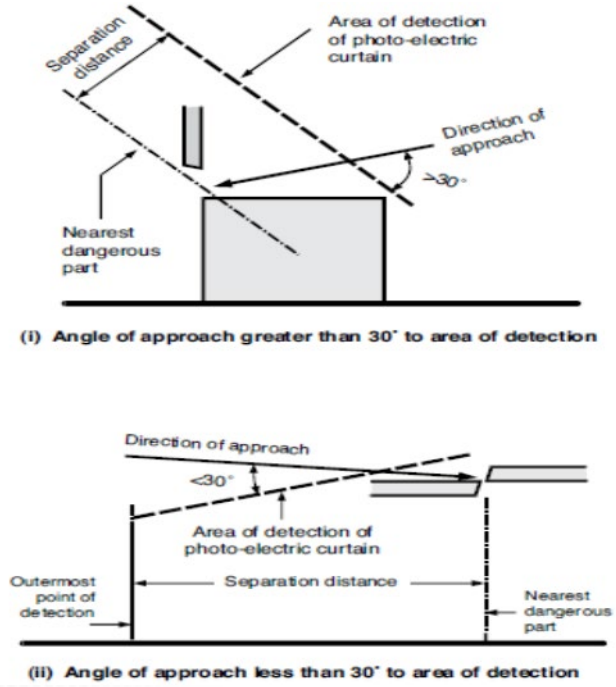
215. Normally the height of the light curtain should be such that it is positioned just below the lowest limit of the danger zone and its object detection capability should be such that it is not possible to stand within the detection zone without actuating the light curtain. For parallel approach light curtains, H should not exceed 1000 mm.

216. For a given height of the detection zone, the corresponding detection capability 'd' can be calculated by using the formula:

d = H + 50 mm

15

217. Constraints imposed by the methods of working at particular machinery will determine whether the light curtain should be positioned above or below the limits of the danger zone. Whichever position is adopted, the light curtain should be positioned as close as possible to the machine. Where necessary, additional steps should be taken to prevent access to the danger zone from above, below or around the light curtain. These steps may include the use of fixed or interlocking guards, fixed bars, extra light beam devices, or pressure-sensitive mats.



Angled approach light curtains (Figure 1c)

218. It may be advantageous to position the light curtain so that approach to the dangerous parts through the light curtain is in a direction which is neither normal nor parallel to the area of detection. If the light curtain has been installed so that the angle of approach to the detection zone is within 5 degrees of their designed approach (either normal or parallel), then it need not be considered as an angled approach light curtain.

219. For detection zones which are positioned at angles greater than 5 degrees to the direction of approach the separation distance should be calculated in accordance with the most appropriate formula. Light curtains with foreseeable angles of approach greater than 30 degrees should be considered as normal approach, and light curtains with foreseeable angles of approach less than 30 degrees should be considered as parallel approach.

220. When angled approach light curtains are considered to be parallel approach, the formula used to derive the separation distance should apply to that part of the detection zone furthest away from the danger zone.

Fixed or rotating arm dual format light curtains

221. When the detection zone can readily be converted to a configuration which can be either normal or parallel to the direction of approach, then the separation distances for both directions of approach will apply.

NOTE: BS EN 692, 693 & 12622 give the following additional information, which should be used in place of the figures given in HSG 180.

222. With regard to the detection capability of vertical format light curtains, the additional distance *C* in Table A.1 shall at least be used when calculating the minimum distance *S*.

Table A.1 — Additional distance *C*

Detection capability mm	Additional distance *C* mm	Cycle initiation by the light curtain
≤ 14 > 14 ≤ 20 > 20 ≤ 30	0 80 130	Allowed
> 30 ≤ 40 > 40	240 850	Not allowed

Laser systems

223. Applicable only to press brakes conforming to BS EN 12622.

Annex G of BS EN 12622

(normative)

224. Laser actuated AOPD system tests

G.1 General

G.1.1 Initial test: the manufacturer shall carry out the tests in G.3 and G.4 at least ten times before the machine is installed. For these tests the manufacturer shall install punch over the full length of the machine.

G.1.2 Periodic test: the manufacturer shall indicate that the tests in G.2, G.3 and G.4 shall be carried out at least once a year with punch installed over the full length of the machine (see 7.2.2 o in EN 12622)).

G.1.3 Test after tool change: the manufacturer shall indicate that after each change of punch the tests in G.2, G.3 and G.4 shall be carried out with the installed upper tools (see 7.2.2 o in EN 12622)).

225. NOTE For tests in G.1.3, the punch does not need to be installed over the full length.

G.2 Test 1: detection capability

Check the detection capability between the tip of the punch and the laser beam (the nearest to the punch).

The gap shall be ≤ 14 mm along the complete punch area.

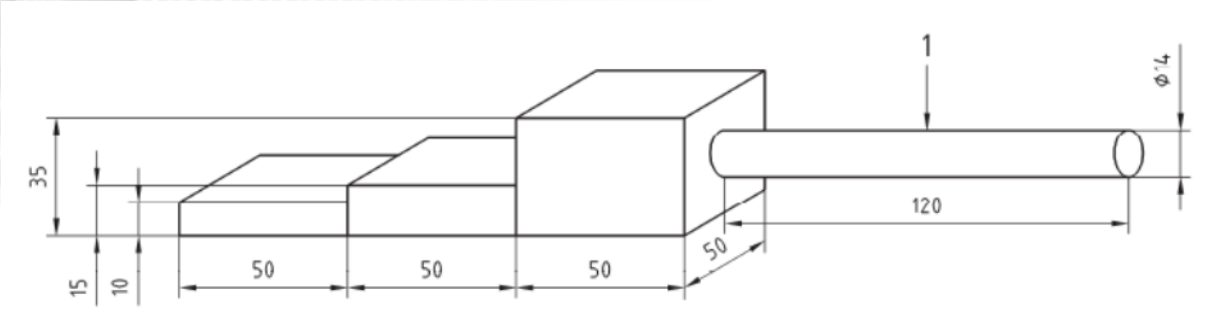
The test shall be carried out with the handle (cylindrical part) of the test piece (see Figure G.1)

G.3 Test 2

226. A test piece (see Figure G.1) of 10 mm thickness made of flexible material, e.g. plastic lying on the die, shall not be touched during down stroke of the punch. In addition, a test piece of 15 mm thickness shall pass between the tools

G.4 Test 3

227. A test piece of 35 mm thickness lying on the die shall not be touched during high speed down stroke of the beam.



1 Handle

Figure G.1 — Test piece - Dimensions in millimetres

Alternative systems may employ camera detection equipment (VBPD) or scanners (AOPDDR - Active Opto-electronic Protective Device responsive to Diffuse Reflection) etc. and reference should be made to relevant standards for guidance, see below

NOTE:

228. For the use of laser scanners (AOPDDR) or vision-based protective devices (VBPD) with a two-dimensional protection zone, the calculation of the minimum distance shall be in line with 6.2, 6.3 or 6.4, of BS EN ISO 13855 depending on the approach direction.

Monitoring of machine control elements and stopping performance

229. The machine's primary control elements, which are directly responsible for ensuring the integrity of the overall system stopping performance, and the machine secondary control elements which are directly responsible for ensuring that power is removed from the machine, should have their monitoring devices connected to the monitoring inputs of the photo-electric safety system so that any failure in these control elements (e.g. valves, contactors) can be detected. The safety system should respond to a failure by removing the electrical power to the main drive in such a way that it can be restored only by an authorised person.

NOTE: The failure of a machine secondary control element should not allow restoration of power until the failure has been corrected.

230. Press brakes employing mechanical means of stopping, which are subject to gradual loss of effectiveness in use due to wear or other factors, should be provided with stopping performance monitoring.

231. The stopping performance monitor should check that the overall system stopping performance i.e. the maximum time used for the calculation of curtain distance, or the corresponding amount of linear or rotational displacement, is not exceeded.

232. Ideally, the monitoring should be carried out whenever the machine's primary control elements are de-energised during dangerous motion, but it is permissible at other times provided monitoring is carried out at least once per cycle and that the monitoring conditions are representative of actual braking conditions when the photo-electric curtain is interrupted during dangerous motion (i.e. similar inertia, speed, friction, direction, load).

233. The correct position of any switches and cams should be clearly and indelibly marked so that maladjustment can be readily identified.

234. The stopping performance monitor should comply with BS 6491: Specification for Electro -Sensitive Safety Systems for Industrial Machines and should be specified for use with the machine and photo-electric safety system to which it is applied.

Further requirements

235. Access to the dangerous parts from any direction not protected by a photo-electric safety system should be prevented by effective fixed or inter-locked guards or screens

236. Additional arrangements should be made, e.g. by the provision of effective guards and/or by extension to the photo-electric curtain to prevent or detect a person standing between the curtain and the trapping area. Where inner light beams, or other sensing units, are fitted to a vertical format system the curtain object detection capability for such an extension should conform to the requirements for horizontal format systems.

237. The overall system must not fail-to-danger in respect of failure of electrical and all other power supplies and so far as is reasonably practicable, in all other respects. Particular consideration should be given to the following environmental conditions the severity of which may vary widely among different applications.

A. Electrical interference

B. Vibration or shock from the machine or from any other causes

C. Dust, oil, moisture and corrosion

D. Variations in ambient temperature

E. Variations of supply voltage and frequency

238. In circumstances where apparatus is exposed to potentially explosive atmospheres the apparatus should be suitable for this environment.

APPENDIX 2: REFERENCES AND BIBLIOGRAPHY

Health and Safety at Work etc. Act 1974 (HSW Act)

PUWER 98 – L22

PUWER 98 (as applied to power presses) – L112

British Standard PD5304 Guidance on the Safe Use of Machinery

British Standard 6491 Specification for Electro-Sensitive Safety Systems for Industrial Machines (withdrawn but referenced for older machines)

Guidance Note PM 41: The application of photo-electric safety systems to machinery (withdrawn 1999 but referenced for older machines)

Seventh report of the Joint Standing Committee on Safety in the Use of Power Presses: Safety in the Use of Press Brakes (superseded but referenced for older machines)

Eighth report of the Joint Standing Committee on Safety in the Use of Power Presses: Electro-Sensitive Safety Devices for Friction Clutch Press Brakes (superseded but referenced for older machines)

IND(G) 7(c): Press brakes, minimum tests for photo-electric safety devices (superseded but referenced for older machines)

Power Press Safety - Standards prepared by the Joint Standing Committee on Safety in the Use of Power Presses (superseded but referenced for older machines)

INDG316 Procedures for daily inspection and testing of mechanical power presses and press brakes.

HSG180 Application of electro-sensitive protective equipment using light curtains and light-beam devices to machinery.

HSG236 Power presses: Maintenance and thorough examination.

INDG375 Power presses: A summary of guidance on maintenance and thorough examination.

BS EN ISO 13855:2010 Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body.

BS EN 999_1999 Safety of machinery - The positioning of protective equipment in respect of approach speeds of parts of the human body. (withdrawn but referenced for older machines)

BS E 692:2005+A1:2009 Machine tools. Mechanical presses. Safety.

BS EN 693:2001+A2:2011 Machine tools. Safety. Hydraulic presses.

BS EN 12622:2009 +A1:2013 Safety of machine tools. Hydraulic press brakes.

The Supply of Machinery (Safety) Regulations 2008 No 1597. (withdrawn but referenced for older machines)

SAFed is grateful to the British Standards Institution for the use of information given in BS 6491, BS EN 61496, BS EN 999 etc. and the HSE for information from PM41 & HSG180.