CBM CONFEDERATION OF BRITISH METALFORMING

Guidance on Safety Requirements for Hot Forging

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1. Introduction

This guidance document describes the various types of equipment used in producing hot forgings, the facilities in which hot forging equipment is used, as well as the appropriate safety procedures to be followed in operating hot forging equipment in these facilities.

This guidance document replaces HSE OC 641/6, dated 21.10.2003, and its associated Information Document, "Guidance on the Safeguarding of Presses Used for Hot Forging".

The guidance applies to work equipment currently in service.
New machines should comply with the current Supply of Machinery (Safety) Regulations, 2008.

2. Scope and Purpose

This guidance document covers the safety requirements for all classes of power forging machinery, both for closed, (impression) die and open, (flat), die forging, including power-driven and gravity-drop hammers; mechanical, hydraulic and screw-forging presses; hot trimming presses; upsetters; forging rolls; ring-rolling and bolt-heading machines used in conjunction with a hot forging process.

The level of safeguarding required will depend on the outcome of a risk assessment. The hierarchy of risk control measures, specified under Regulation 11 of the Provision and Use of Work Equipment Regulations 1998 (PUWER 98) must be applied, taking into account the particular range of applications the machine is used for. Accident history indicates that the risks are higher at manually loaded/unloaded machines (as opposed to those machines where manipulators or other automatic feeding arrangements are provided) and where more than one person is involved in the forging operation. The latter may, for example, include persons removing forged components e.g. at the rear of the machine, or those carrying out cleaning and die lubrication etc. During the risk assessment, consideration should be given to inadvertent operation of the machine while the operator, or another person, has any part of their body between the tools.

An example format for a risk assessment is given in Appendix 1.

It is recognised that no one safeguarding application is available to cover all hot forging applications and equipment.

This guidance document does **not** apply to equipment used in the cold forging process, such as cold headers or cold formers, nor to equipment used in sheet metal forming.

Power presses used for hot work are exempt from the requirements of part IV of PUWER 98 i.e. the statutory requirements for daily inspections and thorough examination and test which apply to power presses used for work on cold metal. It is the responsibility of the employer to ensure that the equipment is in good working order before being used. In accordance with Regulation 6 of PUWER 98, the equipment should be inspected at appropriate intervals to ensure that this is the case.

There may be some misunderstanding that this exemption also applies to the requirement to provide safeguards under Regulation 11 of PUWER 98. This is not the case. The exemption only relates to the need for inspections and thorough examination, under Regulation 31 to 35 of PUWER 98. In all cases, access to dangerous moving parts of machinery must be prevented "where or to the extent that it is practicable to do so".

For power presses working cold metal, reference should be made to the Approved Code of Practice and Guidance “Safe use of power presses - Provision and Use of Work Equipment Regulations 1998 as applied to power presses” L112, ISBN 0-7176-1627-4 and the guidance book “Power presses: Maintenance and thorough examination” HSG 236 ISBN 0-7176-2171-5.

The purpose of this guidance document is to provide safety recommendations to the hot forging industry to ensure that safe operating conditions and practices are universally applied by the industry in the UK.

3. Definitions

The following definitions apply in this guidance document;

Bolt Headers – the same as an upsetter except that the diameter of the raw material fed into the machine is much smaller, typically 1.9cm, (¾ inch), or less.

Forging Presses – a class of forging equipment in which the shaping of metal between dies is performed by mechanical or hydraulic pressure and is usually accomplished with a single stroke of the press for each die station. Screw presses are also included in this category.

Forging Rolls – a class of auxiliary forging equipment in which raw material is shaped between power-driven rolls, incorporating contoured dies. Forging rolls are usually employed for pre-forming., e.g., to reduce the thickness and increase the length of the raw material.

Gravity-drop Hammers – a class or type of forging hammer in which energy for forging is obtained by the weight and velocity of a freely falling ram and the attached upper die. Board, air-lift and hydraulic-lift hammers are examples of this type of machine.

Hot Forging – the product of work done on metal, formed to a desired shape, by impact or pressure in hammers, upsetters, presses, rolls, and related forming equipment. Forging hammers, counterblow equipment impart impact to the work-piece, whereas most other types of forging equipment impart a squeeze pressure in shaping the metal.

Impacter – a type of air-operated, horizontal counterblow hammer. Mutually opposed rams, called “impellers”, move toward one another simultaneously to apply successive blows to the work-piece, which is held in position by a programmable manipulator.

Power-driven Hammers

Open-single-frame or open-double-frame, (or blacksmith), hammers – these are used primarily for the shaping of forgings by means of impact with flat dies.

Air or hydraulic hammers – a type of drop hammer in which the ram is raised for each stroke by a double action air or hydraulic cylinder. The energy delivered to the work-piece is supplied by the velocity and weight of the ram and attached upper die driven downward by air or hydraulic pressure. Energy delivered during each stroke may be varied.

Ring Rolls – a class of forging equipment used for shaping seamless rings from pierced discs or thick-walled, ring-shaped blanks between rolls that generate the wall thickness, ring diameter, height, and contour.

Scotch - mechanical restraint device placed manually or automatically between two parts of machinery and capable of preventing them closing under gravity or power.

Treadle – a foot-operated control for a hammer, designed to regulate the mechanical linkage that controls the movement of the ram. Typically, hammer treadles are of sufficient length to allow the operator to operate the hammer from several different work positions.

Trimming Presses – a class of auxiliary forging equipment that removes flash or excess metal from a forging. Both trimming and coining, (sizing), can be done hot or cold.

Upsetters, (forging machines or headers) – a type of forging equipment, related to the mechanical press, in which the main forming energy is applied horizontally to the work-piece, which is gripped and held by prior action of the dies.

Scale Guard – a self-standing, sheet metal fabrication, of sufficient height and width, located at the rear of the machine to prevent oxide scale flying out into the surrounding area.

4. General Requirements

This section of the guidance document should be read in conjunction with Part II of PUWER 98. Specific industry requirements have been added, where practicable, as follows:

4.1 Suitability of work equipment

4.1.1 Working Space

- Machines should be located to ensure that there is sufficient clearance between them so that the movement of one operator will not interfere with the work of another. There should also be sufficient room for cleaning and handling the work, including material and scrap. The machines should be arranged so that operators will not have to stand in the aisles. Work areas should be kept free of tripping or slipping hazards.

4.1.2 Aisles

- Aisles around the machines should be wide enough to allow free movement of employees bringing and removing materials. The aisles should not be used as work areas or for storage and should be defined by marking or other identification.

4.1.3 Platforms

- Platforms used on the floor should be constructed for their intended purpose, not create hazards and be kept in good repair.

4.1.4 Storage of Dies and Die Blocks

- Racks or shelves for dies and die blocks should be suitably designed to prevent the contents from falling. Storage should be located in an area away from excessive vibration.

4.1.5 Facility Maintenance

- Physical facilities such as floors, walls and ceilings should be properly maintained to ensure safe conditions.

4.2 Inspection and Maintenance

4.2.1 Inspection and Maintenance

- The employer is responsible for maintaining all forge shop equipment in a condition that will ensure continued safe operation. This responsibility includes;
    - Establishing periodic and regular maintenance safety checks
    - Where applicable, inspecting the guards and point-of-operation protection devices regularly
    - Training personnel for the proper inspection and maintenance of forging machinery and equipment
    - Fastening or protecting all overhead parts in such a manner that they will not fly off or fall in the event of failure of these parts
    - Keeping accurate records of maintenance and safety inspections and any modifications affecting operator health and safety

4.3 Training

4.3.1 Training

- Forging machinery operators must be trained for their duties and be made fully aware of safe operating methods and practices. Training programmes should be of a formal nature, should be properly documented, updated as required and include an assessment and recording of the event.

4.4 Dangerous parts of machinery

- Access to any dangerous part of machinery should be prevented by the provision of fixed guards where it is practicable to do so.
- Where it is not practicable, then other guards or protection devices (such as interlocked guards, electro-sensitive protective equipment and pressure mats) should be provided where it is practicable to do so.
- Where and to the extent that it is not practicable, then the provision of tongs, jigs, holders or similar protection appliances should be used in conjunction with the machinery, to the extent that it is practicable to do so.
  Should access to the danger zone be required during a cycle, then additional measures must be taken to maintain existing levels of protection.
- The presence in the workplace of ancillary equipment such as : work bins, fume hoods, conveyors for billets or forgings, lubrication systems, may constitute physical protective barriers, as long as they are effective, cannot be moved, or otherwise easily bypassed. If used for this purpose they must be part of the recognised risk reduction strategy for the machinery.
- It is important that all guarding is clearly marked with unique identification numbers for each press, where appropriate. The fitting of an incorrect guard to a press could result in exposure to a trapping area or to the introduction of an additional trapping hazard on the guard itself.

4.5 Protection against specified hazards

4.5.1 Securing Against Falling Objects

- All major assemblies and fittings that can loosen and fall should be properly secured in place.

4.5.2 Risk of Falling or Flying Objects

- Where there is a risk from falling or flying objects, operators should be protected by personal protective equipment such as: helmets, aprons, gloves, etc. In addition, careful attention to maintenance should be taken, especially when it is not possible to establish an effective guard. In the case of hot working, the risks are greatly reduced by pre-

heating the machine and the tools, prior to the start of work and maintaining the temperature during the different prolonged periods of stop.

4.5.3 Cooling Fans

- When necessary, for employee protection, fans should be guarded and any electrical wires should be arranged so as not to present a hazard.

4.6 Controls for starting or making a significant change in operating conditions

4.6.1

- There should be clear guidelines for starting machines. These instructions should be placed close to the workplace. In addition, to avoid involuntary starts, particularly during the fall of objects, the control pedal, where used, must be fitted with a shroud. Only competent personnel should be allowed to operate the machine.

4.7 Emergency stop controls

4.7.1 Emergency Stop

- On some hot forgings machines, emergency stops are ineffective due to the fact that the cycle cannot be stopped once initiated. On other machines an emergency stop should be provided.

4.8 Isolation from sources of energy

4.8.1 (Refer also to Paragraph 5.1)

- A written isolation procedure should be available. The isolation procedure should include dissipation of any stored energy, and the locking off of the energy supply.
- Where a scotch is required to prevent movement once the sources of energy and stored energy are isolated or dispersed, it should be designed to withstand the static weight of the machine.

4.9 Lighting

4.9.1

- Areas of work, adjustment or maintenance must be adequately lit. In the case of hot work, for good execution and monitoring of the deformation of the hot metal, the operator may often need limited ambient lighting only.

5. General Requirements for Hammers

All hammers should be positioned or installed in such a manner that they remain on, or are anchored to, foundations sufficient to support them according to applicable engineering standards.

5.1 Lock Off

Means should be provided for disconnecting the power to the machine and for locking off or rendering cycling controls inoperable. These lockouts should disconnect electrical, air, hydraulic and mechanical power in either normal or emergency situations.

5.2 Permanently Stuck Forgings

Stuck forgings should be removed after the ram is scotched and the machine isolated.

Note. Never place any cold material between the dies for the purpose of dislodging a stuck forging. Metal objects have been violently ejected from between the dies when a blow has been struck.

Industry Experience: Warm/hot material is used to perform this function.
In the case of one company, the dies would be removed from the hammer along with the stuck forging and remedial action taken off-line.

5.3 Scotching

For gravity drop hammers, the ram should be scotched when dies are being changed or before any part of the workers body is placed under the ram or top die area. Scotches should be designed and constructed to be fit for purpose taking into account the forces involved in supporting the ram in a safe position.

5.4 Tongs

Workers should be instructed in the proper body position when using tongs and, in no case, should the workers body, or any part of the body, be allowed to enter the die-striking area while operating the unit. When long tongs are used, they should be of sufficient length to ensure that the body of the worker is clear of the tongs in case of kickback. Tongs should not have sharp handle ends and should be designed to:

- Conform to the shape of the work being handled
- Be proportioned so as to grip the work-piece efficiently and
- Have handles far enough apart to prevent trapping of fingers should the jaws be struck while in the work area.

Tongs should be periodically inspected to ensure they are in good working order and repaired or replaced as necessary. When rings, or equivalent devices, for locking tongs are used, they should also be inspected periodically to ensure they are in good working order.

5.5 Safeguarding With Tongs

In cases of hot forging applications that require continual use of tongs, utilising both hands on the tongs, Clause 5.4 will apply and is considered to be adequate provided that the temperature of the metal or work-piece is sufficiently hot not to allow manipulation with gloves.

5.6 Keys and Shims

Die keys and shims should be made from a grade of material that will not crack or splinter and shall not normally project more than 50mm (2 inches), in front and 100mm (4 inches), at the back of the ram or bolster. The operator should regularly inspect the keys for signs of cracking or spalling and ensure that they are repaired or replaced immediately if damage is discovered.

Industry Experience: On very large hammers, e.g., Beche DG40 and DG80 it is not practicable to reduce the overhang to two inches or less as there is no equipment available that could remove the keys if these lengths were adhered to.

5.7 Oil Swabs and Scale Removers

Oil swabs, scale removers, or other devices to remove scale should be provided. These devices should be long enough to enable the worker to reach the full length of the die without placing the body, or any part of the body, within the die-striking area while operating the unit.

5.8 Dies

5.8.1 Die-Setting

Die handling equipment should be of sufficient strength, size and dimension to handle die-setting operations safely.

5.8.2 Die Shank Inspection
Die shanks should be inspected for cracks prior to set-up and should be repaired as required.
5.8.3 Die Design
Closed-die design should incorporate adequate gutters, flash land and flash clearances to inhibit flying flash.

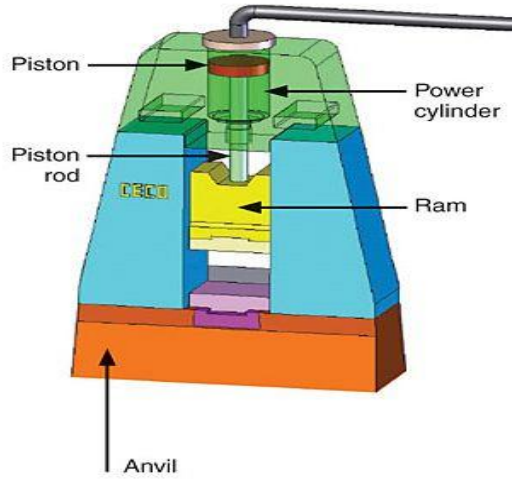
Industry Experience; On very large hammers, e.g., Beche DG40 and DG80, this practice is not used.

5.9 Scale Guards
A suitably constructed scale guard should be provided at the back of every hammer.

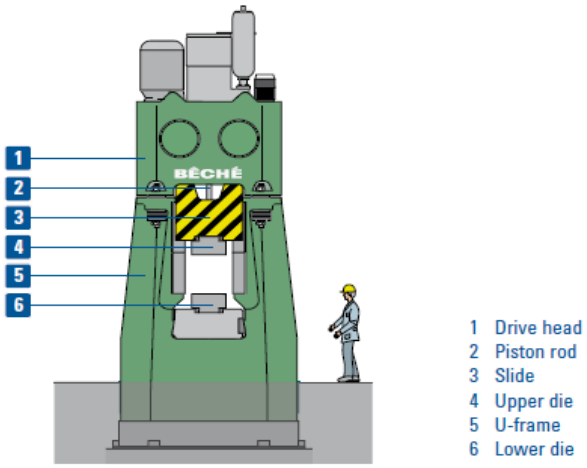
5.10 Cold-coining, Cold-straightening and Cold-forming
Hammers performing cold-coining, cold-straightening or cold-forming operations are not covered by this Guide.

6. Specific Requirements for Power-driven Hammers and Gravity-drop Hammers

6.1 Air & Hydraulic Driven Hammers



Air Driven Hammer
Image courtesy of Forge Magazine



Hydraulic Driven Hammer
Image courtesy of Schuler Group.

6.1.1 Characteristics
These machines deliver an impact blow and are used for hot forging. Together, the moving parts; lifting system, falling weight (ram) and upper die are returned back up to the top of the stroke by a mechanical system composed of a piston in a cylinder. This system adds a downwards force to the effect of gravity, at the moment of impact.

6.1.2 Safety Cylinder
Every air-operated hammer, (power driven), should have a means to cushion, or safely arrest, the motion of the piston at the top of the cylinder if the rod should break or pull away from the ram. This device may be of the direct-cushion type integral with the main cylinder or it may be of the separate-cushion type whereby a constant supply of air is applied behind a separate piston adjacent to the main cylinder. A spring, suitably constrained, may also be employed.

6.1.3 Piping Under Pressure

Piping under pressure should conform to the standards current at the time of manufacture; please note that standards are not retrospective. When modifying a machine, the piping must conform to the latest standards.

6.1.4 Safeguarding the Moving Parts of Work Equipment

Access to the danger zone at the tools from the front or normal operating position should be prevented by fixed or interlocked guards or suitable presence sensing devices such as light guards or pressure sensitive mats. Where this is not practicable, protection devices such as tongs, tools, jigs, holders or similar protection appliances should be used in conjunction with a safe system of work.

Unauthorised access to the danger zone at the tools from the sides and rear should be prevented by fixed or interlocked guards or other fixed barriers that give an equivalent level of safeguarding.

Industry Experience: Although many attempts have been made to design bespoke guarding systems for hot forging hammers, a practical device has yet to be identified. Alternative methods are therefore employed, such as;

1) During production with a single stamper, (operator): The side of the hammer opposite the stamper should be made inaccessible with a physical barrier, e.g., a screen, a work bin, a conveyor, a fume hood, a lubrication system, etc. Such a device should be set up in accordance with 4.4.

2) The operators manipulate the billets and forgings with the aid of tongs of appropriate length and shape.

3) During die-setting or adjustment: The ram is immobilised at top dead centre with a scotch or a lock.

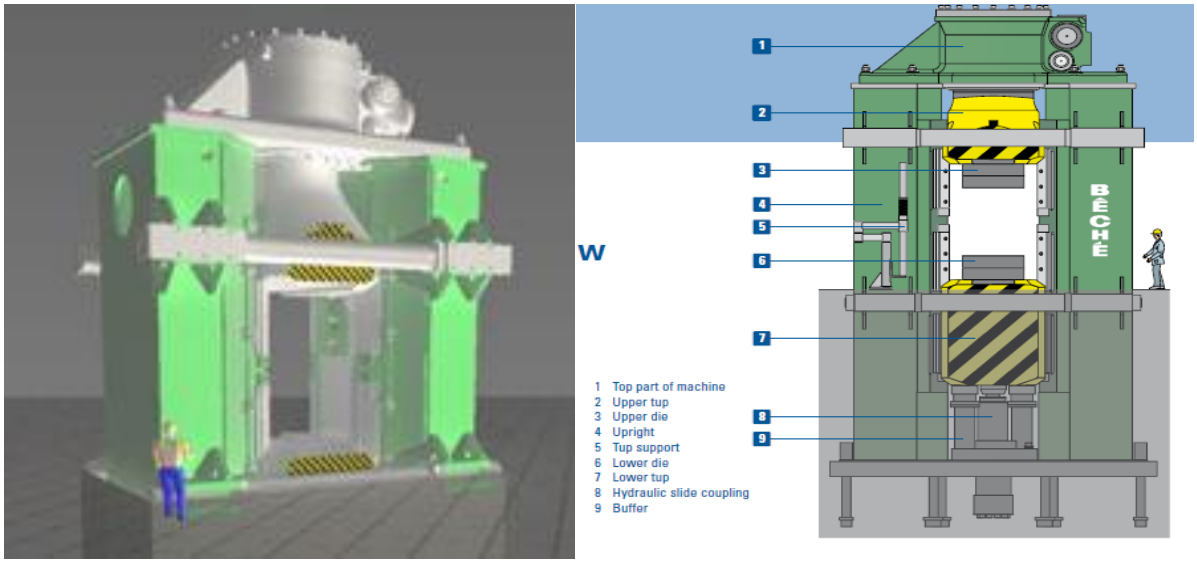
6.1.5 General Stop of the Hammer at the Workplace

- A means of stopping the hammer should be provided within reach of the operator which, when activated, immobilises the ram, but does not also cut off the compressed air as this may result in an instant collapse of the rams or belts driving the units.

6.1.6 Isolation of Energy Sources

- Electric: see general recommendations.
- Pneumatic: provide a chain operated valve.
- Potential energy of the ram: provide dissipation by bleeding the air chamber to bring the ram to bottom dead centre, die to die at a controlled speed.

6.2 Counter-blow Hammers



Counter-blow hammer. Images courtesy of Schuler Group.

6.2.1 Characteristics

These machines deliver an impact blow and are used for hot forging. The moving parts are composed of two different sub-sets of tooling that approach each other simultaneously. The links that provide these movements can be mechanical or hydraulic.

6.2.2 Safeguarding the Moving Parts of the Power Transmission

- On machines with bands, a physical guard should be put in place in the side openings of the hammer legs.

6.2.3 Safeguarding the Moving Parts of the Work Equipment

Access to the danger zone at the tools from the front or normal operating position should be prevented by fixed or interlocked guards or suitable presence sensing devices such as light guards or pressure sensitive mats. Where this is not practicable, protection devices such as tongs, tools, jigs, holders or similar protection appliances should be used in conjunction with a safe system of work.

Unauthorised access to the danger zone at the tools from the sides and rear should be prevented by fixed or interlocked guards.

Industry Experience:

1) A single operator, stamper side: The use of light curtains on the opposite side of the hammer from the stamper has proved to be partially acceptable as they offer a form of protection to the operators. Where this system is impracticable, the side of the hammer opposite the stamper should be made inaccessible with a physical barrier, e.g., a screen, a work bin, a conveyor, a fume hood, a lubrication system, etc.

2) Two operators, one stamper side and one opposite: An equivalent level of safeguarding should be provided for each operator. The press should be fitted with two run buttons, one at the front and one at the rear. To operate the press under two-person working, the two run buttons should be depressed within 2 seconds of each other. The press should not double stroke if the buttons are kept depressed. Both operators should be able to clearly view the working area of the press.

If the operator's helper must remain at his workstation during the blow, he should be instructed by the principal operator about the safe working of the machine. If the press is a full revolution press, then a photo-electric device would protect the operator's helper from the moving parts of the press, but not protect him from the ejection of parts. A fully interlocked guard screen, with guard locking, would provide full protection. The press should be fitted with two run buttons, one at the front and one at the rear. To operate the press under two person working, the two run buttons should be depressed within 2 seconds, or less, of each other. The press should not double stroke if the buttons are kept depressed. Both operators should be able to clearly view the working area of the press.

3) Where guarding or light curtains etc. are not possible, safe retreat havens may be applicable.

4) Where bespoke guarding is not possible, the forgings must always be manipulated by tongs or manipulators which guarantee a safe working distance from the danger zone.

5) A visual flashing light on an electric beam curtain indicates the lock off or release to all crew members.

6.2.4 Normal Stop

- A means of stopping the hammer should be provided within reach of the operator which, when activated, immobilises the ram, but does not also cut off the compressed air as this may result in an instant collapse of the rams or belts driving the units.

6.3 Clear Space Hammers

Image courtesy Forge Tech Services (UK) Ltd

6.3.1 Characteristics

These machines deliver repetitive impact blows and are used for open-die hot forging. The moving parts have a reciprocating action linked to a piston, typically driven by a motor. Access to the working area is required on three sides of the machine.

6.3.2 Controls for starting or making a significant change in operating conditions

On clear space hammers it is normal to have a continuous control treadle on three sides of the frame. This is necessary to permit flexible working around the tool area. It is not, therefore, possible to provide a shroud on the treadle.

7. General Requirements for Forging Presses and Upsetters

7.1 Installation
All presses should be installed so that they remain where they are positioned or should be anchored to foundations sufficient to support them according to applicable engineering standards.

7.2 Isolation
Means should be provided for local isolation of the power to the machine and for locking off or rendering controls inoperable. These lockouts should disconnect electrical, air, hydraulic and mechanical power in either normal or emergency situations and dissipate any stored energy. A written isolation procedure should be available.

7.3 Tongs
Workers should be instructed in the proper body position when using tongs and, in no case, should the workers body, or any part of the body, be allowed to enter the die-striking area while operating the unit. When long tongs are used, they should be of sufficient length to ensure that the body of the worker is clear of the tongs in case of kickback.
Tongs should not have sharp handle ends and should be designed to:

- Conform to the shape of the work being handled;
- Be proportioned so as to grip the work-piece efficiently; and
- Have handles far enough apart to prevent trapping of fingers should the jaws be struck while in the work area.

Tongs should be periodically inspected to ensure they are in good working order and repaired or replaced as necessary. When rings, or equivalent devices, for locking tongs are used, they should also be inspected periodically to ensure they are in good working order.

7.4 Safeguarding with Tongs
In cases of hot forging applications that require continual use of tongs utilising both hands on the tongs, Clause 7.3 will apply and is considered to be adequate provided that the temperature of the metal or work-piece is sufficiently hot not to allow manipulation with gloves.

7.5 Die Lubrication
Lubrication devices should be long enough to enable the worker to reach the length of the die and, in no case, should the worker's body, or any part of the body, be allowed to enter the die-striking area.

7.6 Dies
Die-setting
Die handling equipment should be of sufficient strength, size and dimension to handle die-setting operations safely.

Where there is a requirement to keep dies apart during die heating, the use of steel blocks should, where possible, be avoided.

7.7 Scale Guards for Presses
Where appropriate, a suitably constructed scale guard should be provided at the back of every press.

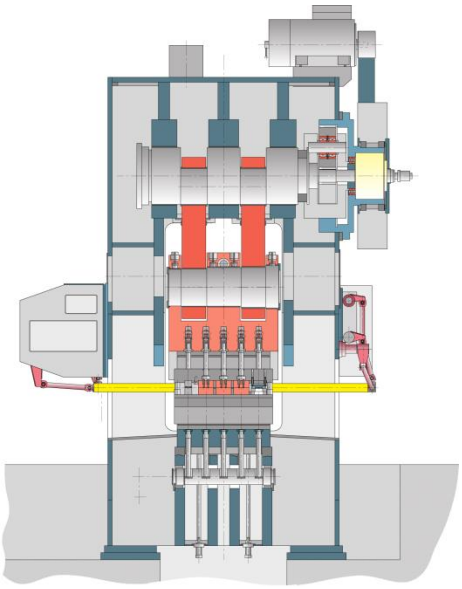
7.8 Manually Operated Controls

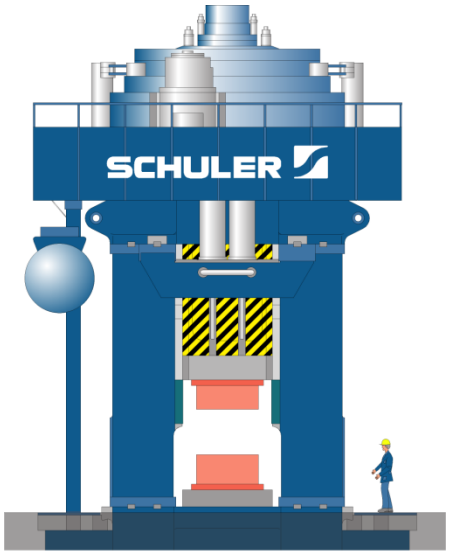
Manually operated valves and switches should be clearly identified and located so as not to interfere with normal operations.

7.9 Periodic Checks

Mechanical presses used for hot working, (both key and friction type clutches), should be periodically stripped and examined using non-destructive testing (NDT) procedures, where appropriate, to ensure that all the internal parts are in good working order. This can form part of the examination by a competent person/engineering surveyor at an agreed interval. This is particularly important for hot working presses without fixed/interlocking guarding.

8. Specific Requirements for Mechanical Forging Presses





Crank Press **Screw Press**

Images courtesy of Pearson Panke Ltd/Schuler Group

8.1 Characteristics

These machines have a pressing or squeezing action and are used for hot forging. A mechanical system transforms the rotational movement of a crankshaft or a screw into a sliding movement of a ram. The top die is fixed to the ram. The bottom die is fixed to the press table.

8.2 Safeguarding the Moving Parts of Work Equipment

A recognised difficulty of providing safeguards at a forging press is that the machine applications vary considerably and there is no single solution that will necessarily suit all situations. The risk assessment should determine which control measures are suitable depending on the circumstances of use. The following safeguarding arrangements may be considered.

- Electro-sensitive protective equipment (ESPE's) - light curtains

- Light curtains can be provided to act as a presence-sensing device (rather than acting as a trip device) at the danger zone of the machine. The device may be used to detect if an operator's hand is within the tool area while the machine is stopped and prevent a stroke being initiated until the area is clear. On occasions it may be necessary to allow, for example, the tongs or a bar to interrupt the light curtain during the forging process. A facility known as 'floating blanking' can be provided which allows this situation. However, it is very important that the 'object detection capability' (ODC) of the light curtain is not so large that it will allow a person's hand to enter the danger zone and remain undetected. This would normally be compensated for by adjusting the separation distance from the curtain to the nearest dangerous part based on the ODC.

  To ensure ongoing effective operation of the ESPE device it should be inspected, tested and its functionality checked by a suitably competent person in line with the HSE publication 'Application of electro-sensitive protective equipment using light curtains and light beam devices to machinery' which can be found at http://www.hse.gov.uk/pubns/books/hsg180.htm.

Industry experience:
1) It has been shown that light curtains have limited application on forging presses due to the environment, i.e., fume, dust, lubricant, etc., in the working area. Some companies have installed light guards, but found them to be impracticable to use and have removed them.

2) Light curtains are manufactured to have a high level of integrity so that they will perform the safety function reliably. The standards which currently apply to these devices are BS EN 61496-1:2004 and DD CLC/TS 61496-2:2006 . The overall integrity of the safety related parts of the control system, including the light curtain, the interfacing arrangements and the press control system need to be considered.

3) Light guards are unsuitable for mechanical or screw presses fitted with full revolution clutches or mechanical controls.

4) Unauthorised access to the danger zone from the sides and rear of the press should be prevented by fixed or interlocked guards. There may be an issue with C-Frame presses.

5) Pressure sensitive mats have been used successfully on some larger presses. These devices act as a presence-sensing means and prevent the press from operating if a person is in the danger zone. These devices may be unsuitable if there are restrictions on where the operator needs to stand to work at the press. However, they may be used at the rear of presses where a second operator may be working. Mats are vulnerable to damage from heavy or sharp objects falling on them and should be of the monitored/fail safe type.

8.3 Press Control Devices
The different commands should be identified on the control panel.

8.4 Normal Stop
The normal stop cuts the power, but it does not provide an immediate cessation of the drive as the flywheel will continue to rotate until the stored energy is exhausted.

8.5 Flywheel Brake
To reduce the time to stop the flywheel, which can take several minutes due to the energy of the

machine, it is possible to fit a flywheel brake providing that the flywheel brake line is fitted with a pressure switch which, when the flywheel brake is depressed, isolates the power to the main motor. The flywheel brake should not be operated whilst the motor is still driving the flywheel.

8.6 Particular Risks

- The length of the tongs should help to keep the hands out of the danger zone. It is therefore imperative to adapt the tongs to the work being done within the danger zone.
- The working method should not require the operator to enter the danger zone.
- Whenever it is necessary to place the hands or any part of the workers body into the die area, such as for cleaning, repairing, or adjusting, the following shall be accomplished;
    - The power of the press should be locked out;
    - The flywheel should be at rest; and
    - The ram should be scotched, where necessary, with a material, the strength of which is sufficient to withstand the static load to be supported.
- Depending on the type of lubricant used, the press should be provided with fume extraction in the working area.

9. Specific Requirements for Hydraulic Forging Presses

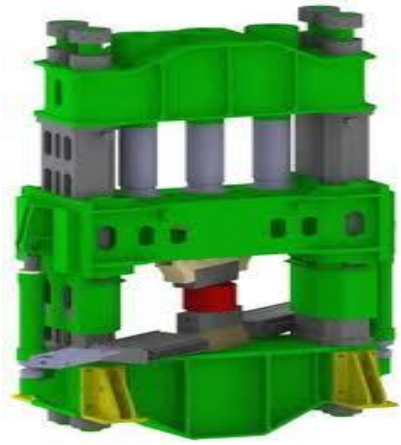


Image Courtesy " Made in Korea"

Image Courtesy Action Machinery Industry Co., Ltd.

9.1 Characteristics

These machines apply a pressing or squeezing action during hot working of the metal. The moving assembly is driven by a hydraulic pump using oil or water. When used for open-die forging, unrestricted access to the working area is required to the front and back of the machine.

9.2 Particular Risks

Whenever it is necessary to place the hands or any part of the workers body into the die area, such as for cleaning, repairing, or adjusting, the following must be done:

- The hydraulic pumps and power apparatus must be locked out and any stored energy e.g. within an accumulator, dissipated; and
- The ram should be scotched. Scotches should be designed and constructed to be fit for purpose taking into account the forces involved in supporting the ram in a safe position.

9(a) Large Multi-ram Hydraulic Hot Forging Presses

9(a).1 Characteristics

These large hydraulic forging machines apply the pressing load during the hot working of the metal. The pressure is generated using high power pumps, pumping a water / oil emulsion, normally to an accumulator system.

9(a).2 Particular Risks
When it is necessary for the worker to access the press operational window to install / adjust / clean or apply lubricant the following must be in place.

- The hydraulic safety valves on the pushback columns should be closed.
- Closing the safety valves prevents operation of the main ram control valve.
- Apart from operations where movement of the knock-out ram and side rams is required for tooling set up or die lubrication (see industry experience for best practice), for all other operations the press should be locked off and all energy dissipated.
- For certain operations, for example any operations where the worker places part of their body between the tools, a safety column or scotch will be required.

9(a).3Loading of Parts into the Press
On presses of this size, billets are removed from the furnace and placed into the press by rail bound manipulators. These machines are driven by a trained operator and can move the full length of their tracks, as well as being capable of 360 degree rotation. The trained operator should have good visibility of the area.

Industry experience:
9000T to 30,000T Hydraulic Presses

Safeguarding
All forging operations on these large hydraulic press's, both aerospace and extrusion are mainly closed-die operations, some upset operations are not.
During a forging operation the press is controlled by a press operator from an armoured press control cabin overlooking the forge bay.

Each type of forging operation has been subject to a risk assessment and has in place a Safe Standard Operating Procedure (SSOP).
These SSOP's detail the forging procedure as follows,
 The forge crew training and PPE requirements
 The sequence of events to produce the parts
 Any exclusion zones required and when in the forging operation
 Safe zones for the operators to move to during the forging operation
The safety of visitors as well as the work force must be taken into account.

Forge Crew
The forge crew are part of a team and have been trained and are experienced in the close operation of the press. At the start of a shift there is a tool box talk by the team leader running through the tasks ahead and any other item's such as machines down for repair or restriction on any equipment.

Access to the Forge Complex
Access to the forge area is controlled by exclusion zones. The outer zone is restricted to authorised personnel only and is defined by barriers and gates around the perimeter of the forge complex.
The inner zone is the area adjacent to the presses. Access is through barriers, blast gates and fences.

This is restricted to the forge crew and specialist engineering staff that all require a high degree of awareness of the operations in the area.

Guards
Guards should be fitted in line with the hierarchy demanded by PUWER as far as practical. If guards are not fitted then this needs to be justified and an alternative control method applied.

During the risk assessment carried out at the design stage of any additional guards, the following should be considered;

i) The size of the press window to be guarded will influence the type of guards to be used. Mechanical guards would need to be power operated and very quick in movement to achieve the transfer times, which, in turn, would lead to additional hazards that would need to be controlled.

ii) For certain products, additional die heating is required to maintain temperature.

iii) The operation of top and bottom slides.

iv) Access to the tooling to apply lubricant; some products need application of up to four lubricants.

v) Billet spotting; some products need to be accurately placed on the die set.

Safe Access when press has to be live for lubrication

The press should be set in a safe state with as many as possible of the following in place:

1) The press operator is at the controls and the press is in pushback
2) The power valve is closed and the green light, (indicating that the press is in a safe state), is on. The Power Valve isolates the press side of the system from the accumulators and safety devices are in situ should a failure be experienced.
3) A column is in place and the press is rested on the column
4) Top and bottom tools are rested on each other

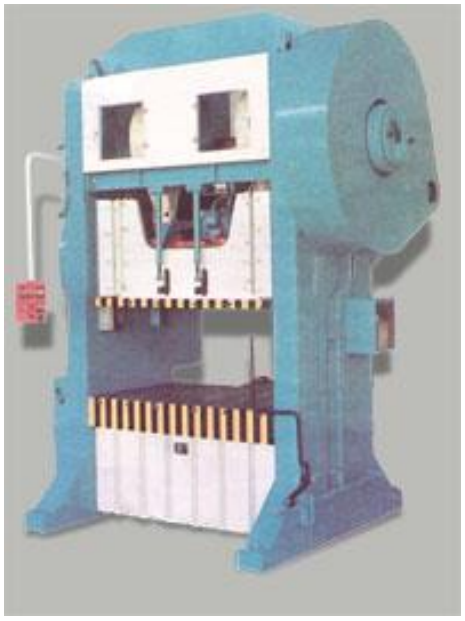
A safe system of work must be established and must be in place. As a minimum, the safe systems of work should cover:

1) The use of an extended lube gun(s) to ensure hands are kept a safe distance away from the tools.
2) Use of an air lance to blow the scale out of the pot to maintain a safe distance from any pinch point
3) Use of a billet spotter to ensure that the lubrication is carried out to procedure. The billet spotter must be standing in a designated safe location, (e.g. on the opposite side of the loading, and where they are clearly visible to the press operator, and have good visibility of the tool and work area), clear of the nip and press while the nip removes the forged part.
4) Entry to the press window is controlled by the press operator, and is only permitted when the press is in a safe state and the press operator is at the controls.
5) If the billet spotter leaves the designated location, or cannot be seen by the press operator, all movement of the press must be stopped immediately.
6) Billet spotter to NEVER stand in front of press / window while in operation (line of sight)
7) Billet spotter to NEVER stand on steps while the knockout is being moved.
8) Heat shields MUST be installed where possible (NB some setups don't allow for heat shields).

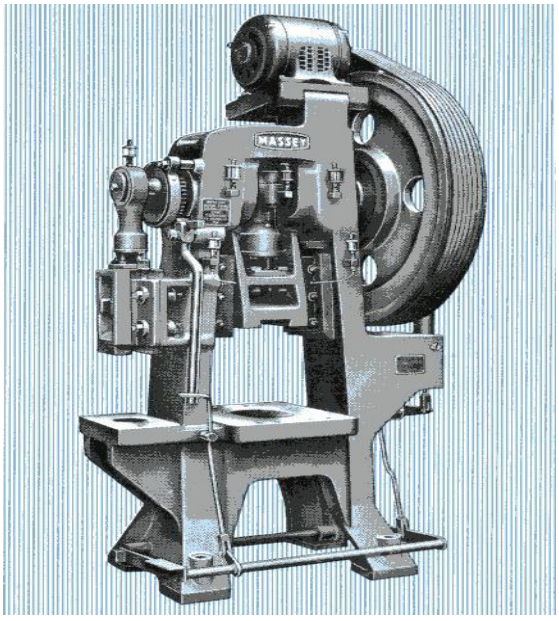
9) Anyone not part of the procedure is excluded from the area and, if anyone approaches, all movement is stopped.

All rules for spraying MUST be followed including the press in a safe state when access is required. Line of sight from the presses should cover a large, wide area. Ensure that this area is kept clear while the press is in operation. Proper PPE must be worn at all times in this area.

10. Specific Requirements for Trimming and Hot Coining Presses



Wide bed mechanical press.
Image courtesy W H Tildesley Ltd.



Side shear mechanical press.
Image courtesy B&S Massey Ltd.

10.1 Characteristics

Following closed-die forging, the flash is trimmed off and any required piercing and hot coining work is performed on general purpose mechanical or hydraulic presses. Since each of these processes may require an individual toolset, wide bed presses are typical.

Forging "off the bar" is still practiced by some companies. In this case, side shear trimming presses may be used.

10.2 Safeguarding the Moving Parts of Work Equipment

The safety requirements are similar to those for mechanical forging presses; refer to Section 7 and Clause 8.2.

Industry experience:
In the case of trimming presses, depending on the specific operating conditions, light curtains in some circumstances have proved to be effective. Where they are not applicable, other safeguarding methods must be used. For example, during production with a single clipper, (operator),

1) The side of the press opposite the clipper should be made inaccessible with a physical barrier, e.g., a screen, a work bin, a conveyor, a fume hood, etc. (See 4.4)

2) The operator/s manipulates the forgings with the aid of tongs of appropriate length and shape.

3) In the case of side shear presses – work bin placement is considered to be the best means of guarding.

4) During production where a clipper operator needs to have a further operator at the reverse of the press, then specific and clear work instructions / permits must be in force.

10.3 Permanently Stuck Forgings
See Clause 5.2

10.4 Cold-trimming, Cold-coining and Cold-straightening Operations
All presses performing cold work, such as cold-trimming, cold-coining, or cold-straightening operations should be safeguarded in accordance with the Provision and Use of Work Equipment Regulations 1998 (as applied to power presses).

11 Other Forging Equipment

11.1 Forging Rolls

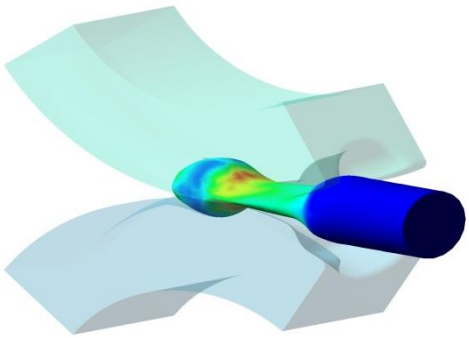


Image courtesy of Micas Simulations Ltd.

11.1.1 Characteristics
Forging rolls consist of two driven rolls that rotate in opposite directions and have one or more matching grooves in each roll. The cross-sectional area of a heated bar or billet is reduced by passing it between the rolls in a similar manner to a continuous rolling mill.

11.1.2 Particular Risks
Rolls should be started in an open position and brought gradually closer until the stock reaches the right size. Personnel operating forging rolls shall be trained on proper body position and stock feeding methods.

Operators should pay careful attention when setting up the front or rear stops. Front and rear stock guides should be used during operation of the unit. Precautions should be taken to prevent contact between the tongs and the rolls. When front or rear stops are not used, handling

tongs are sometimes equipped with welded stops. As stock is being fed into the rolls, the welded stop will touch the worktable or roll guard to prevent the tongs from being pushed too far into the rolls.

11.2 Ring Rolling

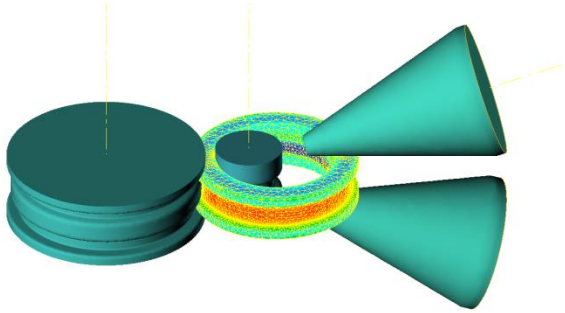


Image courtesy of Micas Simulations Ltd.

11.2.1 Characteristics
Using a simplified description, in a ring rolling machine, an idler roll, over which a doughnut shaped hot forged blank is placed, is moved latterly toward a driven roll, thus applying pressure on the diameter of the blank. As the blank is rotated between the rolls under squeezing pressure, its cross section is decreased and its circumference increased. Ring rolling machines are of two general types, horizontal and vertical, which differ primarily in the direction of rotation of the work-piece.

11.2.2 Operation
Tongs should be clear of the mill when the mill is in motion. Rolls should be inspected regularly for condition and alignment.

11.2.3 Safeguarding
Transparent, shatterproof heat shields should be provided and strategically placed for protection of personnel in rolling operations.
Thin sections may be prone to buckling during rolling operations. Horizontal ring rolling is also hazardous when the operator must be close to the work-piece. Therefore, adequate protection should be provided to ensure the worker's safety.

12 Other Forge Facility Equipment

12.1 Key Drivers
Key drivers should be inspected regularly for end-splitting or cracks and employees should be instructed in the proper method of use.

12.2 Manipulators
Manipulators used in forging operations should be inspected regularly to check that they can handle the designated loads. Employees should be instructed in the proper method of use. Tracks or slides for manipulators should be kept free of dirt or materials that would hinder their smooth operation.

12.3 Shears

Shears should be safeguarded in accordance with the requirements of PUWER 98. BS EN 13985: 2003 +A1: 2009 Machine Tools - Safety - Guillotines and Shears may also be relevant. A positive-type local isolator for disconnecting the power to the shear should be provided.

Note. The maximum size and specification of material being sheared, as recommended by the manufacturer of the shear, should not be exceeded.

12.4 Saws

Saws should be safeguarded in accordance with the requirements of PUWER 98, (but see also BS EN 13898:2003 + A1: 2009 Machine Tools - Safety - Sawing machines for cold metal).

12.5 Heating Equipment

12.5.1 Control of Heat Exposure

Whenever there is exposure to excessive heat, suitable protective measures should be provided. Control of exposure of individuals to excessive heat may be provided by such methods as;

PPE
Reflective shielding
Controlled openings
Evaporative cooling
Water jackets
Chain curtains; or
Air curtains
Signage

12.5.2 Combustion Safeguards

Protection against dangerous accumulations of unburned mixtures of fuel and air within the furnace, caused by accidental burner-flame extinguishment or lack of automatic pre-ventilation, should be provided.

12.5.3 Lighting Oil and Gas Furnaces

A lighting torch should be provided to light oil-fired and gas-fired furnaces, unless automatic means are provided.
Note. Operators should stand clear of furnace openings to avoid being exposed to possible flashback. They should also be wearing appropriate PPE see 12.5.1 When lighting oil-fired or gas-fired furnaces, the torch should be placed near the burner opening before the burner valve is opened. The operator should be appropriately trained and following the systems of work described by the manufacturer of the equipment.

12.5.4 Electrical Heating

Manufacturer's recommendations should be followed in the operation and maintenance of all electrical heating equipment.

12.6 Heat Treating

Manufacturer's recommendations should be followed in the operation and maintenance of all heat treatment furnaces.

With oil-quenching operations, good practice recommends the installation of a temperature control device that will shut down the furnace or set off a warning device if the oil temperature reaches a danger point. Adequate ventilation should be provided.

13 Cleaning and Finishing Equipment

13.1 Shot Blast

The cleaning chamber should have doors or guards to protect operators. The exhaust system to remove spent shot should be kept free of obstructions and leaks. Elevators should be enclosed or have the controls constantly attended by the operator when the elevator is raised or lowered. The controls should be remotely located away from the elevator area to ensure the worker's safety. The control position should be such that the operator also has a sufficient view of the elevator to ensure the safety of others.

13.2 Chemical Treating
Fume hoods or other ventilating apparatus should be used with chemical baths for cleaning and pickling and should comply with the requirements of the Control of Substances Hazardous to Health 2002 (as amended) COSHH.

13.3 Grinding
Suitable personal protective equipment (PPE), and extraction systems, should be used during grinding operations. Grinding equipment must be used and maintained in line with the requirements of PUWER 98.

Summary of Safeguarding Measures

Page No.	Equipment Type	Potential Measures
7	Air & Hydraulic Driven Hammers	Use of tongs of appropriate length and shape
		Scale guards
		Restricted access using ancillary equipment
7	Gravity-drop Hammers	As above
8	Counter-blow Hammers	Use of tongs of appropriate length and shape
		Physical guards in the side openings of the hammer legs
		Restricted access using ancillary equipment
		Light curtains on the opposite side of the hammer from the stamper have proved to be partially acceptable
		Safe retreat havens
10	Clear Space Hammers	Physical guarding of the motor drive
12	Mechanical Forging Presses	Use of tongs of appropriate length and shape
		Scale guards
		Restricted access using ancillary equipment
		Pressure sensitive mats

		Light curtains/beams
14	Hydraulic Forging Presses	As above
16	Trimming and Hot Coining Presses	Use of tongs of appropriate length and shape
		Restricted access using ancillary equipment
		Light curtains/beams
17	Other Forging Equipment	See document text

APPENDIX 1
Risk assessment
The use of this template is not compulsory and you are free to use other means to complete the risk assessment.

MACHINE DETAILS

Machine type and plant/ref no.

Name of assessor/date of assessment

General description of machine, including ancillary equipment

Intended function of machine and suitability for function

PREVENTING ACCESS TO DANGEROUS PARTS
Is access possible to any part that could injure particularly the closing tools? What access is needed during normal operation of the machine?

Machine part	Location	Who is at risk?	Estimated injury

For the parts identified above, what method of guarding or protection will be necessary? Will they be suitable taking into account the operation of the machine?

Machine part	Fixed guard	Other guard	Other protective measures – e.g: jigs, tongs

Where guards are provided are they effective? Will they prevent risks from inadvertent operation when more than operator is working at the machine?

Guard/device	Effective? E.g. - of sound construction, not easily by-passed/disabled, adequately distant from danger but allowing a good view of the process where necessary, maintenance access only, etc

MAINTAINING GUARDS

What maintenance is necessary for the guards and protective devices? What preventive maintenance required for safety related parts of the control system?

Guard/device	Maintenance	Frequency	Responsible person

INFORMATION, INSTRUCTION AND TRAINING

What information must be provided to operators and others working at that machine?	Who is responsible for providing that information

What instruction and training must be provided to the following:

Operators	Maintenance staff	Supervisors

Who is responsible for providing instruction and training to the following:

Operators	Maintenance staff	Supervisors