Guarding of Machinery

Guidance from the Quarry Products Association

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QUARRY PRODUCTS ASSOCIATION

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Preface

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Historically, a persistent feature of all industries operating machinery and equipment has been the many injuries - including fatalities - caused by the inadequacy or absence of guarding.

Although standards have improved significantly, it remains a fact that - for some - the basic principles are still not sufficiently understood, implemented or maintained.

The Health and Safety Executive welcomes, therefore, the publication of this richly illustrated Industry Guidance which is an evolution of its predecessor published by BACMI (the forerunner of the QPA).

The Quarrying Industry has made tremendous strides in recent years in its quest to improve the health and safety of its workforce. This publication is a further example of the Industry's resolve to maintain this positive impetus, and as such I commend it to you.

Contents

1 Introduction

Since the publication of the predecessor to this Guide, there have been many legislative changes, including :-

- The Supply of Machinery (Health and Safety) Regulations 1992;
- The Provision and Use of Work Equipment Regulations 1998; and
- The Quarries Regulations 1999.

British and European Standards have also been updated accordingly.

The principal factors in many machinery related injuries are poor design of guards; inadequate provision for cleaning and maintenance; and inappropriate construction of guards for the working environment.

As a vital component of the competence of everyone within the industry, training as to the importance of machinery guarding cannot be over emphasised. This is of particular relevance to ensuring that machinery with missing or defective guarding is not operated.

Everyone in the 'life cycle' has a part to play to improve safety, i.e. designers, manufacturers, suppliers, installers, users and maintenance staff.

This document:

- aims to provide practical guidance on the effective guarding of machinery typically found in quarries, asphalt, concrete and mortar plants, recycling and other related activities.

- has relevance to fixed processing plant, mobile processing plant and mobile vehicular plant.

- should not be regarded as fully comprehensive as other methods of guarding may be applicable to particular situations.

Neither the Quarry Products Association nor its Members accept responsibility for any acts or omissions arising from the use of this Guide.

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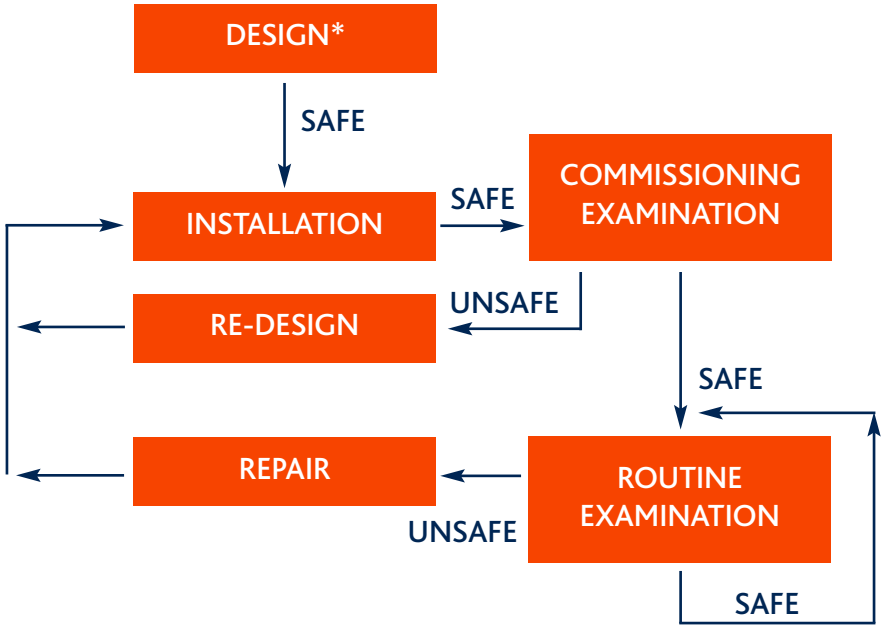
Guarding Life Cycle

2.1 Flow Chart

Design = Provision of original equipment or a change to the machinery installed



2 Guarding Life Cycle

2.2 Design

All guards should be designed to be fit for purpose. Principal features to include:-

- Robust construction
- Use of sound materials
- Be suitable for the conditions in which they are used
- To allow moving machinery to be seen, where necessary
- Avoid the introduction of additional risks
- Endeavour to prevent by-pass or rendering non-operational
- Be designed, located and installed to ensure that access is prevented by any person, their body parts or clothing.

NB: Where guards are fitted to the underside of conveyors there may be a risk of spillage accumulating within the guard. In such situations, the guard mesh should be of a size sufficient to allow spillage to fall through (where safe to do so) whilst preventing access to the moving parts within the guard.

2.3 Installation

Fixed close guards

- Must be held in place by fastenings which require a tool to release them. This excludes cable ties and wire or other such bindings.

- Where possible, should not remain in place once their fastenings are removed

Perimeter/ Distance Guards

- Guards should be secured to a solid foundation or adjacent structure.

- Be equipped with a suitable interlocking device to prevent moving parts starting up whilst these parts can be accessed. Electrical interlocks must be on mains voltage, not control voltage, though this may not be possible due to the configuration of certain electrical installations.

All guards

- Where possible, to be installed to allow routine adjustment and maintenance of the guarded machinery without the need to remove the guard. If this is not possible, then a strict safe system of work should be enforced.

- Be subject to an initial commissioning examination and subsequent routine inspection regime to ensure they are - and remain - fit for purpose

2 Guarding Life Cycle

2.4 Cleaning, maintenance, repair and adjustment

Before the removal of guards for the purpose of carrying out cleaning, maintenance or adjustment on any machinery, the power source should be isolated and locked off.

Isolation and lock off should be considered from **ALL** forms of energy in static and mobile plant, i.e.:

- Electrical
- Pneumatic
- Hydraulic
- Mechanical

All forms of stored ('potential') energy should be assessed and safely dissipated/released/ locked before the removal of guards from machinery.

Before working on any electrical apparatus or opening any electrical panel/enclosure where live conductors may be exposed, the power source shall be isolated. (An exemption to the above rule may be made where a fully qualified electrician is required to carry out live testing under a permit to work system).

All relevant personnel shall be trained in isolation and lock-off procedures to include a practical demonstration of the isolation and lock off. On completion of training, a record of training shall be completed and filed.

Isolation lock off shall only be carried out by individuals using their own personal isolation padlocks.

When entering guarded enclosures personnel must fit their own personal isolation padlocks, even where a key exchange system is operational. When personal locks are installed these must prevent guard openings or access gates being closed and re-energised.

Automatic isolation systems such as 'key exchange systems', which disconnect all three electrical phases, may be considered to provide effective electrical isolation, and may be used for repeated activities of short duration inside guarded enclosures.

Where it is necessary for numbers of personnel to enter guarded areas, all individuals will fit their own lock by means of a multi hasp. Pull wires and emergency stops are not considered as providing sufficient isolation.

No employee or contractor should remove any isolation padlock other than the one allocated to them personally.

Spare or duplicate keys shall only be used by management for the removal of isolation locks, following the necessary checks/head count of all relevant personnel.

When work is expected to last longer than one shift or day, it is recommended that the responsible person for operations (Manager, Foreman, or Electrician) should fit a Passover padlock to the multi-hasp to ensure the equipment remains locked between the shift change.

2.5 Re-design

- All guards should be repaired or replaced if they are damaged or changes to machinery render them ineffective
- Under no circumstances should machinery operate if guards are removed or damaged

3 Principles of Safe Guarding

- A risk assessment must be carried out to identify the hazards relating to the equipment, the potential for an injury, its severity and the likelihood of occurrence for each hazard identified. Risk reduction measures can then be applied.

  The measures to be taken ranked in the order that they should be implemented where practicable.

  - Close-fitting guard.
  - Other guards or protection devices such as interlocked distance guards, pressure mats and induction loops.
  - Light beams and light curtains.
  - Protection appliances such as jigs, holders and push sticks.
  - Provision of information instruction training and supervision.
  - Guarding may also be required from extreme temperatures of machinery the potential for ejected particles and the potential to fall into storage hoppers and silos.

- Wherever possible machinery should be close guarded

  ie no-one can enter the guarded area and then the guard closed behind the individual

- Where it is not possible to close guard machinery a suitable electrically interlocked perimeter guard should be fitted. This should be applied with a Safe System of Work involving isolation and lock off.

- All designers, managers, supervisors and operatives who have responsibility in the life cycle of a guard must be trained in the safe guarding of machinery.

3 Principles of Safe Guarding

Hot Storage Skip Winch (sited at ground level)

Suggested Guarding

A mesh panel guard fence should surround the mechanism and be securely fixed to the structure or foundations. An access gate will be required which should be secured by means of a suitable electrically interlocked system.

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Principles of Safe Guarding

Skip Loading Point Distance Guarding

Suggested Guarding

A mesh panel guard fence should surround the mechanism and be securely fixed to the structure or foundations. An access gate will be required which should be secured by means of a suitable electrically interlocked system.

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Principles of Safe Guarding

Asphalt Mixer driven by direct drive from two electric motors

Suggested Guarding

A fixed guard is required to enclose the drive shafts and flexible couplings connecting the electric motors to the mixer shafts.

3

Principles of Safe Guarding

Mobile Asphalt Dryer

Suggested Guarding

Panel type guards need to be securely fastened to the main dryer chassis on both sides and running the full length of the dryer cylinder. The guards should be attached such that a tool is required for removal. Guards should extend upwards as a minimum to the centre line of the cylinder. Measures must be taken to prevent access to moving parts of the machine from underneath the chassis.

3 Principles of Safe Guarding

Man Protective Grids in Feed Hoppers

Suggested Guarding

Steel grids, to prevent unauthorised or inadvertent entry, should be provided in the top of all process plant feed hoppers (with the exception of primary dump hoppers or where products of a large dimension are being processed which may obstruct the grid). The grids should be secured such that they require a tool for their removal. The aperture size of the grid should be designed to enable process material to pass through and be of sufficient strength to withstand any anticipated loads.

Points for Consideration

- If access hatches are built in the grid then they should be secured to require a tool to open them.
- Fitment of grids on elevated hoppers may encourage people to walk on them next to an unprotected edge. Appropriate access prevention measures should be incorporated in the design

3 Principles of Safe Guarding

Ground Feed Hopper Protective Grids

Suggested Guarding

Steel grids, to prevent unauthorised or inadvertent entry, with sufficient strength to withstand any anticipated loads, should be provided in the top of all ground feed hoppers (with the exception of primary dump hoppers or where products of a large dimension are being processed which may obstruct the grid).The grids should be secured such that a tool is required for their removal. The aperture size of the grid should be designed to enable process material to pass through. Provision should be made to enable lorry drivers to release tail gate latches from a position of safety.

3

Principles of Safe Guarding

Perimeter Guarding around Asphalt plant dryer

Suggested Guarding

Panel type guards are required which should be secured to fixed uprights. The minimum height of the guard above ground level should be a minimum of two metres. All access gates should be secured with a suitable electrically interlocked system. Remote greasing lines should be provided to enable lubrication of bearings to be carried out without entering the guarded area. (See also page 20).

3

Principles of Safe Guarding

Screw Conveyor

Suggested Guarding

Where screw conveyors are provided with inspection covers all covers should be secured with fastenings that require a tool for their removal. Exposed rotating shafts on the ends of screw conveyors should be fitted with adequate secure covers.

3 Principles of Safe Guarding

Gravity Take-Up Unit Guarding

Suggested Guarding

Conveyor gravity take-up units should be enclosed with mesh panels which prevent access to moving parts within the tower including the risk of the gravity take-up weight falling to ground level in the event of the belt breaking. All panels should be secured such that they require a tool for removal.

3 Principles of Safe Guarding

Head Drum Guarding

Suggested Guarding

Guards should be provided to prevent access to head drums and all associated nip points. The distance from the guard end to the centre shaft of the head drum should be a minimum of 1000mm. Where troughing idlers are positioned close to the head drum and place the belt under tension, the guard should be extended a further 1000mm beyond such idlers.

NB: Wide walkway extending around both sides of the head drum.

3 Principles of Safe Guarding

Tail Drum Guards

Suggested Guarding

Guards should be provided to prevent access to tail drums and all associated nip points. The distance from the guard end to the centre shaft of the tail drum should be a minimum of 1000mm. Guards should be provided on the underside of the conveyor to prevent access to the return nip of the tail drum. All guards should be designed such that lubrication and adjustment can be carried out without removing the guard. Pull cords where possible should be linked through all sections of guard as a further safeguard, so that the pull cord system is activated/dismantled when maintenance is taking place. This should not be regarded as a method of isolation. The guard should be of robust construction with a mesh of sufficient size to prevent the accumulation of spillage within the guard and yet prevent finger or hand contact with the trap points within.

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Principles of Safe Guarding

Skirting Guards

Suggested Guarding

In situations where fixed skirts are fitted above conveyor idlers, a trap point exists between the idler and the belt. Panels of guards should be fitted to prevent access to the trap points associated with the skirts of the conveyor.

3

Principles of Safe Guarding

Snub Drums - Conveyors

Suggested Guarding

Conveyor Snub drums/pulleys are generally situated on the underside of a conveyor directly behind the head drum and serve the purpose of providing a maximum contact area between the drum and belt. Trap points exist between the underside of the belt and the in-running nip of the drum.

A suitable open mesh guard should be provided to prevent access to the in-running nip of the belt and drum from the underside of the conveyor and each side. The guard should be of robust construction with a mesh of sufficient size to prevent the accumulation of spillage within the guard and yet prevent finger or hand contact with the trap points within.

3 Principles of Safe Guarding

Conveyor Return Rollers

Plate Type Guard

Open Mesh Guard

Suggested Guarding

Conveyor return rollers do not generally present a trap hazard. However, in the following situations a trap hazard exists.

- Where the belt cannot freely lift sufficiently it presents a trap point because a structure is positioned above the belt.
- Where a tensioning roller has been positioned on the upper side of the return belt the belt is under tension and several nip points are created.

There are varying types of guard available to guard nip points relating to return rollers.

- Plate type guards can be fitted along the full length of the roller in front of the in-running nip point. Measures should also be taken to prevent access to the nip from each side of the roller.
- A suitable open mesh guard can be provided to totally enclose the roller. The guard should be of robust construction with a mesh of sufficient size to prevent the accumulation of spillage within the guard and yet prevent finger or hand contact with the trap points within.

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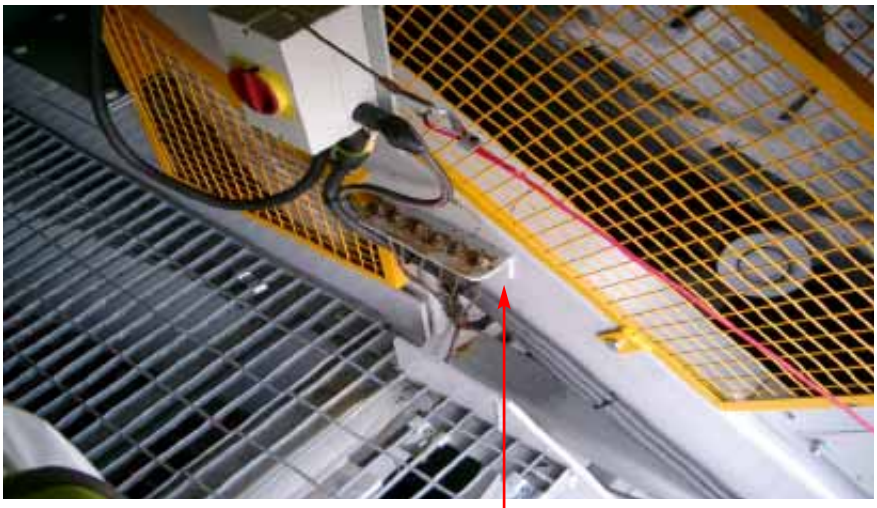
Principles of Safe Guarding

Remote Greasing



Remote greasing provision for all bearings
All guards should be designed such that lubrication and adjustment can be carried out without removing the guard for all bearings.

3 Principles of Safe Guarding

Motor and Reduction Box drive Coupling

Suggested Guarding

Where using electric motor and worm reduction gearboxes for driving equipment, the drive assembly utilises directly coupled shafts with flexible couplings. Guards are required to enclose the couplings.

It is necessary to guard the flexible couplings on both the input and output shafts of the gearbox. The guards can be constructed in sheet metal or by welding expanded mesh to a steel framework. Where guards obscure lubrication points extension pipes should be fitted to avoid removal of the guard when lubricating the equipment.

3 Principles of Safe Guarding

Batch Feeder Belts

Suggested Guarding

Batch feeder belts whilst generally slower possess the same hazards as a normal conveyor.

The feeder and all associated nip points should be enclosed within suitable mesh guards fitted along the full length of the feeder. Guards should be provided on the underside to prevent access to tail and head drums. Guards should be designed such that routine maintenance and adjustment can be carried out without removal of the guards.

3 Principles of Safe Guarding

Vee Belt Drive Guard

Suggested Guarding

Vee belt drives are commonly used on various items of equipment on process plants.

The type illustrated with open mesh enables more efficient cooling of the Vee belts and pulleys and allows Vee belt tension to be visually checked without removal of the guard.

A mesh guard totally enclosing the drive with the outer section manufactured from steel sheet. Where joints are necessary for easy removal of the guard, sections should be joined by flat metal or angle iron welded to each section and drilled to secure the bolts.

Gaps at the point where shafts enter the guard (which may be necessary for adjustment) should be kept to a minimum.

3

Principles of Safe Guarding

Drive Guard - Primary Jaw Crusher

Suggested Guarding

A mesh guard totally enclosing the drive with the outer section manufactured from steel sheet. Where joints are necessary for easy removal of the guard sections should be joined by flat metal or angle iron welded to each section and drilled to secure the bolts. Gaps at the point where shafts enter the guard (which may be necessary for adjustment) should be kept to a minimum. Consideration should be given to manual handling requirements when maintenance is being carried out. The provision of lifting attachments should be considered where mechanical means of lifting may be required. Similar guards will generally be provided to enclose the flywheel on the opposite side to the crusher drive.

3

Principles of Safe Guarding

Primary Jaw/Toggle Plate Guarding

Suggested Guarding

A panel of guard is required to prevent access to the area immediately behind the crusher swing jaw where movement of the jaw presents a trapping hazard between the jaw and the crusher frame.

3 Principles of Safe Guarding

Guarding over Resonance Type Screens/Vibrators

Suggested Guarding

Totally enclosing sheet metal guards should be provided over each of the vibrating units with additional sheet metal guards over the associated shafts and couplings.

3

Principles of Safe Guarding

Vibrating Screen Vee Belt Drive and Flywheel Guards

Suggested Guarding

Drive guards with mesh sides and sheet metal around the guard should be provided. In addition a sheet metal guard should be provided to enclose the flywheel.

3

Principles of Safe Guarding

Pan Mixer Guarding and Interlock

Pan mixer with fibre hatch and interlock system

Suggested Guarding

The mixer top door should be provided with a suitable electrically interlocked device to prevent the cover being opened unless the electrical power is disconnected. However full isolation of the mixer should be undertaken when working on the mixer. Inspection hatches on the mixer cover should be provided with secondary grids to prevent contact with the moving paddles within, when the mixer is in operation.

Mixer discharge guarding

Suggested Guarding

A guard manufactured from sheet metal with a hinged mesh access cover should be provided to prevent access to moving parts of the mixer at the discharge point. The hinged mesh top cover should be secured and require a tool for it to be opened, if frequent access is required to this area it should be electrically interlocked. Where appropriate, lifting eyes should be attached to the pan mixer lid.

3 Principles of Safe Guarding

Ready-Mixed Concrete Recycling Plant Discharge Point

Suggested Guarding

A substantial mesh guard is secured at the discharge point of the aggregates recycling equipment on a ready-mixed concrete plant. The mesh guard should be provided such to prevent access to the screw mechanism of the recycler.

3 Principles of Safe Guarding

Fines Dewaterer

Suggested Guarding

Fines dewaterer using slowly rotating scraper blades to extract the finer particles.

In addition to a sheet metal guard on the main dewatering section, a mesh guard should be provided around the trough of the scraper blade section. This should be fitted high enough to avoid personnel falling into the trough or being able to reach the scraper blades and be at least 2 metres above ground level.

3 Principles of Safe Guarding

Small Pan Mixer

Suggested Guarding

This equipment is normally used in laboratories.

A cover should be provided over the mixer drum which is electrically interlocked to prevent the mixer operating unless the guard/cover is in position.

3 Principles of Safe Guarding

Fixed Ladder Gate Systems

Suggested Guarding

Where access to ladders needs to be controlled, a hinged lockable gate should be provided to prevent unauthorised access. If required, such gates can be fitted with a suitable electrically interlocked system.

NB: Wherever possible, consideration should be given to replacing vertical-rung ladders with inclined stairways. New designs should incorporate inclined stairways in preference to vertical-rung ladders.

3 Principles of Safe Guarding

Fixed Ladders

Suggested Guarding

Fixed permanent vertical access ladders to platforms, landings and walkways.
Ladders rising more than 3.5m should be fitted with hoops commencing at 2.5m from ground level. The hoops should be spaced at 1.2m intervals and connected by three vertical flats attached so as to support the weight of the hoops and the user. The internal clearance of hoops should be in the region of 0.8m.

The Workplace, Health, Safety and Welfare Regulations (1992) specify that high rise fixed ladders be provided with rest platforms at distances not exceeding 6m.

A physical device should be provided to ensure that there is no risk of personnel falling into the ladder-way from the top of the ladder.

.NB: Wherever possible, consideration should be given to replacing vertical-rung ladders with inclined stairways. New designs should incorporate inclined stairways in preference to vertical-rung ladders

3 Principles of Safe Guarding

Robot Guarding

Suggested Guarding

A fixed perimeter fence should be provided around the working area of the robot. Entry gates into the fenced area should be provided with a suitable electrically interlocked system. Light curtains may be installed as an additional safeguard to protect personnel if they enter the robot's immediate working area.

Entry to Guarded Enclosures around Robots

- Before entering the guarded enclosure for teaching purposes, the system must incorporate the facility to request access to the enclosure via a control which will park the robot in a safe position such as home or datum point. The key exchange system must disable the ability to remove the key until such time as the robot arm has returned to this safe point.
- Facility to enable switching from auto mode to 'teach' mode must be provided within the guarded enclosure using the previously released key. This will be possible with the guarded enclosure access gate open utilising a sentry to prevent unauthorised access.
- The robot must operate at no more than 10% of its maximum speed in the 'teach' mode.
- If the 'teach' mode pendant is to be operated within the guarded enclosure, a clear working space of 500mm safety zone must be provided around the robot operating envelope. This safety zone must be clearly marked on the floor and communicated to all relevant personnel.
- The robot will be fitted with physical stops to ensure it remains within the necessary safety zone. The physical stops must also prevent the robot extending outside the guarded enclosure.
- Operation of the 'teach' pendant will disable the operation of the robot from any other control point.
- If all of these points cannot be complied with, the operation of the 'teach' mode from within the guarded enclosure is prohibited.
- The 'teach' mode can only be operated by personnel who have received the relevant training from either the robot manufacturer or someone who is an authorised trainer.

3 Principles of Safe Guarding

Vehicular Mobile Plant

Measures should be taken to guard the following areas of vehicular mobile plant.

- Engine cooling fans and their associated drive belts and pulleys.
- Any ancillary drive belts and pulleys which are accessible when engine covers are open.
- Injector pump drive couplings in certain equipment.
- Power take off shafts on agricultural type tractors.
- Ancillary prop shafts.

Appendix 1

The Supply of Machinery (Safety) Regulations 1992 – ISBN 0 11 0257 19 7

Safe Use of Work Equipment (Provision and Use of Work Equipment Regulations 1998) Approved Code of Practice – ISBN 0 7176 1626 6

British Standard BS7300: 1990 Code of Practice for Safeguarding of the hazard points on troughed belt conveyors – ISBN 0 580 18346 7
NB: At time of going to Press, this standard has been proposed for withdrawal and will be superseded by BS EN 618 and 620

Public Document – Safe Use of Machinery PD5304: 2000 – ISBN 0 580 33207 1

BS EN ISO 12100-1: 2003 (replaced BS EN 292-1: 1991): Safety of Machinery – Basic concepts and general principles for design – Part 1: Basic terminology and methodology.

BS EN ISO 12100-2: 2003 (replaced BS EN 292-2: 1991, as amended in 1995 and 1997): Safety of Machinery – Basic concepts and general principles for design – Part 2: Technical principles and specifications.

BS EN 294: 1992, Safety of Machinery – Safety distances to prevent danger zones being reached by the upper limbs. Amended by AMD 7655 of 15 March 1993

BS EN 349: 1993, Safety of Machinery – Minimum gaps to avoid crushing of parts of the human body.

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