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Control of hazardous energy on machinery – Specification

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Foreword

Publishing information

This British Standard is published by BSI Standards Limited, under licence from The British Standards Institution, and came into effect on 29 February 2020. It was prepared by Technical Committee MCE/3, *Safeguarding of machinery*. A list of organizations represented on this committee can be obtained on request to its secretary.

Presentational conventions

The provisions of this standard are presented in roman (i.e. upright) type. Its requirements are expressed in sentences in which the principal auxiliary verb is “shall”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Requirements in this standard are drafted in accordance with *Rules for the structure and drafting of UK standards*, subclause **G.1.1**, which states, “Requirements should be expressed using wording such as: ‘When tested as described in [Annex A](#), the product shall ...’”. This means that only those products that are capable of passing the specified test will be deemed to conform to this standard.

Where websites and webpages have been cited, they are provided for ease of reference and are correct at the time of publication. The location of a webpage or website, or its contents, cannot be guaranteed.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

0 Introduction

This British Standard provides requirements and guidance to users of machinery on how to control hazardous energy on machines for safe working during all types of interaction.

[Table 1](#) identifies five potential types of interaction on a machine, two for normal operation and three for maintenance, based on the risk profile of each interaction.

During normal operation of machines, fixed and interlocked guards are commonly provided to prevent access to dangerous parts. Maintenance tasks (which could include setting, process changeover, cleaning, unblocking as well as planned and unplanned maintenance), might require alternative methods and controls to prevent injury, as the risks could well be different, requiring different risk reduction measures. Organizations need to risk assess how workers interact with a machine to determine which interventions can be carried out while relying on interlocking and which interventions require isolation.

NOTE [Table 1](#) is not intended to be hierarchical and there is always be the need to assess the element of risk involved for any given interaction and an adequate level of risk reduction applied.

[Table 1](#) contains references to the clauses which give appropriate requirements and guidance on risk reduction measures for each type of interaction.

It is important to include all forms of hazardous energy in any risk assessment, e.g. electrical, pneumatic, hydraulic, and energy due to inertia or gravity.

Table 1 — Hazardous energy control

	Type of interaction	Typical examples	Typical risk reduction measures (See Note 1)	Necessary documents (See Note 2)	References
During normal operation	Producing goods as described in the safe operating procedure (SOP).	Normal production.	Fixed or interlocked guarding.	SOP	Clause 5
	Working through an interlocked guard or protective device.	Clearing a jam, loading and unloading of material.	Safety controls to prevent unexpected start-up.	SOP	Clause 5 and Annex A
	Localized intervention or maintenance.	Changing a motor.	Local isolation/lock-out, tag-out (LOTO).	Safe system of work (SSoW).	Clause 6
During maintenance	Long-term maintenance.	Scheduled or unscheduled maintenance/cleaning.	Whole machine isolation; lock-out, tag-out (LOTO).	Maintenance procedures and SSoW.	Clause 6
	Whole machine cleaning.	Fault finding on live electrical equipment/teaching a robot/commissioning (see Note 3).	Partial isolation; hold to run controls; low energy; low voltage; low speed.	SSoW and permit to work (PtW).	Clause 7
<i>NOTE 1 The competence of those carrying out the work needs to be determined, as this can be an important contribution to the risk reduction measures (see 8.5).</i>					
<i>NOTE 2 The Management of Health and Safety at Work Regulations 1999 [1] require employers and self-employed persons to assess risks to workers and others who might be affected by their work or business. See also HSE publication INDG163 [2] which gives advice on these regulations.</i>					
<i>NOTE 3 Live fault finding and commissioning can be particularly high risk activities (see Clause 7). All activities could be applied during commissioning.</i>					

1 Scope

This British Standard provides requirements for the control of hazardous energy whilst work is being carried out on machines.

This British Standard includes requirements for machinery in relation to electrical and mechanical hazards (i.e. moving parts, or parts that could move).

NOTE 1 For requirements for other hazards, see, for example, BS EN ISO 4413 and BS EN ISO 4414, which provide guidance on hydraulic and pneumatic systems.

NOTE 2 For guidance on controlling electrical hazards, see The Electricity at Work Regulations 1989 (EWR) [3] and associated guidance HSR 25 "The Electricity at Work Regulations 1989 Guidance on Regulations" [4] and HSG85 "Electricity at work safe working practices" [5].

This British Standard also provides requirements for fixed equipment, such as motors and pumps fed via plug and socket-outlets.

This British Standard does not apply to:

- a) machines fed at high voltage;

NOTE 3 High voltage is defined in BS 7671 as above 1 000 volts A.C. or 1 500 volts D.C.

- b) material handling vehicles (e.g. forklifts, pallet trucks), rider operated vehicles, construction plant machinery, mobile elevated working platforms or road vehicles;
- c) transportable or portable work machine (including powered hand tools), although the basic principles can often be applied; and
- d) process plant equipment.

NOTE 4 For general guidance on isolation of process equipment, see HSG253 [6].

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes provisions of this document¹⁾. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

BS EN ISO 7010, *Graphical symbols — Safety colours and safety signs — Registered safety signs*

BS EN ISO 12100, *Safety of machinery — General principles for design — Risk assessment and risk reduction*

BS EN ISO 13732-1, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 1: Hot surfaces*

BS EN ISO 13732-3, *Ergonomics of the thermal environment — Methods for the assessment of human responses to contact with surfaces — Part 3: Cold surfaces*

BS EN ISO 13849-1, *Safety of machinery — Safety related parts of control systems — Part 1: General principles for design*

BS EN ISO 13855, *Safety of machinery — Positioning of safeguards with respect to the approach speeds of parts of the human body*

¹⁾ Documents that are referred to solely in an informative manner are listed in the Bibliography.

BS EN ISO 13857, *Safety of machinery — Safety distances to prevent hazard zones being reached by upper and lower limbs*

BS EN ISO 14119, *Safety of machinery — Interlocking devices associated with guards — Principles for design and selection*

BS EN ISO 14120:2015, *Safety of machinery — Guards — General requirements for the design and construction of fixed and movable guards*

[BS EN IEC 62046](#), *Safety of machinery — Application of protective equipment to detect the presence of persons*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 duty holder

person responsible for compliance with health and safety requirements relating to hazardous energy control within a specific work area

NOTE This can include isolation.

3.2 energy dissipation

dissipation (or restraint/containment) of any stored energy which might give rise to danger

NOTE Examples of stored energy include:

- a) *mechanical parts which could continue to move through inertia;*
- b) *mechanical parts liable to move by gravity;*
- c) *springs;*
- d) *capacitors, inductors or batteries; and*
- e) *pressurized fluids.*

3.3 isolation

procedure to securely disconnect and separate a machine from all hazardous energy sources

3.4 isolator

device designed or intended to provide physical separation for a source of energy, capable of being secured in the isolated position

3.5 lock-out, tag-out (LOTO)

isolation procedure involving disconnecting a machine from all energy sources, then secured by locking the equipment in the off position and attaching a tag (sign) to warn against re-energization

NOTE 1 This term is commonly used by maintenance and production departments.

NOTE 2 Tag out alone without lock out is not considered sufficiently safe as a means of securing an isolation.

3.6 machine

installed machinery or equipment

NOTE 1 Examples include those used in manufacturing and processing, filling and packing, utilities, laboratories, engineering workshops, warehouses, waste treatment.

NOTE 2 The associated tanks, silos, pipes and services can also be included.

NOTE 3 Attention is drawn to the Supply of Machinery (Safety) Regulations 2008 [7] with regard to the definition of installed machinery.

3.7 maintenance

inspection, planned works, fault finding and breakdown repair

3.8 operation

start-up, set-up, routine running, changeover, and cleaning

3.9 safety related parts of the control system (SRPCS)

part of the control system which contributes to reducing risk and is required to function correctly to maintain or achieve safety

3.10 safe system of work

written procedure derived from a task-based risk assessment which defines safe working methods and any controls necessary to eliminate the hazards or minimize the risks

3.11 test engineer

person responsible for incorporating temporary or permanent equipment for application of stored energy for the purposes of the pressure test

3.12 test inspector

person certifying the pressurized system is integral and meets the required pressure rating, without leak

NOTE Also referred to as an independent witness or competent person.

3.13 user

person who operates, cleans, maintains or otherwise interacts with a machine or piece of equipment

NOTE This definition relates to users of machinery or equipment and also includes those who manage such persons.

4 Risk assessment

COMMENTARY ON CLAUSE 4

One of the aims of an intervention risk assessment is to decide, in advance of any work activity, whether it is acceptable to rely on machine interlocking to prevent unexpected start-up of the machine, or whether a secure isolation is required for each activity.

Maintenance activities that require, for example, the dismantling of machine parts or wiring alterations, typically require a secure isolation to be performed. This prevents the machine from being re-energized until all work has been completed, and all workers and their tools are clear of the machine.

In some instances the risk assessment could allow some tasks to take place without a secure isolation being necessary and the work carried out safely by relying on the SRPCS to prevent unexpected start-up. In such cases the machine needs to be brought to a safe state before work can commence so that the machine is maintained in a safe state while the task is being performed. Typical tasks might include material loading or unloading, inspections, minor adjustments or lubrication, unblocking or unjamming (see [Annex A](#) for examples of tasks).

The default position should be to enter a danger zone only after performing a secure isolation, unless alternative arrangements are supported by a risk assessment. Risk assessments should be periodically

reviewed to make sure that the risks have not changed over time, e.g. through changes to the environment or from a change in use.

Employees should not be expected to carry out a dynamic risk assessment (DRA) as a substitute for effective planning and the preparation of a written risk assessment.

Workers should make a final on-site assessment at the point of work before starting a task to check that the risk assessment and any method statements provided fully cover the risks present on site. If modifications are required they should discuss the modification with an authorized person, preferably the person who wrote the original documentation, before updating the documentation and agreeing how to proceed.

Whenever possible, risks from hazardous energy should be determined in the initial machinery design in order to reduce or eliminate them.

In addition to any risk assessment provided by the machine manufacturer, the end user of a machine shall carry out risk assessments so that workers are able to interact with a machine safely. Such risk assessments shall be carried out in accordance with BS EN ISO 12100, taking account all the interactions in [Table 1](#), so that risks from the hazards are reduced and safe systems of work or standard operating procedures are created.

Risks shall be reduced according to the following hierarchy:

- a) design out the hazard, but where this not possible;
- b) protective measures are taken (e.g. fixed or moveable guards); and/or
- c) where necessary to control any residual risk:
 - 1) safe systems of work implemented, and
 - 2) information, and training provided.

5 Normal operation

5.1 Safeguarding

5.1.1 General

During normal operation, safeguarding shall be used to prevent intentional or accidental contact with dangerous parts of the machine, e.g. moving parts (or parts that could move), hot or cold surfaces, and electrical conductors.

Safeguarding shall be selected and installed in accordance with relevant standards, including:

Fixed guards or fences	BS EN ISO 14120 and BS EN ISO 13857
Interlocked guards	BS EN ISO 14120 and BS EN ISO 14119
Electro sensitive protective equipment (ESPE), e.g. scanners, pressure mats, light curtains	BS EN ISO 13855 and BS EN IEC 62046
Thermal or electrical insulation	BS EN ISO 13732-1, BS EN 13732-3 and BS EN 60204-1

Users shall not be able to access energized parts by reaching over, under, through or around guards (see BS EN ISO 13857).

If parts continue to move after being de-energized, safeguarding shall prevent parts being accessed before coming to a complete stop (e.g. by using guard locking).

NOTE 1 See BS EN ISO 13855 and BS EN ISO 14119.

Fixed guards shall only be opened with a tool or key. Guards that need to be opened or removed frequently shall be interlocked.

NOTE 2 See BS EN ISO 14120:2015, 6.4.4.

Guards shall protect users from objects which might fall or be ejected from the work machine, including ruptured parts.

5.1.2 Preferred design features for guarding

Guarding shall be designed such that it minimizes interference with operation and maintenance by providing safe and easy access to relevant parts, and a clear view, whenever possible, of the operation. A risk assessment shall be undertaken so that guards are compatible with the working environment.

Guards shall not give rise to any additional hazard. Any additional hazards shall be determined as a result of the risk assessment.

5.1.3 Interlocked guards

Interlocking devices shall form an integral part of the safety related parts of the control system (SRPCS).

NOTE 1 See BS EN ISO 14119.

NOTE 2 Many interlocked guards on older machines rely on mechanical switches that have poor reliability and are easy to defeat; the need to replace these should be considered as part of a wider review, for example as part of a PUWER assessment.

The SRPCS (e.g. interlocks, light curtains, safety relays, safety PLCs and safety networks), shall be designed in accordance with BS EN ISO 13849-1 and/or BS EN 62061.

NOTE 3 See [Annex A](#) for further guidance.

6 Isolation for maintenance operations

6.1 General

Except in interactions where maintenance requires the machine to be wholly or partially energized, an isolation procedure shall be carried out so that all hazardous energy has been dissipated, or, as a minimum, controlled.

Those carrying out isolations shall be formally authorized to do so, based on their knowledge, training and experience.

On complex isolations, including different types of hazardous energy, co-operation between disciplines is required, however, one person shall have overall responsibility for the isolation.

NOTE 1 Typically, isolating the work machine from all sources of energy can suffice, but in some instances it is necessary to deal with energy which remains on the work machine even after the source has been de-energized. Such residual energy could be in the form of electrical (capacitive or inductive energy), mechanical, (springs or residual pressure), or potential energy from the position of a part of the machine acting under force of gravity.

Isolation procedures for maintenance shall include the following steps:

- identifying relevant machines and any adjacent equipment;
- identifying all the forms of hazardous energy and their points of isolation (see [6.3](#));
- communicating to all affected personnel that isolation is about to take place;

- d) stopping the machine requiring maintenance (see 6.2);
NOTE 2 This is typically be carried out by production personnel using the normal stop controls.
- e) using an isolator to disconnect the energy (see 6.3);
- f) locking-off the isolator to prevent inadvertent re-energization (see 6.4);
- g) applying a sign (tag or warning sign) to the isolation point(s) confirming that the machine has been isolated and is being worked on (see 6.5);
- h) releasing or blocking any stored energy (see 6.6); and
- i) verifying that the machine has been correctly de-energized and no other hazardous energy remains uncontrolled (see 6.7).

NOTE 3 This procedure is commonly referred to as Lock-out, Tag-out (LOTO).

NOTE 4 As part of the verification of an isolation, an additional step of trying to start the machine can be included. This is sometimes known as "try out", making the procedure LOTOTO.

Only authorized persons shall carry out the isolation, ensuring the requirements of 6.2 to 6.8 are met.

6.2 Identify types and isolation points for all hazardous energy

The persons authorized to carry out isolation shall determine:

- a) the number and types of energy source;
- b) the most appropriate location and method to isolate these energy sources; and
- c) whether stored energy is present and, if so, how this should be released or controlled.

In cases where a) to c) have already been determined and documented in a machine-specific isolation procedure (as might be the case for particularly complex machines), any such documentation shall be controlled so that any changes to the procedure can be tracked and verified. If a controlled procedure exists, those carrying out the isolation shall visually inspect the machine to confirm that nothing has changed or if there is no machine-specific isolation procedure, all sources of energy identified before starting isolation.

NOTE 1 Controlled documents can take the form of instructions, placards, signs, or notices.

NOTE 2 In some cases, this might require seeking assistance from other personnel, referring to machine manuals, or checking up to date machine diagrams to create a documented isolation procedure.

6.3 Disconnection of all hazardous energy sources

6.3.1 General

All machines shall be provided with isolation devices capable of:

- a) securely isolating the machine from all external sources of hazardous energy;
- b) safely releasing any internal stored hazardous energy; and
- c) blocking any residual hazardous energy that cannot be released.

6.3.2 Devices used for isolation

6.3.2.1 General

The devices used for isolation shall be:

- a) designed for the task in accordance with the relevant standard;
- b) instigated by a manually applied physical action;

NOTE 1 The use of electrically, hydraulically, or pneumatically operated/controlled devices to isolate, or release or block hazardous energy is not recommended.

- c) clearly and permanently labelled to indicate their function and the machine parts that they isolate;
- d) where practicable, clearly and permanently labelled to indicate their ON and OFF positions;
- e) lockable in the OFF or de-energized position with a padlock or other suitable means; and
- f) suitably located (e.g. close to the machine and outside any danger zone; easily visible from the machine; accessible from ground level or from a permanent platform).

NOTE 2 Contactors, variable speed drives with a "safe torque off" feature, relays and other electromechanical control devices are not suitable for performing isolations.

NOTE 3 Trapped-key power interlocking systems can provide a suitable form of isolation by interlocking the guard(s) and the machine power supply via a key-operated isolator. Typically, obtaining the key to open the guard(s) is only possible when the isolator is in the off position. The key is trapped in the isolator when switched on and trapped in the guard access lock when it is unlocked. This has the advantage over manual guard padlocking as it provides a mechanical interlock between the guard access lock(s) and the isolator (via a key), thus reducing the risk of human error that could lead to unexpected start-up. Trapped-key systems can also provide individual personal protection (carrying of an interlock key while inside the hazardous area that prevents unexpected start-up by another person).

Interlocks or other control devices that interrupt the control circuits, including any SRPCS, shall not be used for isolation purposes even if they are capable of being locked-off.

6.3.2.2 Fluid flow

Isolation of fluid flow (including pneumatic/ gas flow) shall be achieved by an isolation valve capable of being:

- a) secured in either the open or closed mode; and
- b) manually restrained in the open or closed position, via an isolation padlock.

NOTE 1 Depending on the process medium, there are different types of valve suitable for isolation:

- a) *ball valves –suitable for smaller diameter pipework where the change in state from open to close is rapid, with minimal disruption to pressure and flow. Ball valves are typically used on hydraulic fluid and pneumatic power systems;*
- b) *plate (knife) valves – these typically include a long external valve spindle that progressively opens or closes the plate from its entry into the process flow. The change in state from open to closed is gradual, with progressive changes to pressure and flow. Plate valves cut through the flow and tend to provide a secure isolation when the valve plate is fully extended. Plate valves are typically used on steam systems;*
- c) *gate valves –similar to plate valves. Gate valves are typically used on process pipework or water systems; and*
- d) *diaphragm valves – include a rubberized internal lining that progressively opens or closes by rotation of the handle. This results in the central faces of the internal lining moving further apart as the valve opens. Diaphragm valves are typically used in chemical environments.*

NOTE 2 Control valves cannot be relied upon for isolation purposes.

Storage vessels, including pressure vessels and pipework, shall have the facility for manual draining. There is no requirement to drain the contents for work outside these vessels unless necessary for reasons of safety, however, if work is required inside the vessels, or to the attached valves and fittings, the vessel shall be drained and ongoing flow prevented by use of the appropriate valve (secured in the correct position).

6.3.3 Isolation of fluid power

6.3.3.1 General

For hydraulic fluid, the fluid in the pipework shall be isolated and manually secured in position by the use of valve(s).

NOTE 1 This is typically achieved by an in-line valve specifically installed for isolation purposes.

NOTE 2 In some circumstances, process valves are used for isolation purposes, depending on the type of fluid the pipework conveys (and the consequences from fluid leakage).

Pneumatic systems shall be isolated by exhausting the residual air through a combined isolation and dump valve.

In fluid power systems, the actuator of the valve shall be positioned so that flow is prevented.

The valve spindle shall be chained off and padlocked, or a padlock attached directly to the valve lever arm so that the valve is maintained in a fully closed position.

The associated section of pipework containing the fluid medium shall be drained and verified as empty via use of an inline pressure gauge, or dedicated test gauge point (and insertion of a calibrated test gauge). The drain valve shall be secured in the open position, wherever possible.

6.3.3.2 Consequences from stored energy

Hydraulic or pneumatic power isolation shall be specifically assessed as either the retention or loss of the medium could lead to subsequent danger where:

- a) residual pressure is held in place – to hold a mechanical part in a fixed position such that it remains pressurized (with continued risk of stored energy); or
- b) residual pressure is exhausted – to remove the risk from any further unintended motion or expansion of the stored energy; this could result in the uncontrolled movement of a component or falling due to gravity.

The risk assessment shall determine primary hazards relating to the specific task(s) to be undertaken and an appropriate means of temporary supporting mechanical output device (chocking, temporary props, etc.) to be put in place which should be clearly stated in the resulting method statement.

6.3.3.3 Use of blanking spades

COMMENTARY ON 6.3.3.3

On bolted pipework connections, blanking spades (also known as slip plates, slip blinds or spectacle blinds) can be inserted into the pipework as a means of physical obstruction to prevent ongoing flow. Blanking spades are typically slipped in between two flanges after a process line has been discharged. They are typically secured in place by the flange bolts and sealed by a gasket or O-ring, similar to how wafer pattern valves are installed. Dedicated "blind flanges" are sometimes provided in the pipeline for this purpose, but often the inlet or outlet flanges on valves or equipment are used.

Where a risk assessment determines that the risk is high, e.g. for long duration work, a secondary means of isolation shall be provided.

NOTE Blanking spades are an additional layer of protection during maintenance work, guarding against leaking valves or negligent opening of an isolation valve.

Blanking spades shall be:

- a) installed as close to the isolated equipment as possible;
- b) rated to withstand the upstream pressure; and
- c) removed before the pipeline is put back into service.