Machinery Safety at Rotational Moulding Machines
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At a glance
- risk assessment
- identifying hazards
- machine safeguarding
- buying machinery
- legal duties

Scope
This guidance:
- is aimed at employers, managers, supervisors and workers responsible for the safe operation of rotational moulding machines;
- gives advice on the safeguarding requirements for foreseeable hazards associated with rotational moulding machines;
- sets out the approach to risk assessment, safeguarding and safe systems of work;

Following this guidance:
- can help you with your own assessment of risks and so ensure that all necessary control measures are in place on your machine.
- Following this industry guidance is not compulsory, unless specifically stated, and you are free to take action to comply with the law in another equally effective way. But if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance.

Foreword
The Health and Safety Executive (HSE) was involved with the British Plastics Federation (BPF) and Safety in Manufacturing Plastics and Composites Committee (SIMPL) in producing this guidance. HSE endorses the guidance, as it follows a sensible and proportionate approach to managing health and safety.

Descriptions and terminology
Rotational moulding machines
Rotational moulding machines are used to make products from thermoplastics. Plastic powders or granules are placed in a mould that is then heated whilst being rotated and, in some cases, rocked. As the plastic melts, it coats the inside of the mould to form the product being manufactured. Once the process is completed, the mould is opened and the product removed.

Products made this way range from small to very large items, for example traffic bollards, water tanks, crash barriers etc.
There are a wide variety of machines classified as rotational moulding machines. These include, but are not restricted to the following types of machines:

- Open flame machines
- Clam Shell rocking frame machines encompassing direct or indirect heat, radiation and hot air induction heating
- Rock and Roll batch-type oven machines, e.g. rock and roll, including clam shell machines
- Shuttle (Single or multi-station) bi-axial, e.g. shuttle, box-oven, carousel (turret/spindle) and ferris wheel machines
- Carousel jacketed mould machines
- Ferris wheel up and over machines

BS EN ISO 12100:2010 - Safety of machinery - General principles for design - Risk assessment and risk reduction defines safeguarding as:

A protective measure using safeguards to protect persons from the hazards which cannot reasonably be eliminated or risks which cannot be sufficiently reduced by inherently safe design measures.

Risk assessment

The law places both general and specific duties on employers and requires that significant risks in the workplace are identified and adequately controlled. This includes providing safe equipment for work and ensuring that this equipment is used correctly and maintained in a safe condition.

Any risk assessment should not only deal with the machine when it is operating normally, but should also cover activities such as setting, maintenance, cleaning or repair. The assessment may indicate that these activities require a different combination of protective measures from those appropriate to the machine doing its normal work. In particular, parts of machinery that are not dangerous in normal use because they are not then accessible may become accessible and therefore dangerous while this type of work is being carried out.

More information can be found on the HSE website at risk assessment FAQs.

Risk assessments must be maintained and reviewed if anything changes. They should be used to inform employees of any residual risks that may still exist and the relevant control measures that apply.

Identifying hazards

The reasonably foreseeable hazards associated with rotational moulding machines and related equipment, such as conveyors etc, typically includes – but are not restricted to - those listed below. These hazards can be a problem during normal operation of the machine and also during non-routine interventions, which can include maintenance, setting up, cleaning etc. Risks may increase or new ones may be introduced with the level of automation.

Additional information on risk assessment can also be found in BS EN ISO 12100:2010 - Safety of machinery - General principles for design - Risk assessment and risk reduction – Annex B.
Hazards associated with rotational moulding machines:-

- Where whole body access is possible there is a risk of entrapment within the oven compartment. The consequences of a person becoming trapped inside an oven, which is then heated up, is almost certain death due to the high temperatures that the ovens can reach.

- Entrapment/trapping between fixed and moving powered elements of the machine, which could include automatic doors, carousel arms etc; trapping by the moulds or mould carriers against fixed parts of the machine, such as the oven or cooling station structures; trapping between the carriage and the track or trapping by excessive or out of balance mould weights on a box oven or shuttle type of machine; trapping by the mould and carrier on vertical and horizontal indexing machines, eg ferris wheel and carousel types; entrapment within the pit area.

- Crushing; shearing; puncture, friction, abrasion, cutting or severing as a result of coming into contact with unguarded dangerous moving elements of the machines, which could include conveyor systems, automatic doors, carousel arms etc.

- Struck by moving/rotating moulds and carriers; eg becoming struck by excessive or out of balance mould weights on a box oven or shuttle type of machine; on vertical and horizontal indexing machines, eg ferris wheel and carousel types: being struck by the mould and carrier; or moulds or parts of moulds separating from indexing arms and falling into the operator area.

- Entanglement, eg on rotating shafts (even at slow speeds) or in spoked pulleys, belt and pulley drives, gears, mould carriage or rotating elements.

- Drawing in, eg through nips such as belts, pulleys, chains, sprockets, toothed spurs or gears; or nip points between the oven or frame and fixed points.

- Impact, stabbing or puncture, friction, abrasion; eg on vertical and horizontal indexing machines, eg ferris wheel and carousel types, being trapped or struck by the mould and carrier; and by rolling hoops and spokes on rock and roll machines.

- High pressure fluid or gas ejection.

- Fall or ejection of machine parts, eg falling moulds.

- Radiant and convective heat, direct and indirect heat, eg when the oven door(s) open. Burns as a result of coming into contact with hot frames and moulds, which can be at temperatures of up to 300°C; also other hot surfaces. See also heat stress.

- Burns and other injuries as a result of over-pressurisation of moulds.
<table>
<thead>
<tr>
<th>Hierarchy of control measures</th>
<th>Safety Guidance</th>
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<tbody>
<tr>
<td>Falls, eg into the machine pit or from work platforms, eg falling between platform and carriage when the guard is open on a box over or shuttle type of machine; or falling into the pit of a rock and roll machine. See also work at height. Some machines, such as large shuttle machines, may have either elevated platforms for mould servicing or for the machine to be located in a pit, with operator access at ground level.</td>
<td>Effective measures must be taken to prevent access to dangerous parts of machinery or stop their movement and inadvertent start-up before any part of a person enters a danger zone. The law (PUWER) requires that safeguarding of each dangerous piece of machinery should follow a hierarchy of control as follows:</td>
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<td>Entry into confined spaces, eg the machine pit that is sometimes used to house the oven and cooling stations; or the central turret of carousel rotational moulding machines.</td>
<td>• eliminate risks through machinery design or position; if this is not possible, then</td>
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<tr>
<td>Powered and unpowered conveyors and their associated risks.</td>
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<td>Gas, e.g. release of gas following flame failure; also gas connections that need protection against mechanical damage from heat or abrasion. Advice may need to be sought from appropriate competent bodies.</td>
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<td>Radiation</td>
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<td>Electricity, including electrical connections that need protection against mechanical damage from heat or abrasion.</td>
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<td>Fire and explosion</td>
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<td>Noise</td>
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<td>Vibration</td>
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<td>Lifting operations, e.g. associated with mould movements into and out of the oven.</td>
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<td>Manual lifting, carrying and handling</td>
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<td>Slips and trips, e.g. slips on polymer powder or granules, slipping from a work platform; trips from the umbilicals that connect carousel machine satellite control podiums to the main panel.</td>
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<td>Exposure to dust, fumes or other substances hazardous to health; see also local exhaust ventilation.</td>
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<td>Psychological, e.g. monotonous work</td>
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• provide fixed guards enclosing every dangerous part where and to the extent that it is practicable to do so, but where to the extent that it is not, then

• provide other guards or protection devices (such as interlocked guards, light curtains, pressure mats etc) where and to the extent that it is practicable to do so.

Information, instruction, training and supervision for all persons who use work equipment will be needed regardless of the level of protection chosen. This will include operators, supervisors, managers, maintenance, temporary workers etc.

For further information see PUWER Appendix 1 Further guidance on regulation 11 – Dangerous parts of machinery.

Safe systems of work

Where a significant risk for example, inadvertent start-up, is associated with a machine and the consequences present a reasonably foreseeable risk of harm, it is essential that access into the machine and any subsequent work with that machine is controlled appropriately. The provision of a safe system of work – i.e. a formal procedure that covers the level of isolation and lock off that must be applied and instructions that should be followed to ensure that work is carried out safely - is fundamental to the effective control of reasonably foreseeable risks.

You need to:

• assess the specific intervention tasks needed for each machine;

• identify controls e.g. covering: level of isolation, lock off and release of stored energy that has to be applied for each energy source, including gravity;

• challenge whether it is necessary to carry out the tasks in this way;

• identify how safety for these and any other tasks can be ensured and where necessary improved. Your starting point for this should be: can these tasks be done remotely? This may involve installing access platforms or modifying the machine to be able to make adjustments remotely. Where it is not possible to intervene remotely after modifications then you will need to identify other controls to protect workers. This may include Permit to Work systems, isolation procedures, etc.

• equally cover the re-instatement of the machine to ensure everyone is out of the machine, and power is returned safely before it is restarted.

Machine safeguarding

The duty holder has to take effective measures to prevent access to dangerous parts of machinery or to stop their movement before any part of a person enters a danger zone.
The first step is to review the adequacy of existing safety controls and to protect areas that are not adequately safeguarded. The safeguarding of dangerous machinery should follow the hierarchy of control measures (see section above).

Restricting access to hazardous areas, isolation, using fixed and interlocked guards and fencing are the first steps to guarding rotational moulding machines.

Guards must be properly maintained and care should be taken to ensure that they do not cause their own hazards, eg trapping, decreased visibility or increased build-up of heat etc.

Typical safeguarding of rotational moulding machines includes - but is not restricted to:

- Isolation of machinery if access to dangerous parts/areas of moving parts of machinery or hazard/danger zones is required.

- Perimeter fencing to prevent unrestricted access to the machine's hazard/danger zones (eg carousel arms, spinning mould etc.). This will almost certainly include a combination of fixed and interlocked guards, as well as other protective devices. Perimeter fencing should be manufactured to BS EN ISO 13857:2008 - Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs and BS EN ISO 14120:2015 - Safety of machinery - Guards - General requirements for the design and construction of fixed and movable guards.

- Additional local lighting within the machine to illuminate areas either in shadow or that are obscured.

- Operators should be able to check the basic status of the machine before any movements are initiated. If they do not have a good line of sight then take steps to provide this e.g. by relocating the control panel or providing other visual aids such as mirrors and CCTV.

- Position control podiums so that the main panel and the area of the machine being controlled are visible. It is essential that there is a good line of sight into the oven. This will help the operator ensure there is no-one in the oven before they close the doors and turn it on. This is particularly important when there is more than one access door present.

- When there is more than one access door into the oven there will need to be robust management systems in place to ensure that an operator does not become trapped. Sequencing door closing mechanisms, for example, so one door closes first while the operator observes the inside of the oven to make sure on-one enters before closing the second door may reduce the risks.
Consider the door closing system and identify if the door speed is appropriate and whether a door closing alarm is needed. This combination will enable anybody inside the oven time to escape and also to give the operator time to register someone is in there.

Where there is a risk of entrapment in the oven you will need to consider a means of escape. Measures that can be implemented if a person does become trapped in the oven may fall into one or all of the following areas:

- providing a means to escape easily e.g. through kick panels or by means of opening the door from inside; or

- providing means to raise the alarm from the inside of the oven to let people know they have become trapped; or

- Means to turn the oven and rotational moulding arm off from inside the oven e.g. by an emergency stop button that is actuated from inside the oven.

An interlocked guard to prevent access to dangerous parts in the loading opening:

- the machine should stop when this interlocked guard is opened, e.g. to gain access to the mould. Guard locking may be necessary if the machine takes or requires time to run down and stop.

- there should be no power drive to the mould.

If hold-to-run controls are fitted, and the operator is: out of reach of the hazards; has a full view of the area; and the machine is single person operation with 3rd party access restricted; then the charging area does not need a fence; but if these requirements cannot be met, then perimeter fencing, as above is required.

Openings kept to a minimum, e.g. only those necessary for filling the mould and removing the product or for setting or maintenance and these would have to meet the reach distances specified in EN ISO 13857:2008.

Fixed panels or guards at maintenance access points where access is not expected to be frequent;

Where access is likely to be frequent, such as at maintenance access points, the panels or guards should be fitted with interlocking devices that stop the hazardous functions covered by the guard when the panels or guards are opened;

All Interlocking devices used with hinged or sliding interlocking guards should be of the positive-operated fail-safe type.
Safety Guidance

**An audible warning system** - with a unique sound where there are several machines in close proximity - for, for example, just before the mould emerges from the final cooling chamber.

- Isolate the central turret area of carousel machines separately with fixed guards or fencing.

- Interlocked/fixed guarding around open flames and pits, and pit entry points.

**Additional issues to consider**

- If moulds are lifted above the working position of the operator, there should be automatic mechanical intervention to prevent the mould dropping/falling under gravity or power. There should also be a manual system to prevent the mould falling, e.g. a prop, chock, scotches or other suitable devices, as well as a safe system of work.

- Wherever there is a risk of movement occurring unexpectedly as a result of inertia or gravity, props, chocks or other devices should be used.

- The mould should cease spinning automatically prior to it emerging from the final cooling compartment.

- It should not be possible to spin the mould under power while it is at the front of the machine, except at low speed and via a hold-to-run control.

- Protection/restricted access may be required in the cooling area when the potentially hot mould emerges.

- Locate operator areas sufficiently far from the oven so that they are not subjected to undue radiant and convective heat when the oven doors open.

- An automated system for checking oven temperatures.

- The oven should be clean and free from build-up of spilled materials.

- Ventilation and systems in place to prevent the build-up of any hazardous carbon monoxide or other noxious gases.

- Shut-off valves will be required to prevent gas escape in the event of failure of a rotation or flexible joint.

- Safe storage of chemicals/solvents used in the rotational moulding process.

- Mark clearly and cover umbilicals from satellite podiums to main control panel.

- Hazards associated with operator access platforms on large machines which may have a moveable section that enters the machine envelope whilst mould servicing is being carried out.
Maintenance includes all planned/unplanned and routine/non-routine maintenance to machinery.

Maintenance is often undertaken at job changes including daily adjustments, engineering repairs, inspection, testing and cleaning.

During all job changes, or periodically for long-run jobs, the following maintenance checks and housekeeping should be carried out to ensure the safe operation of machine controls:

- control panels should be cleaned thoroughly and markings clearly legible;
- controls should be checked for correct operation and illumination;
- housekeeping on and around the machine.

In most cases the need for safe maintenance will have been considered at the design stage and attended to by the manufacturer and you will need to do little other than review the measures provided.

In other cases, particularly when a range of interconnecting components may be put together, for example in a research laboratory or a production line, you will need to consider when carrying out your risk assessment whether any extra features need to be incorporated so that maintenance can be done safely and without risks to health.

Faults that affect production are usually apparent within a short time. However, a fault in a safety-critical element of a machine or system could remain undetected unless appropriate safety checks are included in maintenance activities. The frequency of maintenance activities is therefore crucial and the following should be taken into account when deciding upon appropriate maintenance intervals:

- intensity of use - frequency and maximum working limits;
- operating environment - for example extremes of heat, contamination;
- variety of operations - is the equipment doing the same task all the time or does it change?
- the risks presented to health and safety resulting from any sort of malfunction.

The extent of the actual maintenance carried out at each interval may vary considerably from basic checks to complex integrated programmes. At all levels you must ensure that the maintenance is effective and is targeted at those parts of work equipment where failure or deterioration could lead to health and safety risks.

Maintenance activities should take place while machinery is stationary, isolated and locked off from its energy sources, and be carried out by competent machine engineers. Risk assessment will determine the requirements to ensure the safety of the employee carrying out the task and of others within the vicinity.
If equipment will have to be running or working during a maintenance operation and this presents risks, you should take measures to enable the operation of the equipment in a way that reduces the risk. These measures include further safeguards or functions designed into the equipment, such as limiting the power, speed or range of movement that is available to dangerous parts or providing protection during maintenance operations. Examples are:

(a) providing temporary guards;
(b) limited movement controls;
(c) crawl speed operated by hold-to-run controls;
(d) using a second low-powered visible laser beam to align a powerful invisible one.

Isolation, lock off, temporary guarding, safety devices and safe systems of work should be applied as necessary. All safeguards should be replaced before the machine is tested under power or returned to service.

The necessary level of competence will vary according to the type of equipment and where and how it is used. For some equipment, the level of competence to determine the nature of the inspections or even to carry them out may not be available in-house, in which case the help of another body with relevant competence will be needed.

Employers must ensure that those using work equipment have received adequate training for the purposes of health and safety, including:

- training in the methods that may be adopted when using the work equipment
- the risks that such use may entail
- the precautions to be taken

More guidance and information about training and competence can be found on the HSE website at Training and competence and Competence.

Users have duties under the Provision and Use of Work Equipment Regulations 1998 (PUWER). PUWER requires all equipment whether it is new, existing or second-hand provided for use at work:

- to be suitable for the purpose for which it is used or provided;
- to be maintained in an efficient state, in effective working order and in good repair;
- employers to ensure that measures are taken which are effective to prevent access to any dangerous part of machinery or to stop the movement of any dangerous part of machinery before any part of a person enters a danger zone.
- employers to ensure that all persons who use, supervise or manage the use of work equipment have available to them adequate health and safety information and, where appropriate, written instructions pertaining to the use of the work equipment.
employers to ensure that all persons who use, supervise or manage work equipment have received adequate training for purposes of health and safety, including training in the methods which may be adopted when using the work equipment, any risks which such use may entail and precautions to be taken.

Guidance on PUWER is contained in the Approved Code of Practice, Safe use of work equipment.

For further information, see previous sections on 'risk assessment' and 'maintenance'.

**Legal duties**

**BUYERS of rotational moulding machines**

New machinery must be designed and constructed to comply with the Machinery Directive (2006/42/EC), which is implemented in the UK by the Supply of Machinery (Safety) Regulations 2008 (as amended).

We have these laws to make sure that manufacturers and suppliers provide safe work equipment. This means that, when this equipment is used correctly and safely, the risk of accidents and ill health occurring is reduced.

The Supply of Machinery (Safety) Regulations 2008 (SMSR) require that machinery:

- is safe when supplied
- comes with a Declaration of Conformity and user instructions in English; and
- is CE marked

The purchaser/user of a machine, usually 'the employer' is responsible for specifying and ensuring that it is safe. A risk assessment must be carried out on new machinery.

Users are required by PUWER to check it complies with all relevant supply laws, this means checking that it complies with the above requirements and that it is free from any obvious defect (such as missing or damaged guards).

Guidance on the SMSR for machinery designers, manufacturers and/or suppliers can be found at the following links:

- HSE New machinery and Essential health and safety requirements (EHSRs) of the Machinery Directive
- Department for Business, Energy & Industrial Strategy BEIS) Machinery manufacturers: legal responsibilities
## Existing machines

The safeguarding requirements for existing machines are covered by PUWER (see Legal duties).

## Legal duties

**IMPORTERS and MANUFACTURERS of rotational moulding machines**

In some cases, SMSR applies to others including:

- importers of non-CE-marked equipment from outside the EU;
- those who design and construct machinery for their own use.

Links to guidance can be found in the previous section.

## References and further information


- HSE webpages [health and safety in the plastics industry](https://www.hse.gov.uk/plastics/)

- British Plastics Federation Plastipedia - [rotational moulding](https://www.bpf.org.uk/plastipedia/)

- Further industry guidance can be obtained from the [British Plastics Federation](https://www.bpf.org.uk/).


- BS EN ISO 13857:2008 - Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs.

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


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- Health and Safety Executive – Judith Botwood