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Interlocks as machine safety devices

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Multiple configurations, types, and approaches U.S. and abroad

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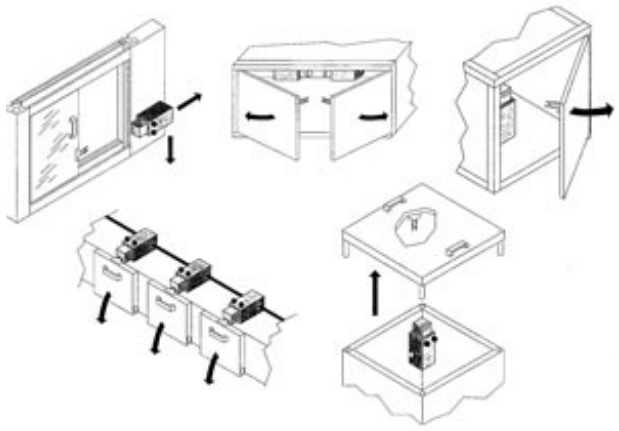
Interlocks serve as safety devices on industrial equipment and many consumer products. This article explains some applications, describes different types of interlocks, and provides recommendations for resources that can help you determine the requirements for interlocks, along with their advantages and disadvantages.

An interlock can be defined as a device that prevents you from making an inappropriate maneuver, or adjusts the system to a safe state if you make an inappropriate maneuver.



In the context of safety, interlocks can prevent a user from making unsafe actions, or minimize the hazard of unsafe actions by rendering the machine in a safe condition when an unsafe maneuver occurs. For example, a guard may be interlocked to prevent machine operation when a guard is removed, or a control may be interlocked to make it nonoperational if a dangerous condition will result. Safety interlocks may have additional or combined features to reduce hazards.

Interlock Examples

Many product standards mandate interlocks in both industrial equipment and in everyday consumer products. Examples of consumer products incorporating interlocks are:

- Removal of a guard on a food processor prevents the operation of the motor and blade, thereby reducing the opportunity for spinning blade injury (example of guard).
- Removal of the filter access door on a forced-air furnace prevents operation of the blower motor and possible contact with the blower blade and/ or combustion gas recirculation hazard (example of guard and secondary hazard of recirculation).
- The gear shift selector on a car allows the engine to start in Park position only, which prevents the operator from starting the engine in gear and the possible unexpected vehicle movement (control example).
- The inability to open the door on a clothes washer during the high-speed extraction cycle either prevents access to the spinning drum or stops the drum's rotation upon door opening (example of either guard or control feature).

While many often think an "interlock" is simply a safety method that relies on an electromechanical switch (like a limit or magnetic switch) to perform the interlock feature, modern interlocking mechanisms may take the form of other sensors and actuators. Many interlock switch providers currently have multipole magnetic switches, unique-shaped keyswitches, and hidden features buried within structural components.

The single-beam light curtain at the bottom of a garage door acts as an interlock to reverse the door so it can't close on a child or animal. The deadman control on a modern snow thrower (ANSI B71.3) acts as an interlock by placing the snow thrower in a safe condition (engine off or blade brake on) when the user leaves the controls to reach into the discharge chute. The thermocouple on a gas stove prevents the release of unburned gas if there is no ignition of the gas. A light curtain, a captured lever device, and a thermocouple are examples of interlock sensors and actuators.

Standards

Several safety standards address both interlocked guarding and interlocked controls on industrial equipment. American National Standards Institute (ANSI) standard B11.1- 1982 for mechanical power presses defines an "Interlocked Press Barrier Guard" as:

> *2.22.3 A barrier interlocked so that the press stroke cannot be started normally unless the guard itself, or its hinged or movable sections, encloses the point of operation.*

Paragraph 3.5.2.10 of the same standard, "Press-Drive Motor Interlock," addresses controls:

> *The clutch/ brake control shall incorporate an interlock means to prevent initiation or continued activation of the single-stroke or continuous functions unless the press-drive motor is energized and in the forward direction.*

The ANSI standard for "Hydraulic Power Presses," B11.2-1995, does not define the term "interlock" while requiring "interlocks" on certain barrier guards. This standard also defines other terms for devices that can act as an interlock safety device. For example, a control that prevents a cycle operation under hazardous conditions could be considered an interlock device. ANSI B11.2 uses the terms below for these interlock functions:

> *3.3 Antirepeat: The part of the control designed to limit the press to a single cycle even though the actuating mechanism is held in the operated position.*
>
> *3.10.1 Presence sensing device: A device designed, constructed, and arranged to create a sensing field or area or plane that will detect the presence of the operator's hands or other body parts.*

In essence, both antirepeat and presence sensing devices can and do work as safety interlocks.

We often find machine interlocks required by standards or provided based on custom and practice. Additional exemplar domestic and foreign standards regarding interlocks include:

- ANSI B11.19, "Performance Criteria for Safeguarding"
- ANSI/ RIA R15.06, "Safety Requirements for Industrial Robots and Robot systems"
- ISO 14119 (EN 1088), "Safety of Machinery-Interlocking Devices Associated With Guards"

Other Criteria and Risks

Interlocks may be a standard required item for certain features on industrial metalworking machines or an "add on" for other situations. These considerations may be based on U.S. domestic criteria, or criteria from abroad. In the publication *Guide to Machinery Safety*, (Pilz Automation Technology, 6th edition), electrical control interlocks are discussed both in terms of European Union (EU) standards and custom and practice. That publication states:

> *Electrical control interlocks are common where rapid or frequent access is required into a machine. (para. 5.1.2)*

In the "British Standard Code of Practice for Safety of Machinery," BS 5304, Chapter 9 describes "Interlocking Considerations." This standard addresses both guard and braking interlocking and the failure mode needs of interlocks.

An example of U.S.-based nonmandatory criteria for interlocks is included in the National Safety Council publication *Safeguarding Illustrated Concepts*(7th edition, 2002), which uses the term "interlocked" as one of the three categories of point-of-operation guard types (other choices are "fixed" or "adjustable") that are recommended. This publication offers examples of interlocked features on industrial machines or devices, several of which are not required by codes. These examples include an interlocked safety prop on a hydraulic press, an interlocked barrier guard on a bagging machine, and an interlocked clean-out door.

This NSC publication also provides a list of interlock guard advantages and disadvantages. It identifies safety upsides of interlocks, such as "maximum protection" and ease of "access"; downsides relate to "reliability" and "defeatability."

The Occupational Safety and Health Administration (OSHA) publication "Concepts and Techniques of Machine Safeguarding," OSHA 3067, discussion and ranking of interlock guarding is similar to the NSC publication (although it lists interlocks second in a grouping of four options for guards). The OSHA publication also lists certain disadvantages of interlocks.

Many machines are not required to have interlocks per OSHA criteria, but interlocks may be required by other voluntary standards or by custom and practice. Certainly, the decision to have a voluntary interlock system, or a mandatory interlock device, relies heavily on a well-designed, high-reliability configuration.

As noted in General Electric's product catalog (3682-5K-0903, 2003, GE Interlogix Industrial), the European Standards EN-954-1 and EN 1050 "Risk assessment of control circuits" references the "likelihood of occurrence [of injury] if a safety interlock fails" in the risk assessment. Those standards discuss the issues of "redundancy," "self-checking," and "redundancy and self-checking." One publication goes so far as to include an interlock in a category of devices that also may "...increase the danger of the protected system." [1]This appreciation of the potential for poorly designed interlocks to fail is recognized in the OSHA criteria for lockouts.

> *Interlocks for electrical equipment may not be used as a substitute for lockout and tagging procedures.*[2]

The rationale for this consideration is contained in the National Fire Protection Association "Electrical Standard for Industrial Machinery," NFPA 79.

Collectively these various mandatory codes, voluntary standards, foreign and domestic criteria, and fail-safe

considerations identify some philosophical aspects of interlocks on industrial equipment. The reader is encouraged to consult these sources for applying interlocks to industrial equipment.

[1] *"On Classification of Safeguard Devices," Safety Brief, R.L. Barnett, April 1981, v.1, N.1.*
[2] *29CFR 1910.333(b)(2)(B)*

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