Introduction to emergency stops

An emergency stop (E-Stop) is a device that is often referenced in applications where human and machine safety is required. An E-Stop provides a safe and quick disconnection of power in emergency situations. However, rigorous codes and standards must be met in order to ensure the desired result is achieved.

The purpose of this white paper is to provide education on the many different features that make E-Stops different from traditional pushbuttons. This document will cover standards that define the purpose and performance of this fail-safe operator. In addition, some engineering features that prevent this critical device from operating and/or resetting prematurely will be covered. Please note that this document does not replace any local, state and national codes, but is intended to be an overview of E-Stops.

What is an E-Stop?

There are many domestic and international codes that help define this special operator. An E-Stop is a manually operated device, activated by a single human action, which is designed to open a circuit to one or more pieces of equipment without creating any additional hazards. This device must remain in its actuated (open) position until normal operation can be restored. Only then can the circuit be reset to resume normal operation.

What are the parts of an E-Stop?

There are three main components of an E-Stop:

Actuator

The actuator is the component of the E-Stop that is the interface to the human operator. Once pressed, the actuator will mechanically change the state of the contact block. Normally colored red per code, this portion of the E-Stop comes in different sizes. The three different ways to reset an actuator will be discussed in detail later.

Contact block

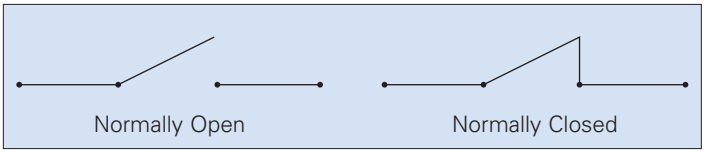
The contact block is where the wiring terminals are located. Contact blocks are built in two different contact configurations: normally open (NO) and normally closed (NC). The different configurations refer to the initial position of the contact before it is actuated. Normally closed contacts are commonly used in E-Stop applications. Stackable contact blocks allow Eaton E-Stops the ability to lock out up to six separate circuits on one actuator. Indicating methods, such as a light emitting diode (LED) or a mechanical switch display are also available, which can help an operator to determine the state of an E-Stop at a glance.

Contact block housing

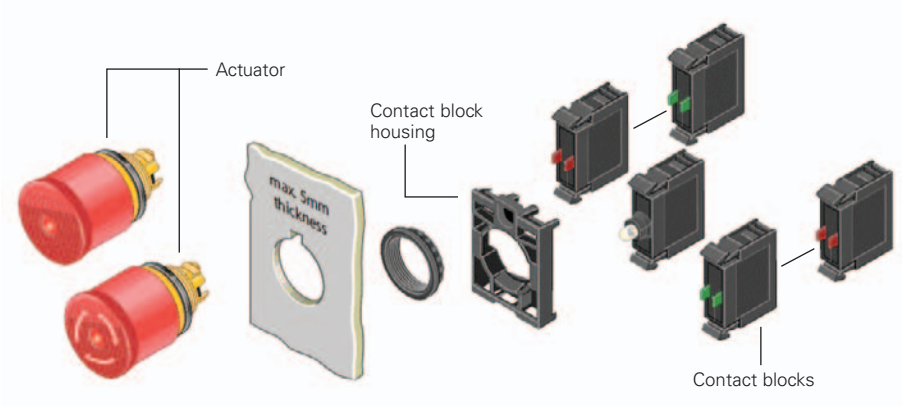
The housing is the part that connects the actuator to the contact blocks. Eaton includes this part with the actuator at no additional charge to the customer.

How does an E-Stop work?

When an emergency occurs, an operator will press the E-Stop actuator to begin the E-Stop sequence. The actuator will mechanically actuate a normally closed contact, which will open the circuit. As a result, power supplied to the equipment will be disconnected, ensuring the equipment stays off until intentionally reactivated.



Schematic of normally open and normally closed contact blocks



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E-Stop actuator types

There are three common types of pushbutton style E-Stops.

Push-pull

To operate the contact, the actuator is pushed in and locked into position. To reset the E-Stop, pull the actuator back to its original position.

Push-pull actuators

Turn-to-release

To operate the contact, the actuator is pushed in and locked into position. To reset the E-Stop, turn in the direction indicated on the actuator.

Turn-to-release E-Stop with luminous ring and self-monitoring contact block

Key release

To operate the contact, the actuator is pushed in and locked into position. To reset the E-Stop, unlock using a removable key provided with the E-Stop.

Key release actuator

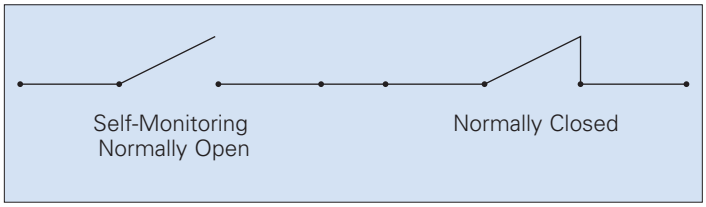
Accessories

In addition to multiple release configurations, there are many innovative accessories to ensure safety and convenience. Standard accessories include guard rings, shrouds, enclosures and LEDs. There is also a tamper-proof sealing shroud that will completely cover an E-Stop. This shroud does not violate code because the E-Stop can be operated while enclosed. Two unique accessories include the luminous ring and self-monitoring contact, described below.

Self-monitoring contact blocks

The self-monitoring contact aids an operator in ensuring that the E-Stop is always operational and ready for an emergency situation. The self-monitoring contact block controls an additional normally open contact for the purpose of monitoring its attachment to the actuator. When this contact is correctly connected to the actuator, the SMCB will close, completing the circuit. This normally open contact is typically wired to a stack light, audible alarm or indicating light. If contact becomes separated from the actuator, this SMCB contact signals either a stack light, audible alarm or indicating light.

Self-monitoring contact blocks



Schematic of self-monitoring normally open contact blocks

Luminous ring

The luminous ring fits as a backplate to the E-Stop with LEDs that illuminate the yellow ring. This feature allows for an E-Stop to easily stand out in a dark or dimly lit environment. The luminous ring reliably indicates the operating state from long distances. In the activated state, three separately controllable LED rows can be activated as a running light.

Luminous ring

E-Stop head and hole sizes

Eaton offers E-Stops in standard 22 mm and 30 mm sizes. Additionally, a 16 mm size is in development. Note that this size references the diameter of the hole needed for the E-Stop installation, not the head size of the E-Stop actuator. The actuator area is commonly referred to as the head size. Eaton offers many different actuator head sizes.

Standards

Several standards that regulate proper operation and application of the E-Stop include the following:

ISO® 13850

ISO 13850 is a British standard for safety of machinery, which specifies the requirements of E-Stop principles for design.

- 4.1.4
  The E-Stop shall function in accordance with either of the following stop categories
  - Stop Category 0
    Stopping by means of immediate removal of power to the machine actuator(s),
    OR
    Mechanical disconnection (declutching) between the hazardous elements and their machine actuator(s), and if necessary, braking
  - Stop Category 1
    A controlled stop with power to the machine actuator(s) available to achieve the stop and then removal of power when the stop is achieved
- 4.4.2
  An E-Stop device shall be located at each operator control station, except where the risk assessment indicates that this is not necessary, as well as at other locations, as determined by the risk assessment. It shall be positioned such that it is readily accessible and capable of non-hazardous actuation by the operator and others who may need to actuate it. Measures against inadvertent actuation should not impair its accessibility
- 4.4.4
  In the case of failure in the E-Stop device (including sustaining function), generation of the stop command shall have priority over the sustaining function. Resetting (e.g., disengaging) of the E-Stop shall only be possible as the result of a manual action at the location where the E-Stop was activated
- 4.4.5
  The actuator of the E-Stop device shall be colored red. When a background exists behind the actuator, and as far as it is practicable, the background shall be colored yellow

ISO 13850 (per IEC 60947-5-5 6.2.1)

When the emergency stop signal has been generated during actuation of the E-Stop device, the emergency stop function shall be maintained by latching of the actuating system. The emergency stop signal shall be maintained until the E-Stop device is reset (disengaged). It shall not be possible for the E-Stop device to latch-in without generating the emergency stop signal. In case of failure in the E-Stop device (including the latching means), the generation of the emergency stop signal shall have priority over the latching function

IEC 60947-5-5

IEC 60947-5-5 is a European standard for control-circuit devices and switching elements, which specifies the requirements for electrical E-Stop device with mechanical latching function.

- 3.1
  E-Stop function or signal that is intended
  - To avert or to reduce hazards to persons, damage to machinery or to work in progress
  - To be initiated by a single human action
- 4.2.1
  Buttons used as actuators of an E-Stop device shall be colored red. When a background exists behind the actuator, and as far as it is practicable, the background shall be colored yellow
- 4.2.2
  The direction of unlatching shall be clearly identified when resetting is achieved by rotation of the button
- 6.3.1
  The resetting of the latching means shall be by turning a key, by rotation of the button in the designated direction, or by a pulling motion
- 6.3.2
  The E-Stop device shall be so designed that removal of the actuator is from the inside of the enclosure only, or from the outside of the enclosure by use of a tool intended for that purpose. This shall be verified by inspection

IEC 60204-1

IEC 60204-1 is a European standard for safety of machinery, which specifies the requirements for electrical equipment of machines. This standard also states some requirements for an E-Stop.

- 9.2.5.4.1
  This part of IEC 60204 specifies the requirements for the E-Stop and the emergency switching off functions of the emergency operations listed in Annex E, both of which are, in this part of IEC 60204, initiated by a single human action. Once active operation of an E-Stop (see 10.7) or emergency switching off (see 10.8) actuator has ceased following a command, the effect of this command shall be sustained until it is reset. This reset shall be possible only by a manual action at that location where the command has been initiated. The reset of the command shall not restart the machinery, but only permit restarting. It shall not be possible to restart the machinery until all E-Stop commands have been reset. It shall not be possible to re-energize the machinery until all emergency switching off commands have been reset.
- 10.2
  The color red shall be used for E-Stop and emergency switching off actuators.
- 10.7.1
  Devices for E-Stop shall be readily accessible. E-Stop devices shall be located at each operator control station and at other locations where the initiation of an E-Stop can be required.
- 10.7.2
  The types of E-Stop devices include:
  - A pushbutton operated switch with a palm or mushroom head type
  - A pull-cord operated switch
  - A pedal-operated switch without a mechanical guard

  The devices shall have direct opening operation
- 10.7.3
  Actuators of E-Stop devices shall be colored red. If a background exists immediately around the actuator, then this background shall be colored yellow

NFPA 79

NFPA 79 is a North American electrical standard for industrial machinery.

- 10.7.1.1
  Stop and E-Stop pushbuttons shall be continuously operable and readily accessible
- 10.7.1.2
  Stop or E-Stop pushbutton shall be located at each operator control station and at other locations where E-Stop is required
- 10.7.2.2
  Pushbutton-type devices for E-Stop shall be of the self-latching type and shall have direct opening operation
- 10.7.3
  Actuators of E-Stop devices shall be colored red. The background immediately around pushbuttons and disconnect switch actuators used as E-Stop devices shall be colored yellow. The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type and shall affect an E-Stop when depressed. The red/yellow color combination shall be reserved exclusively for E-Stop applications
- 10.8.2.2
  The pushbutton-operated switch shall be permitted in a break-glass enclosure
- 10.8.3
  It shall not be possible to restore an emergency switching off circuit until the emergency switching off circuit has been manually reset
- 10.9
  Displays (e.g., visual display units, alarm annunciators, indicator lights and the action-initiating icons of graphic interface devices) shall be selected and installed in such a manner as to be visible from the normal position of the operator

Definitions

Actuator (per IEC 60947-5-5)

The part of the actuating system that is actuated by a part of the human body.

Latching of an E-Stop device (per IEC 60947-5-5)

Function or means which engages and maintains the actuating system in the actuated position until reset by a separate manual action.

E-Stop device (per IEC 60204-1)

Manually actuated control device used to initiate an emergency stop function.

Emergency switching off device (per IEC 60204-1)

Manually actuated control device used to switch off the supply of electrical energy to all or a part of an installation where a risk of electric shock or another risk of electrical origin is involved.

(Per NFPA 79)

An emergency operation intended to switch off the supply of the electrical energy to all or part of an installation.

Resetting of an E-Stop device (per IEC 60947-5-5)

Manual action of returning the actuating system of the E-Stop device from the actuated position to the rest position.

Direct opening action of a contact element (per IEC 60204-1)

Achievement of contact separation as the direct result of a specified movement of the switch actuator through non-resilient members (for example, not dependent upon springs).

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