

Emergency Stop Push Buttons

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Introduction

Many users of emergency stop devices are familiar with their use, but are not familiar with many of the global governing standards. The purpose of this white paper is to familiarize the reader with some of the standards that exist and highlight some of the important issues in these standards. This is not a fully encompassing discussion and the reader is expected to comply with all performance and safety requirements, including any applicable laws, regulations, codes, and standards.

Emergency Stop

Function Definition

According to EN ISO 13850 an emergency stop function is a function that is intended:

- to avert arising or to reduce existing hazards to persons, damage to machinery or to work in progress;
- to be initiated by a single human action when the normal stopping function is inadequate for this purpose.

Hazards for the purpose of this standard are those which may arise from:

- functional irregularities (malfunctioning of the machinery, unacceptable properties of the processed material, human errors);
- normal operation.

Simply put, an emergency stop function is a function that is initiated by a human action and is intended to shut down equipment in the case of an emergency.

Device Definition

The emergency stop device is a manual control device. It is the method of initiating the emergency stop function. The actuator of an emergency stop device is the component that is actuated by a person. Examples of actuators include – mushroom-type push buttons, ropes, wires, etc....

For the purposes of this paper, however, any further references to an Emergency Stop will mean a mushroom-type push button.

Properties of Emergency Stop Push Buttons

Colors and Appearance

According to EN/IEC 60947-5-5, EN/IEC 60204-1, and EN ISO 13850, buttons used as actuators of an emergency stop device shall be colored red. When a background exists behind the actuator, and as far as it is practicable, it shall be colored yellow. Most suppliers of push buttons accomplish the yellow background in one of three ways:

1. Use of a yellow enclosure.
2. Use of a large Emergency Stop legend that is yellow.
3. Coloring the “stem” of the push button yellow.

Note: Use of a yellow guard is also accepted in some industries, though this is not typically allowed. This will be discussed in more detail later in the paper.

NFPA 79 has the same aforementioned color requirements, but takes it a step further stating: “The RED/YELLOW color combination shall be reserved exclusively for emergency stop applications.” NFPA 79 also requires the actuator be a mushroom-head or palm type. The mushroom-head shape is also a requirement of EN/IEC 60204-1 and EN ISO 13850. Mushroom-head means that the top of the button must be extended and rounded like the top of a mushroom. Traditionally, European emergency stop push buttons are actually shaped like a cone with a rounded top (Figure 1), while in North America emergency stops are shaped more like a traditional mushroom (Figure 2). The perceived advantage of the cone shape is that if an object is hung on the stem of the push button, the cone may lift the object out of the way and still operate.

Figure 1



Cone-shaped
Emergency Stop

Figure 2



Mushroom-shaped
Emergency Stop

EN/IEC 60947-5-5: Low-voltage switchgear and controlgear Part 5-5. Control circuit devices and switching elements – Electrical emergency stop devices with mechanical latching function

EN and IEC 60204-1: Safety of machinery – Electrical equipment of machines – Part 1: General requirements

EN ISO 13850: Safety of machinery – Emergency stop – Principles for design NFPA 79: Electrical Standard for Industrial Machinery

Figure 3



Molded-In Arrow

Figure 4



Ink-stamped Arrow

Figure 5



Color-molded Arrow

Yet another appearance requirement comes from EN/IEC 60947-5-5. Section 4.2.2 indicates that if an emergency stop push button is a twist-to-reset variety then the “direction of unlatching shall be clearly identified”. Most suppliers of push buttons accomplish this in one of four ways:

1. Use of arrows molded into the button caps with a different texture. This identification method can be difficult to see in low ambient light conditions. (Figure 3)
2. Use of arrows that are ink stamped onto the button cap. While this provides good contrast in the beginning, the ink can easily wear away leaving no indication at all. (Figure 4)
3. Use of arrows that are molded into the button cap with a different color plastic, usually a white plastic. This method provides the advantage of good contrast and long life. (Figure 5)
4. Use of arrows that are laser-engraved on the button cap. This method provides the advantage of good life and better contrast than molded in arrows, but the contrast is not as good as two-color molded caps.

Mechanical Latching Function

NFPA 79 requires that push button emergency stops be of the “self-latching” type. This means that after an emergency stop actuator is depressed and the contacts open, the emergency stop device must remain in the actuated position until deliberate reset. The European standards go a step further and explicitly state it should not be possible to generate an emergency stop signal, i.e. opening the contacts, without the actuator latching in. This requirement is sometimes referred to as “anti-tease”. The European standards also indicate that it should not be possible to latch in the actuator without generating an emergency stop signal.

Finally, the European standards dictate that in the event of a failure in the emergency stop device, the contact function should take priority over the latching function. In reality, most North American designs comply with these requirements. Some older designs may accomplish this through the requirement of special contact blocks, such as normally closed late break contacts.

Resetting the operator means that a person manually intervenes and unlatches the actuator. Examples of resetting include the rotation of the actuator, pulling the actuator, or inserting and turning a key. In North America, the most popular method of resetting an emergency stop is the pull-to-release mechanism. In Europe, the most popular method of resetting an emergency stop has traditionally been rotating the actuator, sometimes called twist-to-release. However, in recent years, the pull-to-release operator has become popular, largely due to perception that it is much less likely that someone will bump a pull-to-release device and unlatch it as compared to a twist-to-release device. Some manufacturers offer both products so that the user can choose.

One of the key points of the European and North American standards is that resetting the emergency stop device should not cause a restart command. This means that in order to restart the equipment, a person must initiate another start command. This is typically accomplished in a 3-wire system.

While many end users in North America use a maintained push button for an emergency stop, NFPA does still allow exceptions. Momentary devices are allowed in some instances when there is an additional manual reset. This is based more on past tradition as the number of momentary devices used as emergency stops in North America continues to decline.

Direct Drive

NFPA 79, EN/IEC 60204-1, and EN ISO 13850 require that emergency stops must be a direct drive design. A direct drive design switch will have continuous mechanical linkage from the external operating member to the contact carrier. It will not employ the use of any resilient members or springs in the mechanical actuating path to open the N.C. contacts.

EN/IEC 60947-5-1: Low-voltage switchgear and controlgear Part 5-1. Control circuit devices and switching elements — Electro-mechanical control circuit devices

A special case of direct drive design is a switch that complies with EN/IEC 60947-5-1. It is designed so that contact separation will take place even though the contacts may have been welded or “sticking” during fault circuit conditions. A direct drive switch is designed to allow contact separation even if the contacts have been lightly welded during fault circuit conditions. The manufacturer provides the fusing level requirements needed to protect these contacts from welding. The actuator movement and actuator force required affecting contact separation are specified by the switch manufacturer.

This type of switch construction is used to help ensure that contact action takes place when the external operating member is actuated. By avoiding the use of any springs in the actuating path, a solid connection is provided directly from the external mushroom operator to the contacts. Contact opening should always take place at the same point in the actuating stroke and with the same operating force. By their nature, these types of switches fall into the slow break/slow make category of devices although some special designs have been developed that provide positive opening in snap action devices. With increased awareness of safety concerns and the movement toward designing devices that are used globally, greater emphasis has been placed on the direct drive feature.

Tamper Resistant

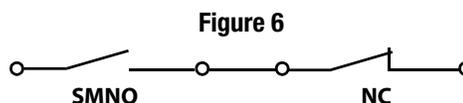
This simply means that the emergency stop cannot easily be removed from the enclosure or cannot easily be tampered with. The European standards state that an emergency stop actuator should be constructed so that it can only be removed from the inside of a panel. Removal from the outside of the panel is acceptable if it requires a tool. Again, most NEMA type designs fully comply with these European standards because they require tools for removal.

Mechanical Life

One of the more interesting parts of the European standards is the mechanical life requirements. Emergency stop push buttons are only required to be tested to 6,050 operations. This implies that emergency stop push buttons are not meant for everyday use. They are only to be used in emergencies.

Self-Monitoring (Guardian) Contact Blocks

Self-monitoring (or guardian) contact blocks (SMCB) utilize a unique, patented contact arrangement that monitors the installation of contact blocks to the actuator. There is a normally open contact (SMNO) that is held closed when the contact block is properly installed on the actuator. This normally open contact is wired in series with the normally closed contact (Figure 6). The normally closed contact operates as a standard contact with the operator. If the contact block is detached from the actuator the normally open contact opens and an emergency stop command is issued. The SMCB does not take the place of a safety relay, which monitors the contact for a change of state.



Schematic of internal wiring of a self-monitoring (guardian) contact block (D7-X01S)

The main goal of the SMCB is to increase reliability. It is clear that a contact block that separates from the actuator can cause a very dangerous scenario. If an actuator is operated and the contacts have separated from the actuator, the emergency stop function will not be initiated and the equipment/process will not be stopped.

There are several reasons that a contact block could separate from an actuator.

1. Improper Installation - this could be due to any of the following examples:
 - Contact block/latch not re-installed after maintenance
 - Contact block mounting screws over/under tightened
 - Contact block/latch not completely “snapped-on”
2. Physical damage
3. Extreme vibration

Safeguarding

Emergency stop devices are not a replacement for proper safeguarding or automatic safety devices. Rather, they should be used as a back-up measure. In addition, the activation of the emergency stop should not impair the effectiveness of other safety devices. EN/IEC 60204-1 state that emergency stop devices must be easily accessed and operated and therefore seems to prohibit guards or shrouds in the installation. While this is generally accepted, there are certain industries/applications which do not follow this standard. An example of such an industry is the semiconductor industry in the United States. The SEMI standards actually allow a guard to prevent accidental operation. It is up to the user to determine if a guard is acceptable, but for most users it is not.

Another form of safeguarding appears on the contact blocks and power modules themselves. It is known as “finger-safe protection”, meaning a person can not inadvertently come in contact with a current carrying terminal or member. EN/IEC designs are required to be finger-safe. NEMA designs traditionally were not finger-safe, but many manufacturers of NEMA equipment now offer finger-safe designs. There are some US standards that are also starting to require finger safety for some applications.

Other Properties

There are many other requirements that are called out in various standards for the manufacturers and users of emergency stop push buttons. These requirements are too detailed to cover in this document, but one should be aware that they exist. They include but are not limited to shock and vibration, utilization categories, force requirements, stop categories, risk assessments, and most importantly local codes and installation requirements which are the responsibility of the user.

Conclusion

There are many global standards that govern emergency stop design and installation. And while there are some discrepancies, the global standards organizations are quickly moving to more uniform standards. This document briefly mentions some applicable standards from the US and Europe, but it is not all-inclusive. The standards mentioned are readily available and provide a detailed description. It is the responsibility of the designer and installer to know the applicable standards, safety requirements, laws, codes, and regulations.



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