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Electrical Standard for Industrial Machinery

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3.3.35 Electromechanical. Any device in which electrical energy is used to magnetically cause mechanical movement.

3.3.36 Electronic Equipment. That part of electrical equipment containing circuitry mainly based on electronic devices and components.

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

3.3.38 Enabling Device. Manually operated control device used in conjunction with a start control, when continuously actuated, will allow a machine to function.

3.3.39 Enclosure. The case or housing of apparatus, or the fence or walls surrounding an installation to prevent personnel from accidentally contacting energized parts or to protect the equipment from physical damage. [70:100]

3.3.40 Energized. Electrically connected to, or is, a source of voltage. [70:100]

3.3.41 Equipment. A general term including material, fittings, devices, appliances, luminaires (fixtures), apparatus, and the like used as a part of, or in connection with, an electrical installation. [70:100]

3.3.42 Exposed (as applied to live parts). Capable of being inadvertently touched or approached nearer than a safe distance by a person. It is applied to parts not suitably guarded, isolated, or insulated. [70:100]

3.3.43* Failure (of equipment). The termination of the ability of an item to perform a required function.

3.3.44* Fault. The state of an item characterized by inability to perform a required function, excluding the inability, during preventive maintenance or other planned actions, or due to lack of external resources.

3.3.45 Feeder. All circuit conductors between the service equipment, the source of a separately derived system, or other power supply source and the final branch-circuit overcurrent device. [70:100]

3.3.46 Flame Retardant. So constructed or treated that it will not support flame.

3.3.47 Ground. A conducting connection, whether intentional or accidental, between an electrical circuit or equipment and the earth, or to some conducting body that serves in place of the earth. [70:100]

3.3.48 Grounded. Connected to earth or to some conducting body that serves in place of the earth. [70:100]

3.3.49 Grounded Conductor. A system or circuit conductor that is intentionally grounded. [70:100]

3.3.50 Grounding Conductor. A conductor used to connect equipment or the grounded circuit of a wiring system to a grounding electrode or electrodes. [70:100]

3.3.51 Grounding Conductor, Equipment. The conductor used to connect the noncurrent-carrying metal parts of equipment, raceways, and other enclosures to the system grounded conductor, the grounding electrode conductor, or both, at the service equipment or at the source of a separately derived system. [70:100]

3.3.52* Guard. Part of a machine specifically used to provide protection by means of a physical barrier.

3.3.53 Hazard. A source of possible injury or damage to health.

3.3.54 Hazardous Condition. A circumstance in which a person is exposed to a hazard(s) that has the potential to result in harm immediately or over a long period of time.

3.3.55* Identified (as applied to equipment). Recognizable as suitable for the specific purpose, function, use, environment, application, and so forth, where described in a particular code or standard requirement. [70:100]

3.3.56 Industrial Machinery (Machine). A power-driven machine (or a group of machines working together in a coordinated manner), not portable by hand while working, that is used to process material by cutting; forming; pressure; electrical, thermal, or optical techniques; lamination; or a combination of these processes. Machine can include associated equipment used to transfer material or tooling, including fixtures, to assemble/disassemble, to inspect or test, or to package. [The associated electrical equipment, including the logic controller(s) and associated software or logic together with the machine actuators and sensors, are considered as part of the industrial machine.] [70:670.2]

3.3.57 Industrial Manufacturing System. A systematic array of one or more industrial machines that is not portable by hand and includes any associated material handling, manipulating, gauging, measuring, or inspection equipment. [70:670.2]

3.3.58 Input. The terminals where current, voltage, power, or driving force may be applied to a circuit or device; the state or sequence of states occurring on a specific input channel; or the device or collective set of devices used for bringing data into another device.

3.3.59 Inrush Current (Solenoid). The inrush current of a solenoid is the steady-state current taken from the line at rated voltage and frequency with the plunger blocked in the rated maximum open position.

3.3.60 Inrush Locked Rotor Current (Motor). See 3.3.67, *Locked Rotor Current*.

3.3.61 In Sight From (Within Sight From, Within Sight). Where this standard specifies that one equipment shall be "in sight from," "within sight from," or "within sight," and so forth, of another equipment, the specified equipment is to be visible and not more than 15 m (50 ft) distant from the other. [70:100]

3.3.62 Interlock (for safeguarding). An arrangement that interconnects guard(s) or device(s) with the control system or all or part of the electrical energy distributed to the machine.

3.3.63* Interrupting Rating. The highest current at rated voltage that a device is intended to interrupt under standard test conditions. [70:100]

3.3.64 Jogging (Inching). The quickly repeated closure of the circuit to start a motor from rest for the purpose of accomplishing small movements of the driven machine.

3.3.65 Live Parts. Energized conductive components. [70:100]

3.3.66 Location.

3.3.66.1 Dry Location. A location not normally subject to dampness or wetness. A location classified as dry may be temporarily subject to dampness or wetness, as in the case of a building under construction. [70:100]

9.2.5.4* Emergency Operations (Emergency Stop, Emergency Switching Off). Emergency operation requirements are as follows:

- (1) This section specifies the requirements for the emergency stop and the emergency switching off functions of the emergency operations listed in Annex E, both of which are, in this section, initiated by a single human action.
- (2) Once active operation of an emergency stop (*see Section 10.7*) or emergency switching off (*see Section 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 at that location where the command has been initiated. The reset of the command shall not restart the machinery but only permit restarting.
- (3) It shall not be possible to restart the machinery until all emergency stop commands have been reset. It shall not be possible to reenergize the machinery until all emergency switching off commands have been reset.

9.2.5.4.1 Emergency Stop. Emergency stop functions provided in accordance with 9.2.5.3 shall be designed to be initiated by a single human action.

9.2.5.4.1.1 In addition to the requirements for stop, the emergency stop shall have the following requirements:

- (1) It shall override all other functions and operations in all modes.
- (2) Power to the machine actuators, which causes a hazardous condition(s), shall be removed as quickly as possible without creating other hazards (e.g., by the provision of mechanical means of stopping requiring no external power, by reverse current braking for a Category 1 stop).
- (3) The reset of the command shall not restart the machinery but only permit restarting.

9.2.5.4.1.2 Where required, provisions to connect additional emergency stop devices shall be provided in accordance with Section 10.7.

9.2.5.4.1.3 The emergency stop shall function as either a Category 0 or a Category 1 stop (*see 9.2.2*). The choice of the category of the emergency stop shall be determined by the risk assessment of the machine.

9.2.5.4.1.4* Where a Category 0 or Category 1 stop is used for the emergency stop function, it shall have a circuitry design (including sensors, logic, and actuators) according to the relevant risk as required by Section 4.1 and 9.4.1. Final removal of power to the machine actuators shall be ensured and shall be by means of electromechanical components. Where relays are used to accomplish a Category 0 emergency stop function, they shall be nonretentive relays.

Exception: Drives, or solid state output devices, designed for safety-related functions shall be allowed to be the final switching element, when designed according to relevant safety standards.

9.2.5.4.2 Emergency Switching Off. Where the emergency switching off function is used, it shall be initiated by a single human action.

9.2.5.4.2.1 Emergency switching off shall be permitted as follows:

- (1) Where protection against direct contact (e.g., with collector wires, collector bars, slip-ring assemblies, control gear in electrical operating areas) is achieved only by placing out of reach or by obstacles

- (2) Where other hazards or damage caused by electricity are possible

9.2.5.4.2.2 Emergency switching off shall be accomplished by disconnecting the incoming supply circuit of the machine effecting a Category 0 stop. Where the machine cannot tolerate the Category 0 stop, it shall be necessary to provide other protection (e.g., against direct contact), so that emergency switching off is not necessary.

9.2.5.5 Hold-to-Run Controls.

9.2.5.5.1 Hold-to-run controls (e.g., jog, inch functions) shall require continuous actuation of the control device(s) to achieve operation.

9.2.5.5.2 Jog or inch functions shall operate only in the manual mode. Manual reverse shall be considered a jog function. The prevention of run or automatic operation during jog or inch shall be accomplished by an operator interface and a separate jog or inch selection method.

9.2.5.6 Two-Hand Control. All two-hand controls shall have the following features:

- (1) The provision of two control devices shall require the concurrent actuation by both hands.
- (2) It shall be necessary to actuate the control devices within a certain time limit of each other, not exceeding 0.5 seconds.
- (3) Where this time limit is exceeded, both control devices shall be released before operation is initiated.
- (4) The control devices shall require continuous actuation during the hazardous conditions.
- (5) Machine operation shall cease upon the release of either control device when hazardous conditions are still present.
- (6) Machine operation shall require the release of both control devices, before the machine operation is reinitiated. (*See Annex B.*)

9.2.5.7 Enabling Control.

9.2.5.7.1 An enabling control function incorporating the use of an enabling device shall, when activated, allow machine operation to be initiated by a separate start control and, when deactivated, stop the machine and prevent initiation of machine operation. An enabling device provided as a part of the enabling control function shall be designed to allow motion when actuated in one position only. In any other position, motion shall be inhibited.

9.2.5.7.2 Enabling controls shall have the following features:

- (1) Connect to a Category 0 or a Category 1 stop (*see 9.2.2*)
- (2) Design follows ergonomic principles
- (3) For two-position types, the positions are as follows:
 - (a) Position 1 is the off function of the switch (actuator is not operated).
 - (b) Position 2 is the enabling function (actuator is operated).
- (4) For three-position types, the positions are as follows:
 - (a) Position 1 is the off function of the switch (actuator is not operated).
 - (b) Position 2 is the enabling function (actuator is operated in its mid position).
 - (c) Position 3 is the off function of the switch (actuator is operated past its mid position).
- (5) A three-position enabling control shall require manual operation to reach Position 3. When returning from Position 3 to Position 2, the function shall not be enabled.

Table 10.3.2 Machine Indicator Lights and Icons

Color	Purposes		
	Safety of Persons or Environment	Condition of Process	State of Equipment
RED	Danger	Emergency	Faulty
YELLOW (AMBER)	Warning/ Caution	Abnormal	Abnormal
GREEN	Safe	Normal	Normal
BLUE	Mandatory action		
CLEAR WHITE GRAY BLACK	No specific meaning assigned		

(3) Indicate a discrepancy between the command and actual states

(4) Indicate a change in process (flashing during transition)

10.4 Illuminated Pushbuttons. Illuminated pushbutton actuators shall be color-coded in accordance with Table 10.3.2. The color RED for the emergency stop actuator shall not depend on the illumination source.

10.5 Rotary Control Devices. Devices having a rotational member, such as potentiometers and selector switches, shall be mounted in such a way as to prevent rotation of the stationary member. Friction alone shall not be relied upon to prevent rotation.

10.6 Start Devices. Actuators used to initiate a start function or the movement of machine elements (e.g., slides, spindles, carriers) shall be constructed and mounted to minimize inadvertent operation. Mushroom-type actuators for two-hand control initiation shall conform to 9.2.5.6.

10.7 Devices for Stop and Emergency Stop.

10.7.1 Location and Operation.

10.7.1.1 Stop and emergency stop pushbuttons shall be continuously operable and readily accessible.

10.7.1.2 Stop or emergency stop pushbuttons shall be located at each operator control station and at other locations where emergency stop is required.

10.7.2 Types.

10.7.2.1 The types of devices for emergency stop shall include, but are not limited to, the following:

- (1) Pushbutton-operated switches in accordance with 10.7.2.2 and 10.7.3
- (2) Pull-cord-operated switches
- (3) Foot-operated switches without a mechanical guard
- (4) Push-bar-operated switches
- (5) Rod-operated switches

10.7.2.2* Pushbutton-type devices for emergency stop shall be of the self-latching type and shall have direct opening operation.

10.7.2.3 Emergency stop switches shall not be flat switches or graphic representations based on software applications.

10.7.3 Emergency Stop Actuators. Actuators of emergency stop devices shall be colored RED. The background immediately around pushbuttons and disconnect switch actuators used as emergency stop devices shall be colored YELLOW. The actuator of a pushbutton-operated device shall be of the palm or mushroom-head type and shall effect an emergency stop when depressed. The RED/YELLOW color combination shall be reserved exclusively for emergency stop applications.

Exception: The RED/YELLOW color combination shall be permitted for emergency stop actuators in accordance with 10.8.4.

10.7.4 Local Operation of the Supply Disconnecting Means to Effect Emergency Stop.

10.7.4.1 The supply disconnecting means shall be permitted to be locally operated to serve the function of emergency stop as follows:

- (1) Where it is readily accessible to the operator
- (2) Where it is of the type described in 5.3.2(1), 5.3.2(2), or 5.3.2(3)

10.7.4.2 Where used as an emergency stop, the supply disconnecting means shall meet the color requirements of 10.7.3.

10.7.4.3 Disconnecting (isolating) electrical devices as described in 5.5.4, where accessible to the operator, shall also be permitted to serve the function of emergency stop.

10.8 Devices for Emergency Switching Off.

10.8.1 Location. Emergency switching off devices as described in 9.2.5.4.2 shall be located as necessary for the given application.

10.8.2 Types.

10.8.2.1* The types of devices that initiate an emergency switching off operation shall be permitted to include, but are not limited to, the following:

- (1) Pushbutton-operated switches
- (2) Pull-cord-operated switches

10.8.2.2 The pushbutton-operated switch shall be permitted in a break-glass enclosure.

10.8.2.3 Emergency switching off devices shall not be flat switches or graphic representations based on software applications.

10.8.3 Restoration of Normal Function After Emergency Switching Off. It shall not be possible to restore an emergency switching off circuit until the emergency switching off circuit has been manually reset.

10.8.4 Actuators.

10.8.4.1 Actuators of emergency switching off devices shall be colored RED. The background immediately around the device actuator shall be permitted to be colored YELLOW.

10.8.4.2* Where the emergency switching off initiating device is separate from the emergency stop device, the emergency switching off initiating device shall be functionally identified.

10.8.5 Local Operation of the Supply Disconnecting Means to Effect Emergency Switching Off. Where the supply disconnecting means is to be locally operated for emergency switching off, it shall be readily accessible and shall meet the color requirements of 10.8.4.1.