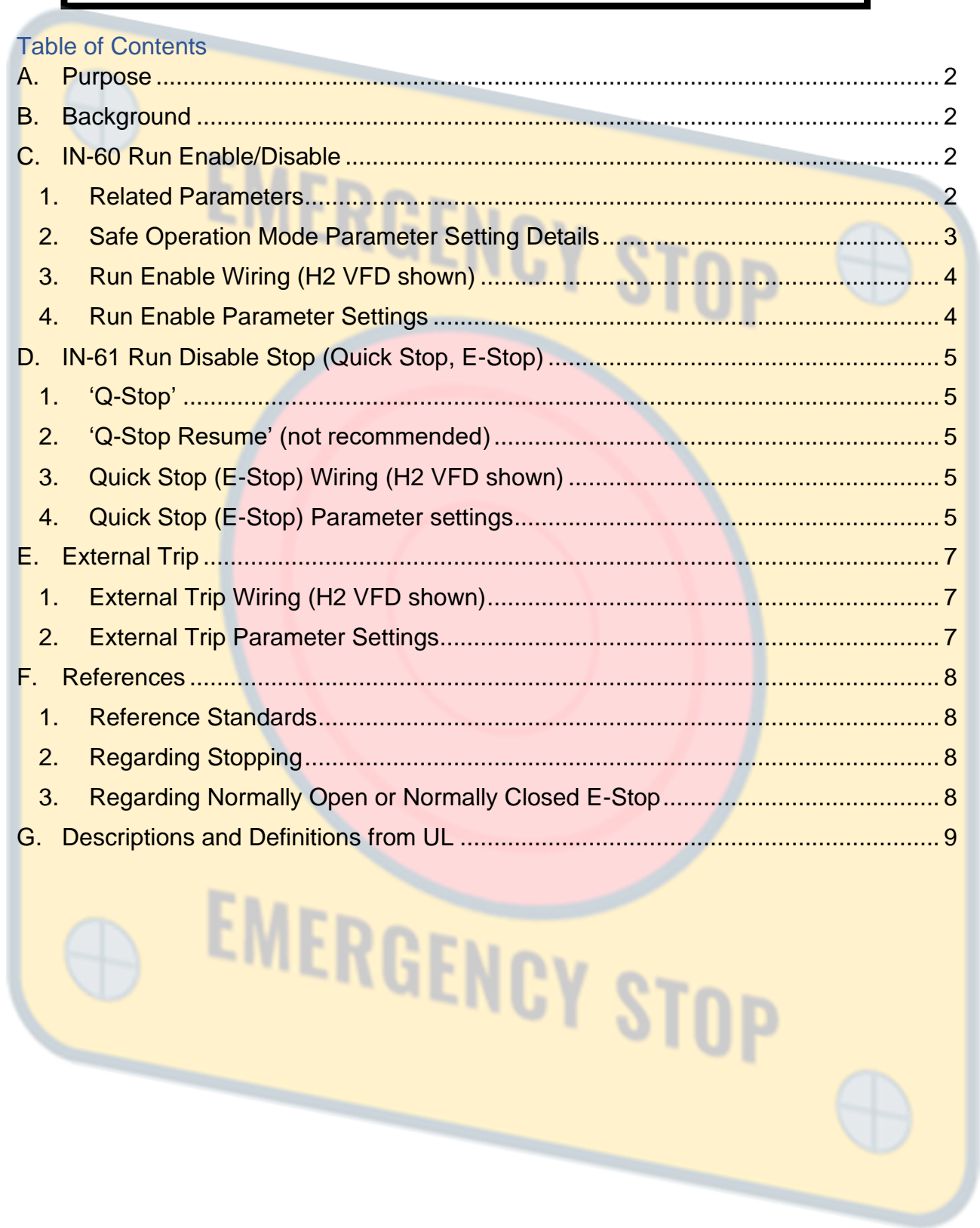


**Benshaw LV VFD's**  
**Run Enable\Disable, E-Stop and External Trip Functions**

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# Benshaw LV VFD's Run Enable\Disable, E-Stop and External Trip Functions

## A. Purpose

- To compare and contrast the Run Enable\Disable, E-Stop and External Trip functions.
- To define the wiring and parameter settings of each.
- Provide definitions of an E-Stop
- What Standards apply to E-Stop?

## B. Background

The H2, GM2, S and SW series LV VFD's all have digital input terminals that can function as a Run Enable/Disable, Quick Stop (E-Stop) and an External Trip. The External Trip function is most commonly used to disable the drive output and has been used as an E-Stop function as it is very easy to set up. However, the **Run Enable/Disable** function is the preferred method to stop a drive/motor in an emergency situation. The manuals refer to this as **Safe Operation Mode**. The Run Enable/Disable feature can function as a normal drive interlock (Run Enable) but also includes additional parameters to define a separate stop mode (Quick Stop). This Quick Stop function is to be used for an E-Stop input to the VFD. When programmed, this operates differently from the External Trip function.

### Questions

Does the Run Enable (E-Stop) function have to bring motor/load to the quickest stop possible? **No, but it can.**

Does an E-Stop switch have to be NO or NC? **NC**

When the E-Stop switch is reset to normal position, can/should operation restart? **It can but should not.**

Do the Ext Trip and Run Enable inputs function while operating in "HAND" Mode? **Yes**

Can the Ext. Trip input terminal to the VFD be changed to a normally closed input. **Yes, with parameter IN-87.**

Can the Run Enable input terminal to the VFD be changed to a normally open input. **Yes, but not recommended when used as an E-Stop function.**

## C. IN-60 Run Enable/Disable

### 1. Related Parameters

Group	Code	Name	LCD Display	Parameter Setting		Setting Range	Unit
IN	65~71	PPX terminal configuration	Px Define (Px: P1~P7)	4	External Trip	0-42	-
				15	RUN Enable		
IN	60	Safe operation selection	Run En Mode	0	Always Enable	0-1	-
				1	DI Dependent		
	61	Safe operation stop mode	Run Dis Stop	0	Free-Run	0-2	-
				1	Q-Stop		
			2	Q-Stop Resume			
	62	Safe operation deceleration time	Q-Stop Time	5.0		0.0-600.0	sec

For GM2 VFD, IN-60 ~ 62 are in the Advance Group as Ad.70 ~ Ad.72.

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## 2. Safe Operation Mode Parameter Setting Details

Code	Description	
IN-65~71 Px Define	Set one of the multi-function (digital) input terminals to 15 (RUN Enable) along with IN-60 (Run Enable Mode).	
IN-60 Run En Mode	Setting                      Function	
	0	Always Enable Inverter is always enabled and does not acknowledge the Run Enable/Disable digital input. Set IN-60 to "1", DI Dependent.
	1	DI Dependent Inverter acknowledges the digital input as Run Enable/Disable. Input must be closed (Enabled) to operate.
IN-61 Run Dis Stop	Selects the Stop mode when the Run Enable/Disable input is opened.	
	Setting                      Function	
	0	Free Run Shuts off the drive output when the Run Enable/Disable input is opened. Motor coasts to a stop.
	1	Q-Stop Decelerates the motor based on the deceleration time (Q-Stop Time) set in IN-62. The operation can only resume when the run command (Fx) is opened and re-applied. The operation will not begin if only the Enable/Disable input is applied.
2	Q-Stop Resume Decelerates the motor based on the deceleration time (Q-Stop Time) set in IN-62. If the Run Enable/Disable input is re-applied during deceleration and the run command (Fx) is maintained, the drive will resume normal operation.	
IN-62 Q-Stop Time	Sets the deceleration time when IN-61 (Run Dis Stop) is set to 1 (Q-Stop) or 2 (Q-Stop Resume).	

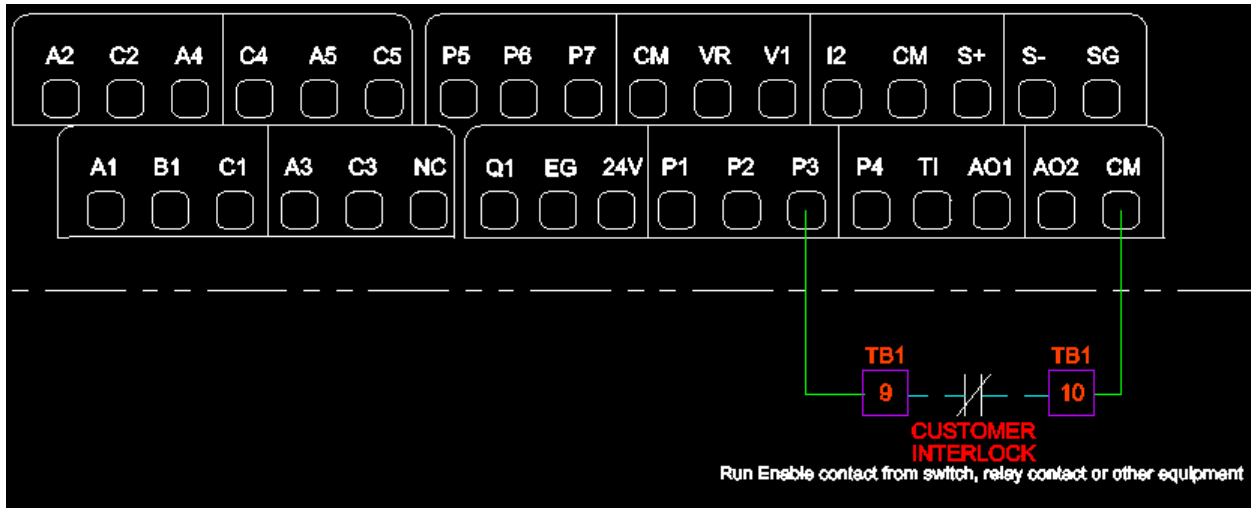
**IN-60 Run Enable/Disable** - This feature can be used as a simple interlock (i.e. as Run Enable) for interlocking drive operation. When set, the input must be closed for inverter operation and to recognize other digital input functions.

A stop mode can be selected (IN-61, Run Dis Stop) when the Run Enable input is opened during operation. Selections include Free Run (coast), Quick Stop and Quick Stop Resume. The deceleration time (IN-62, Q-Stop Time) can be set for the Quick Stop functions.

# Benshaw LV VFD's Run Enable\Disable, E-Stop and External Trip Functions

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### 3. Run Enable Wiring (H2 VFD shown)



### 4. Run Enable Parameter Settings

**Parameter settings** - Set one of the digital input terminals P1~P7 (IN-65 ~ IN-71) to 'Run Enable'. Setting **only** the 'RUN Enable' input does not accomplish the Enable/Disable function. **Another related parameter (IN-60) 'Run Enable Mode' must also be set.** IN-60 is set to 'Always Enable' (default) which means the drive is always enabled and the digital input is not recognized. **IN-60 must be changed to "DI Dependent"**. Now a closed contact at the 'Run Enable' terminal will allow the drive to start via separate start command. An open input will disable the drive from starting and if running, disables the output, the motor coasts to a stop.

Parameter	Name	LCD Display	Parameter Setting	Setting Range	Unit
IN-65 ~ IN-71	Px terminal configuration	Px Define (Px: P1~P7)	15 <b>Run Enable</b>	0-42	-
IN-60	Safe operation selection	Run En Mode	1 <b>DI Dependent</b>	0-1	-
IN-61	Safe operation stop mode	Run Dis Stop	0 <b>Free Run</b>	0-2	-

#### Run Enable/Disable Operation Notes:

- The Run Enable/Disable input does function when operating the inverter in the "HAND" mode (HAND button on LCD).
- During operation, opening the Run Enable input will stop the drive based on the settings of IN-61 "Run Disable Stop". Selections include Free Run, Quick Stop and Quick Stop Resume. Reclosing the Run Enable input will not restart the drive (exception, see **Q-Stop Resume** below). The start command must be removed and reactivated.
- Reverse logic – A Px terminal set to 'Run Enable' requires a NC contact input, open to trip. Reverse logic can be applied by setting the Px terminal digital input (bit) to a NC input with IN-87 and using a Normally Open switch. When the NO switch closes, the drive is disabled and will not start. If running will coast to a stop.
- There is **no message** on the LCD that states when the drive is "Not Enabled". (future firmware revision).
- The Run Enable/Disable function does not meet the requirements of the Safe Torque Off (STO) function.

### D. IN-61 Run Disable Stop (Quick Stop, E-Stop)

An added function of the Run Enable/Disable input is the ability to add a Quick Stop function (E-Stop). A stop mode can be selected (IN-61, Run Dis Stop) when the Run Enable input is opened during operation. Selections include Quick Stop or Quick Stop Resume. The deceleration time (IN-62, Q-Stop Time) can be set for the Quick Stop functions.

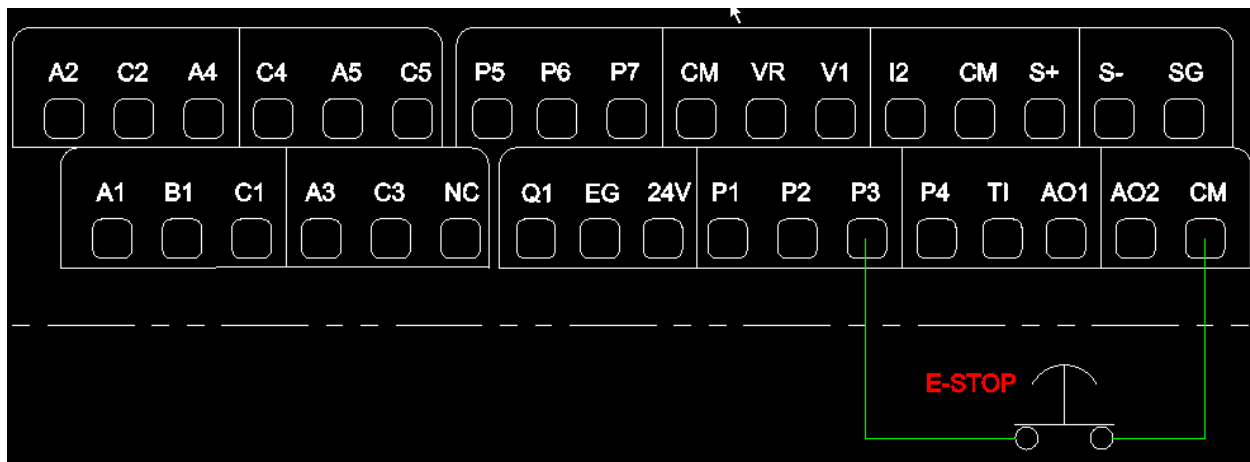
#### 1. 'Q-Stop'

With IN-60 (Run En Mode) is set to 1 (DI Dependent) and IN-61 is set to 1 (Q-Stop), if the Run Enable input is opened during operation, the drive will decelerate to a stop based on the time set in IN-62, Q-Stop Time. To re-start, the Enable input must be re-applied and the Run command (Fx) must be removed then re-applied.

#### 2. 'Q-Stop Resume' (not recommended)

When IN-60 (Run En Mode) is set to 1 (DI Dependent) and IN-61 is set to 2 (Q-Stop Resume), this allows operation (Start/Stop) of the drive based on the Run Enable input. If the Run Enable is opened during operation and the Run command (Fx) is maintained, closure of the Run Enable input will allow the drive to operate (resume operation).

#### 3. Quick Stop (E-Stop) Wiring (H2 VFD shown)



#### 4. Quick Stop (E-Stop) Parameter settings

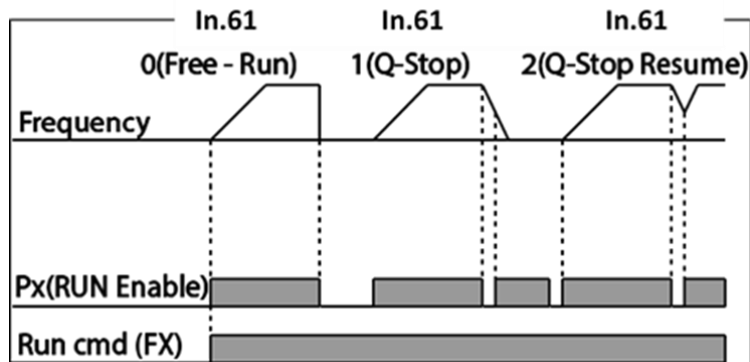
Parameter	Name	LCD Display	Parameter Setting	Setting Range	Unit
IN-65 ~ IN-71	Px terminal configuration	Px Define (Px: P1~P7)	15 Run Enable	0-42	-
IN-60	Safe operation selection	Run En Mode	1 DI Dependent	0-1	-
IN-61	Safe operation stop mode	Run Dis Stop	1 Q-Stop	0-2	-
IN-62	Safe operation deceleration time	Q-Stop Time	5.0	0.0-600.0	sec

NOTE: Perform testing of the switch function to determine if inverter will stop motor within the time set without tripping. If Q-Stop Time (IN-62) is too quick, inverter may trip on an Over Voltage fault and lose control of motor. Adjust Q-Stop Time (IN-62) for satisfactory operation.

# Benshaw LV VFD's Run Enable\Disable, E-Stop and External Trip Functions

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Below diagram shows operational differences between the settings of IN-61 (Stop Modes) in relation to the Run Enable input.



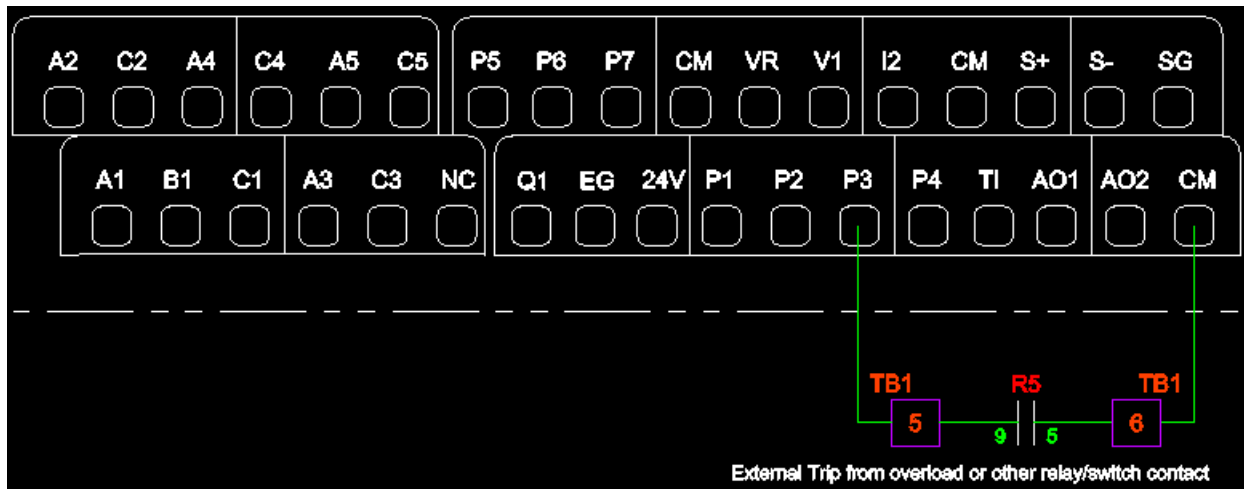
### Q-Stop Operation Notes:

- Both Q-Stop functions, when activated override the normal Stop Mode settings in DRV-04 (Decel Time and ADV-08 (Stop Mode).
- Coast to Stop or Controlled Stop ?? - I reviewed standards (listed in section F and G) on E-Stops. They cover everything from Size, shape color and **operation**.
- Resume Operation or not ?? - Recommendation is to use choice "1, Q-Stop" above. I cannot find any standard that states resuming operation with an E-Stop button is acceptable. From a Rockwell paper: "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."
- Reverse logic - E-stop (Quick Stop) requires a NC contact input, open to trip. Reverse logic cannot be applied to the terminal.

### E. External Trip

The External Trip function, when activated, simply shuts off (blocks) the output of the inverter. At this point there is no control of the motor, it will coast to a stop. The LCD displays the fault as 'External Trip'. Resetting the fault requires 1. addressing the faulted condition and 2. a manual reset (OFF Button on LCD or another momentary digital input programmed as 'Reset'). The NO contact for External Trip can be from a separate switch, OL relay, a Thermal Switch in the motor or other protective functions.

#### 1. External Trip Wiring (H2 VFD shown)



#### 2. External Trip Parameter Settings

Set one of the digital input terminals P1~P7 (IN-65 ~ IN-71) to 'External Trip'. The default logic is for a NO contact input, close to trip.

Parameter	Name	LCD Display	Parameter Setting	Setting Range	Unit
IN-65 ~ IN-71	Px terminal configuration	Px Define (Px: P1~P7)	4 <b>External Trip</b>	0-42	-

#### External Trip Operation Notes:

- The 'External Trip' fault is a latched fault and requires a manual reset.
- The External Trip input does function when operating the inverter in the "HAND" mode (HAND button on LCD).
- Reverse logic – External Trip requires a Normally Open contact input (default), close to trip. Reverse logic can be applied by setting the digital input (bit) to NC (change '0' to '1') with IN-87 and using a normally closed input. When the NC input is opened, External Trip is activated, and the drive will coast to a stop.

## F. References

### 1. Reference Standards

- a) **UL-508A**
- b) **EN/IEC Now UL 60947-5-5**: Low-voltage switchgear and control gear Part 5-5. Control circuit devices and switching elements – **Electrical emergency stop devices with mechanical latching function**
- c) **EN and IEC 60204-1**: Safety of machinery – Electrical equipment of machines – Part 1: General requirements
- d) **EN ISO 13850**: Safety of machinery – Emergency stop – Principles for design
- e) **NFPA 79**: Electrical Standard for Industrial Machinery

### 2. Regarding Stopping

*Within NFPA 70 (NEC) there are 3 ways of stopping noted:*

**■ Category 0 – Disconnection [preferred solution]**

*This is completed by 'disconnecting' the motor/equipment power/actuators instantly in the event of an emergency.*

**■ Category 1 – Controlled**

*A 'controlled stop' with power to the machine actuators available to achieve the stop then power is removed when the stop is achieved.*

**■ Category 2 – Controlled**

*A 'controlled stop' where power remains at the actuators even once the machine is stopped.*

**So according to above, we can coast to stop (Category 0) or control the stop.**

### 3. Regarding Normally Open or Normally Closed E-Stop

The standards include statements like:

*"after an emergency stop actuator is depressed and the contacts open."*

*"It is designed so that contact separation will take place even though the contacts may have been welded or "sticking" during fault circuit conditions."*

*"Direct opening for the button means that upon activation the power supply to the equipment is immediately disengaged. This is achieved by the push button opening the circuit."*

*"A physical e-stop, which must open a physical contact,"*

**So, with the above, it assumes the E-Stop contact is normally closed.**



## G. Descriptions and Definitions from UL

### According to From UL-508A

2 66.11 Operator controls

2 66.11.2 An industrial control panel provided with operator controls, such as pushbuttons and selector switches, shall also be provided with an emergency stop button.

Due to some confusion between Emergency-Stop in Standard Panels: even though some panels were not Control Panels for Industrial Machinery in 2 66.11.2 (above), clarification was added:

f) A emergency stop device, consisting of an actuator (providing mechanically held latching means) and contact block (s), and an emergency stop unit (that receives inputs from multiple emergency stop devices) shall comply with the requirements in the Standard for Low-voltage Switchgear and Control Gear – Part 5-5: Control Circuit Devices and Switching Elements – Electrical Emergency Stop Device with Mechanical Latching Function, **UL 60947-5-5**.

66.11.3 Both the emergency stop button or actuator and the associated contact blocks shall comply with the requirements in the Standard for Low-voltage Switchgear and Control gear – Part 5-5: Control Circuit Devices and Switching Elements – Electrical Emergency Stop Device with Mechanical Latching Function, **UL 60947-5-5**

### According to UL 60947-5-5

#### Defintion

3.1 **emergency stop (function or signal)** function or signal which 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.

3.2 **emergency stop device** a manually operated control circuit device used to initiate an emergency stop function

3.9 **direct opening action (positive opening action) of a contact element** the achievement of contact separation as a direct result of a specified movement of the switch actuator through non-resilient members (e.g. non dependent upon springs)

#### 5 Electrical requirements

5.2 All normally closed contact elements of an emergency stop device shall have a direct opening action (positive opening action), according to annex K of IEC 60947-5-1.