



UNIVERSAL ROBOTS

UR e-Series Safety Functions and Safety I/O are PLd, Category 3 according to ISO 13849-1

TÚV NORD (certificate # 44 207 14097610)

Table 1: G3e Safety Function (SF) Descriptions (see Chapter 2 of manual)

For safety I/O, the resulting safety function including the external device or equipment is determined by the overall architecture and the sum of all PFHds, including the UR robot safety function PFHd.

NOTE: All safety functions are individual safety functions.

Any limit violation, or fault detected in a safety function, results in a Category 0 stop.

SF #	Safety Function	Description	PFHd	What is controlled
1	Emergency Stop 1, 2, 3	Pressing the Estop PB on the pendant ¹ or the External Estop (if using the Estop Safety Input) results in a Cat 1 stop ³ . Command ¹ all joints to stop and upon all joints coming to a monitored standstill state, power is removed. This is a Cat 1 stop ³ . See Stop Time and Stop Distance Safety Functions ⁴ and the User Manual.	1.30E-07	Robot
2	Safeguard Stop (Protective Stop according to ISO 10218-1)	This safety function is initiated by an external protective device using safety inputs which will initiate a Cat 2 stop ³ . See the Stop Time and Stop Distance Safety Functions ⁴ and the User Manual. <i>For the functional safety of the complete integrated safety function, add the PFHd of the external protective device to the PFHd of the Safeguard Stop.</i>	1.20E-07	Robot
3	Joint Position Limit (soft axis limiting)	Sets upper and lower limits for the allowed joint positions. Each joint can have its own limits. Exceeding the joint position limit is a "limit violation" as described in Chapter 2 of the manual. A limit violation results in a Cat 0 stop ³ . <i>Directly limits the set of allowed joint positions that the joints can move to. It is set in the safety part of the User Interface. It is a means of safety-rated soft axis limiting & space limiting, according to ISO 10218-1:2011, 5.12.3.</i>	1.20E-07	Joint (each)

¹ **Communications** between the Teach Pendant, controller & within the robot (between joints) are SIL 2 for safety data, per IEC 61784-3.

² **Estop validation:** the pendant Estop pushbutton is evaluated within the pendant, then communicated¹ to the safety controller by SIL2 communications. To validate the pendant Estop functionality, press the Pendant Estop pushbutton and verify that an Estop results. This validates that the Estop is connected within the pendant, functioning as intended, and the pendant is connected to the controller.

³ **Stop Categories** according to IEC 60204-1 (NFPA79). Only Category 0 and 1 stops are allowed for the Estop.

- **Category 0 & 1** result in the removal of drive power, with Cat 0 being IMMEDIATE & Cat 1 being a controlled stop (decelerate then removal). With all UR robots, a Category 1 stop is a controlled stop where power is removed when a monitored standstill state is detected.

- **Category 2** is a stop where drive power is NOT removed. For Category 2 stops, this specification is defined in IEC 60204-1, A description of STO, SS1 and SS2 in IEC 61800-5-2.

With UR robots, a Category 2 stop maintains the trajectory then retains power to the drives after stopping.

⁴ It is recommended to use the UR E-series' Stop Time and Stop Distance Safety Functions. Their limits should be used as the basis of your application stop time/ safety distance.



UNIVERSAL ROBOTS

SF #	Safety Function	Description	PFHd	What is controlled
4	Joint Speed Limit	Sets an upper limit for the joint speed. Each joint can have its own limit. Exceeding a joint speed limit is a "limit violation" as described in Chapter 2 of the manual. A limit violation results in a Cat 0 stop <i>Directly limits the set of allowed joint speeds which the joints are allowed to perform. It is set in the safety setup part of the User Interface.</i> <i>Used to limit fast joint movements, e.g. limit risks related to singularities.</i>	1.20E-07	Joint (each)
	Joint Torque Limit	Exceeding the internal joint torque limit (each joint) results in a Cat 0 stop ³ . <i>This is not accessible to the user; it is a factory setting.</i> <i>It is NOT shown as a safety function because there are no user settings and no user configuration possibilities.</i>		
6	Pose Limit Tool Orientation Limit Safety Planes Safety Boundaries	Monitors the TCP Pose (position and orientation), any violation of a safety plane or TCP Pose Limit will result in a Cat 0 stop ^{Error! Bookmark not defined.} (IEC 60204-1). Multiple positions are possible – see Chapter 2 of the manual. <i>This safety function consists of two parts. One is the safety planes for limiting the possible TCP positions. The second is the TCP orientation limit, which is entered as an allowed direction and a tolerance. This provides TCP and wrist inclusion/ exclusion zones due to the safety planes. When a limit (plane or pose) is violated, a Cat 0 stop is initiated.</i>	1.20E-07	TCP
7	Speed Limit (TCP & Elbow)	Exceeding the TCP speed limit results in a Cat 0 stop ^{Error! Bookmark not defined.} (IEC 60204-1).	1.20E-07	TCP
8	Force Limit	Exceeding the TCP force limit results in a Cat 0 stop ^{Error! Bookmark not defined.} (IEC 60204-1). <i>Limits the external clamping force exerted by the robot.</i>	1.50E-07	TCP
9	Momentum Limit	Exceeding the momentum limit results in a Cat 0 stop ^{Error! Bookmark not defined.} (IEC 60204-1). <i>The momentum limit is very useful for limiting transient impacts.</i> <i>The Momentum Limit affects the entire robot.</i>	1.20E-07	Robot
10	Power Limit	Exceeding the power limit results in a Cat 0 stop (IEC 60204-1). <i>This function monitors the mechanical work (sum of joint torques times joint angular speeds) performed by the robot, which also affects the current to the robot arm as well as the speed of the robot.</i> <i>This function dynamically limits the current/torque but maintains the speed.</i>	1.50E-07	Robot
New	Stopping Time Limit	Real time monitoring of conditions such that the stop time limit will not be exceeded. Robot speed is limited to ensure that the stop time limit is not exceeded.	1.20E-07	Robot
New	Stopping Distance Limit	Real time monitoring of conditions such that the stop distance limit will not be exceeded. Robot speed is limited to ensure that the stop distance limit is not exceeded.	1.20E-07	Robot



UNIVERSAL ROBOTS

SF #	Safety Function	Description	PFHd	What is controlled
11	UR Robot Estop Output	When configured for Estop output and there is an Estop condition (see SF1), the dual outputs are LOW. If there is no Estop condition, dual outputs are high. Pulses are not used but they are tolerated. <i>For the integrated functional safety rating with an external Estop device, add the PFHd of the UR Estop function (SF0 or SF1) to the PFHd of the external logic (if any) and its components (e.g. Estop pushbutton).⁵</i> <i>For the Estop Output, validation is performed at the external equipment, as the UR output is an input to this external equipment.</i>	4.70E-08	External connection to logic &/or equipment
12	UR Robot Moving: Digital Output	Whenever the robot is moving (motion underway), the dual digital outputs are LOW. Outputs are HIGH when no movement. <i>The functional safety rating is for what is within the UR robot. The integrated functional safety performance requires adding this PFHd to the PFHd of the external logic (if any) and its components.</i>	1.20E-07	External connection to logic &/or equipment
13	UR Robot Not stopping: Digital Output	Whenever the robot is STOPPING (in process of stopping or in a stand-still condition) the dual digital outputs are HIGH. When outputs are LOW, robot is NOT in the process or stopping and NOT in a stand-still condition. <i>The functional safety rating is for what is within the UR robot. The integrated functional safety performance requires adding this PFHd to the PFHd of the external logic (if any) and its components.</i>	1.20E-07	External connection to logic &/or equipment
14	UR Robot Reduced Mode: Digital Output	Whenever the robot is in reduced mode (or reduced mode is initiated) , the dual digital outputs are LOW. <i>See Robot Reduced Mode below.</i> <i>The functional safety rating is for what is within the UR robot. The integrated functional safety performance requires adding this PFHd to the PFHd of the external logic (if any) and its components.</i>	1.20E-07	External connection to logic &/or equipment
15	UR Robot Not Reduced Mode: Digital Output	Whenever the robot is NOT in reduced mode (or the reduced mode is not initiated), the dual digital outputs are LOW. <i>The functional safety rating is for what is within the UR robot. The integrated functional safety performance requires adding this PFHd to the PFHd of the external logic (if any) and its components.</i>	1.20E-07	External connection to logic &/or equipment
--	Reduced Mode SF settings change	Reduced Mode can be initiated by a safety plane/ boundary (starts when at 2cm of the plane and reduced mode settings are achieved within 2cm of the plane) or by use of an input to initiate (will achieve reduced settings within 500ms). When the external connections are Low, Reduced Mode is initiated. Reduced Mode means that ALL reduced mode limits are ACTIVE <i>Reduced mode is not a safety function, rather it is a state affecting the settings of the following safety function limits: joint position, joint speed, TCP pose limit, TCP speed, TCP force, momentum, power, stopping time, and stopping distance.</i>	PFHd is either 1.20E-07 or 1.50E-07 depending on the safety function	Robot

⁵ **Estop validation:** the pendant Estop pushbutton is evaluated within the pendant, then communicated¹ to the safety controller by SIL2 communications.

To validate the pendant Estop function, press the Pendant Estop pushbutton and verify that an Estop results. This validates that the Estop is connected within the pendant, functioning as intended, and the pendant is connected to the controller. The connection from the pendant to the safety controller is by safety communications according to SIL 2.



UNIVERSAL ROBOTS

SF #	Safety Function	Description	PFHd	What is controlled
--	Safeguard Reset	When configured for Safeguard Reset and the external connections transition from low to high, the safeguard stop RESETS. Safety input to initiate a reset of safeguard stop safety function.	Input to SF2 See SF2 safeguard stop	Robot
--	3 Position Enabling Device INPUT	When the external Enabling Device connections are Low, a Safeguard Stop (SF2) is initiated. Recommendation: Use with a mode switch as a safety input. <i>If a mode switch is not used and connected to the safety inputs, then the robot mode will be determined by the User Interface. If the User Interface is in</i> <ul style="list-style-type: none">• “run mode”, the enabling device will not be active.• “programming mode”, the enabling device will be active. It is possible to use password protection for changing the mode by the User Interface.	Input to SF2 See SF2 safeguard stop	Robot
--	Mode switch INPUT	When the external connections are Low, Operation Mode (running) is in effect. When High, the mode is programming or teach. Must be used with an Enabling Device as a safety input. <i>When in Teach/Program (Mode switch inputs high), enabling device is required for operation. When in teach/program, initially the TCP speed will be limited to 250mm/s.</i> <i>The speed can manually be increased by using the pendant user interface “speed-slider”, but upon activation of the enabling device, the speed limitation will reset to 250mm/s.</i>	Input to SF2 See SF2 safeguard stop	Robot