UNIVERSAL ROBOTS

If any safety function limit is exceeded or a fault is detected in a safety function or safety-related part of the control system, UR defines the safe state as a stop with removal of drive power (either a stop category[4] 1 or 0).
All (20) UR safety functions have PFH values that are less than 1.8E-07 (1.8×10^{-7}) for each safety function except Emergency Stop Safety Function which is less than 1.0E-07 (1.0×10^{-7}).

SF#	Safety Function	Description	What happens?	Tolerance	Affects?
1	1, 2, 3, 4 **Emergency Stop** (ISO 13850)	Pressing the Estop PB on the pendant[1] or the External Estop (if using the Estop Safety Input) results in a Stop Cat 1[4] with power removed from the robot actuators and the tool I/O. Controller I/O go "low". Command[1] all joints to stop and upon all joints coming to a monitored standstill state, power is removed. See Stop Time & Stop Distance Safety Functions[5]. **ONLY USE FOR EMERGENCY PURPOSES**, not to be used for safeguarding because actuation requires a manual action.	**Stop Category 1** (IEC 60204-1)	---	**Robot, robot tool I/O, and controller I/O**
2	3, 5 **Safeguard Stop** (Protective Stop according to ISO 10218-1*) **Prior to 2006, this was called "safety stop" or "safeguard stop"*	This safety function is initiated by an external protective device using safety inputs which will initiate a Stop Cat 2[4]. The purpose is to protect people from injury, as compared to protecting the robot, equipment, or products. The tool I/O are unaffected by the safeguard stop. If an enabling device is connected, it is possible to configure the safeguard stop to function in automatic mode ONLY. See the Stop Time and Stop Distance Safety Functions[5].	**Stop Category 2** (IEC 60204-1) **SS2 stop** (as described in IEC 61800-5-2)	---	**Robot**
--	**Safeguard Stop Reset**	When configured for Safeguard Reset and the external reset connections transition from low to high, safeguard stop resets. Safety input to initiate a reset of SF2.	**Reset Input to SF2**	--	**Robot**
3	**Joint Position Limit (software-based axis limiting)**	Sets upper and lower limits for the allowed joint positions. Stopping time and distance is not a considered as the limit(s) will not be violated. Each joint can have its own limits. *Directly limits the set of allowed joint positions that the joints can move within. It is safety-rated soft axis limiting & space limiting, according to ISO 10218-1:2011, 5.12.3.*	**Will not allow motion to exceed any limit settings.** Speed could be reduced so motion will not exceed any limit. A robot stop will be initiated to prevent exceeding any limit.	**5 °**	**Joint (each)**
4	**Joint Speed Limit**	Sets an upper limit for the joint speed. Each joint can have its own limit. This safety function has the most influence on energy transfer upon contact (clamping or transient). *Directly limits the set of allowed joint speeds which the joints are allowed to perform. It is used to limit fast joint movements, e.g. risks related to singularities.*		**1.15 °/s**	**Joint (each)**
	Joint Torque Limit	Exceeding the internal joint torque limit (each joint) results in a Cat 0[4] Stop. This safety function is not accessible to the user; it is a factory setting. It is NOT shown as here because there are no user settings.			

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

[2] **Estop validation**: the pendant Estop pushbutton is evaluated within the pendant, then communicated[1] 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, the estop functions as intended, and the pendant is connected to the controller.

[3] **If a robot safety function** is "integrated" or "connected" with external equipment, devices or logic, the resulting integrated safety function has a PFH that is the sum of all PFH values, including the PFH value of the robot safety function.

[4] **Stop Categories** according to IEC 60204-1 (NFPA79). For the Estop, only stop category 0 and 1 are allowed.
- **Stop Category 0 & 1** result in the removal of drive power, with stop cat 0 being IMMEDIATE & stop cat 1 being a controlled stop (e.g. decelerate to a stop then removal of drive power).
- **Stop Category 2** is a stop where drive power is NOT removed. Stop category 2 is defined in IEC 60204-1. Descriptions of STO, SS1 & SS2 are in IEC 61800-5-2. With UR, a stop category 2 maintains the trajectory & retains power to the drives after stopping.

[5] **Stop Time & Stop Distance** Safety Functions should be used. When used, there is no need for periodic verification of stopping performance.

SF#	Safety Function	Description	What happens?	Tolerance	Affects?
5	*Called various names* **Pose Limit** **Tool Limit** **Orientation Limit** **Safety Planes** **Safety Boundaries**	Monitors the **TCP** Pose (position and orientation) and will prevent exceeding a safety plane or TCP Pose Limit. Multiple pose limits are possible (tool flange, elbow, and up to 2 configurable tool offset points with a radius) Orientation restricted by the deviation from the feature Z direction of the tool flange OR the TCP. *Two parts. (1) is the safety planes for limiting the possible TCP positions. (2) 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.*	**Will not allow motion to exceed any limit settings.** Speed or torques could be reduced so motion will not exceed any limit set for SF 5, SF 6, SF 7 or SF 8. A robot stop will be initiated to prevent exceeding any limit. **Will not allow motion to exceed any limit settings.**	**3 °** **40 mm**	**TCP** **Tool flange** **Elbow**
6	**Speed Limit TCP & Elbow**	Monitors the **TCP** and **elbow** speed to prevent exceeding a speed limit. Equivalent to monitoring the whole arm as the sections between the TCP and elbow cannot move faster than the endpoints of these sections.		**50 mm/s**	**TCP**
7	**Force Limit (TCP)**	The Force Limit is the force exerted by the robot at the TCP (tool center point) and "**elbow**". The safety function continuously calculates the torques allowed for each joint to stay within the defined force limit for both the TCP & the elbow. The joints control their torque output to stay within the allowed torque range. This means that the forces at the TCP or elbow will stay within the defined force limit. When a stop is initiated by the Force Limit SF, the robot will stop. The UR standard controller will cause motion to "back-off" to the position before the force limit was exceeded. This "back-off" is not part of the safety function as it is done by the standard controller. The safety controller has a fixed time (part of the response time) allowed before a robot stop is initiated.		**25 N**	**TCP**
8	**Momentum Limit**	The momentum limit is very useful for limiting transient impacts. *The Momentum Limit affects the entire robot.*		**3 kg m/s**	**Robot**
9	**Power Limit**	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 robot speed. This safety function dynamically limits the current/ torque but maintains the speed.	**Dynamic limiting of the current/ torque**	**10 W**	**Robot**
10	**UR Robot Stop Outputs**	When configured for a robot stop output and there is a robot stop, the dual outputs are LOW. If there is no robot stop initiated, dual outputs are high. Pulses are not used but they are tolerated. For an integrated safety function, see footnote [6] These dual outputs change state for any external Estop that is connected to configurable safety inputs where this input is configured as an Emergency Stop input. *For the Stop Output, validation is performed at the external equipment, as the UR output is an input to this external stop safety function for external equipment.* NOTE: With the IMMI (Injection Moulding Machine Interface), this stop output is not connected to the IMMI to prevent having an unrecoverable stop.	**Dual outputs go low in event of a stop if configurable outputs are set**	--	**External connection to logic &/or equipment**
11	**"Moving" Safety Function with Digital Outputs**	Whenever the robot is moving (motion underway), the dual digital outputs are LOW. Outputs are HIGH when there is no movement. *Functional safety is for what is within the UR robot. For an integrated safety function, see footnote [6].*	**Dual outputs are low during motion and high when no movement.**	--	**External connection to logic &/or equipment**

[6] **If a robot safety function** is "integrated" or "connected" with external equipment, devices or logic, the resulting integrated safety function has a PFH that is the sum of all PFH values, including the PFH value of the robot safety function.

SF#	Safety Function	Description	What happens?	Tolerance	Affects?
12	**"Not stopping" Safety Function with Digital Outputs**	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. *For an integrated safety function, see footnote [6].*	**Dual outputs are high when robot is either in the process of stopping or at a stand-still state**	--	**External connection to logic &/or equipment**
13	**"Reduced Active" Safety Function with Digital Outputs**	**When reduced settings are active (or initiated) for safety functions,** the dual digital outputs are LOW. *The functional safety is for what is within the UR robot. For the integrated safety function, see footnote [6].*	**Dual outputs are low when reduced settings are active**	--	**External connection to logic &/or equipment**
14	**"Reduced Not Active" Safety Function with Digital Outputs**	**Whenever the robot reduced settings for safety functions are NOT active (or not initiated),** the digital outputs are LOW. *The functional safety rating is for what is within the UR robot. For the integrated safety function, see below footnote [6]*	**Dual outputs are low when reduced settings are NOT active**	--	**External connection to logic &/or equipment**
--	**"Reduced Active" Input** ***SF parameter settings change***	Reduced is <u>not</u> a mode. It is a change of settings initiated: • internally by a safety plane/ boundary (starts when at 2cm of the plane and reduced settings are achieved within 2cm of the plane) or • externally by use an external input, which will achieve reduced settings within 500ms of the triggering input. When the external connections are Low, Reduced Mode is initiated. "Reduced Active" makes all reduced limits ACTIVE. ***Reduced is not a safety function. Reduced is a means of parameterization of safety functions. Reduced is a state change affecting the settings of the following safety functions:*** *joint position, joint speed, TCP pose, TCP speed, TCP force, momentum, power, stopping time, & stopping distance.* *Verify and validate all parameter settings for the robot application.*		--	**Robot**
15	**Stopping Time Limit**	Real time monitoring of conditions such that the stopping time limit will not be exceeded. Robot speed is limited to ensure that the stop time limit is not exceeded. [7]	**Will not allow the actual stopping to exceed the limit setting.** Causes decrease in speed or a robot stop so as NOT to exceed the limit.	**50 ms**	**Robot**
16	**Stopping Distance Limit**	Real time monitoring of conditions such that the stopping distance limit will not be exceeded. Robot speed is limited to ensure that the stop distance limit will not be exceeded. **Error! Bookmark not defined.**		**40 mm**	**Robot**
17	**Safe Home Position** ***"monitored position"***	Safety function which monitors a safety-rated output, such that it ensures that the output can only be activated when the robot is in the configured and monitored "safe home position". A stop cat 0 is initiated if the output is activated when the robot is not in the configured position.	The "safe home output" is only activated when the robot is in the configured "safe home position"	**1.7 °**	**External connection to logic &/or equipment**
--	**Mode switch INPUT**	When the external connections are Low, Automatic Mode (running) is active. When High, mode is programming/ teach. ***Recommendation:*** *Use with an enabling device, i.e. UR Teach Pendant with an integrated 3-position enabling device.* *When in teach/program, initially the TCP speed is limited to 250mm/s. Speed can manually be increased using the TP "speed-slider", but upon activation of the enabling device, the speed limitation will reset to 250mm/s.*	**Input to SF2**	--	**Robot**

[7] The stopping capability of the robot in the given motion(s) is continuously monitored to prevent motions that would exceed the stopping limit. If the time needed to stop the robot is at risk of exceeding the time limit, the speed of motion is reduced to ensure the limit is not exceeded. A stop will be initiated to prevent exceeding the limit.

SF#	Safety Function	Description	What happens?	Tolerance	Affects?
18	**3PE (3-position enabling) Safety Function [8] Inputs**	**A 3-position enabling device [9] has 3 switch positions: off, on, off** (in order of actuation when squeezing). When released completely, the device is off. When pressed/squeezed to the centre position, it is on. Completely pressing (squeezing) results in an off state. When the 3P enabling device is "ON", motion is enabled. **When in Manual Mode** and when an external Enabling Device connection is OFF, internally the safety system initiates SF2, which is a Stop Category 2. ***Recommendation**: Use with a mode switch as a safety input.[10]*	**In manual mode, when the SF18 Input is LOW, SF2 is triggered internally** *Stop Category 2 (IEC 60204-1)* *SS2 (IEC 61800-5-2)*	--	**Robot and external connection to SF19 & SF20**
19	**3PE (3-position enabling) Safety Function [8] with Digital Outputs**	**In Automatic Mode ("running"), SF19's outputs are HIGH.** **In Manual Mode** and when any Enabling Device[11] is in the OFF state (not in the centre-ON position, meaning the enabling device is released or fully pressed), a SF2 is triggered causing a Stop Category 2 (SS2) and SF19's outputs are Low. [8] **In Manual mode, when Freedrive and the 3PE are used:** • **If Freedrive is** activated and ○ ALL 3PE are in the OFF state, SF19's outputs are HIGH. ○ Any 3PE is in the ON state, SF19's outputs are LOW. • **If Freedrive is not** activated, and ○ ALL 3PE are in the ON state, SF19's outputs are HIGH. ○ Any 3PE is in the OFF state, SF19's outputs are LOW.	**In manual mode, when the 3PE is in the Off state, the outputs are LOW and SF2 is triggered internally** *Stop Category 2 (IEC 60204-1)* *SS2 (IEC 61800-5-2)*	--	**External connection to logic &/or equipment**
20	**3PE (3-position enabling) "not state" Safety Function** Error! Bookmark not defined. **with Digital Outputs**	**In Automatic Mode ("running"), SF20's outputs are LOW.** **In Manual Mode** and when any Enabling Device[11] is in the OFF state (not in the centre-ON position, meaning the enabling device is released or fully pressed), SF20's outputs are High. **Error! Bookmark not defined.** **In Manual mode, when Freedrive and the 3PE are used:** • **If Freedrive is** activated and: ○ ALL 3PE are in the OFF state, SF20's outputs are LOW. ○ Any 3PE is in the ON, then SF20's outputs are HIGH. • **If Freedrive is not** activated, and: ○ ALL 3PE are in the ON state, SF20's outputs are LOW. ○ Any 3PE is in the OFF state, SF20's outputs are HIGH **Note:** SF20 is an inverted version of the SF19 where the output state is logically reversed compared to SF19.	**In manual mode, when the 3PE is in the Off state, the outputs are HIGH**	--	**External connection to logic &/or equipment**

[8] For the integrated functional safety rating with an external safety-related control system, add the PFH of this safety-related output to the PFH of the external safety-related control system. The safety function and its triggering of a stop are included in the PFH value for this SF.

[9] The enabling device can be on the teach pendant or external connected to the Enabling Function input (SF18).

[10] Use of an external mode switch is recommended when using a 3-position enabling device. If an external 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

- "run mode", the enabling function will not be active.
- "programming mode", the enabling function will be active. Password protection for changing the mode can be configured.

[11] If any 3PE enabling device is released or fully pressed, the 3-position enabling safety function is OFF (not in the Center ON position).

Functional Safety and Universal Robots' Safety Functions

UR robots are certified to EN ISO 13849-1:2015 for functional safety and to EN ISO 10218-1:2011 for robot safety.

EN ISO 13849-1:2023 was published and is listed in the Official Journal to the Machinery Directive while the 2015 edition is listed in the Official Journal of the Machinery Regulation. The 2023 edition has more details and examples, plus a few changes in terminology:

- the subscript "$_D$" has been eliminated from PFH_D to better align with EN IEC 62061, so it is now PFH
- "architecture" is emphasized as it encompasses category (structure) and behaviour under fault conditions.

A lower or smaller PFH (average probability or frequency of a dangerous failure per hour) value is better. A smaller (lower) number means that the probability/ frequency is lower that a dangerous failure per hour will occur.

According to ISO 13849-1 (2015 and 2023), the PL [of each safety function] is determined by the PFH, architecture, $MTTF_D$, and the average diagnostic coverage. Common cause failure evaluation is part of the PL evaluation. If a robot safety function is "integrated" or "connected" with external equipment, devices or logic, the resulting integrated safety function has a PFH that is the sum of all PFH values, including the PFH value of the robot safety function. A safety function must be integrated (implemented) properly to fulfill its intended purpose and its functional safety performance. A product with a rating of "PLd" or "Ple" is meaningless. Only a safety function, not a whole product, has a PL and a PFH value.

For UR safety functions:

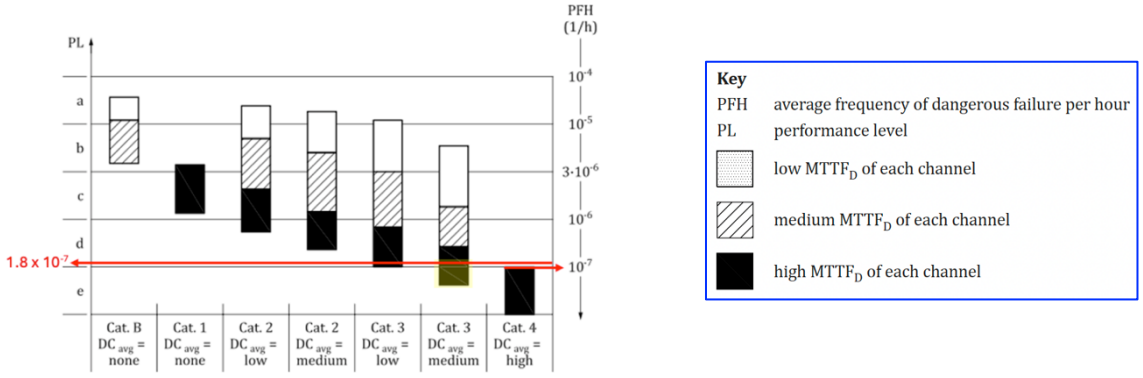
- Functional safety certification is by TÜV Rheinland.
- All safety functions are individual safety functions.
- $MTTF_D$ is high (between 30 to over 100 years) per channel for each safety function.
  The average diagnostics coverage (DC) for all UR robot safety functions is over 90%, which is medium.
- The PFH values are less than: *(See Below excepts from ISO 14849-1, Annex K & Figure 12.)*
  - 1.8E-07 (1.8×10^{-7}) for each safety function except Emergency Stop.
  - 1.0E-07 (1.0×10^{-7}) for the Emergency Stop Safety Function.
- UR does not use fault exclusion for the PL determination of the emergency stop safety function.
  Fault exclusion is permitted for PLe only for the emergency stop safety function.

ISO 13849-1:2015 & 2023, excerpt from Annex K: The red box show PFH values for most UR safety functions:
Note that the UR Emergency Stop safety function PFH value is smaller than 1.03E-07

$MTTF_D$ for each channel	Average frequency of a dangerous failure per hour (PFH) (1/h) and corresponding performance level					
	Cat. B	Cat. 1	Cat. 2	Cat. 2	Cat. 3	Cat. 3
years	DC_{avg} = none	DC_{avg} = none	DC_{avg} = low	DC_{avg} = medium	DC_{avg} = low	DC_{avg} = medium
24	$4{,}76 \times 10^{-6}$ b		$2{,}65 \times 10^{-6}$ c	$1{,}62 \times 10^{-6}$ c	$9{,}47 \times 10^{-7}$ d	$3{,}70 \times 10^{-7}$ d
27	$4{,}23 \times 10^{-6}$ b		$2{,}32 \times 10^{-6}$ c	$1{,}39 \times 10^{-6}$ c	$8{,}04 \times 10^{-7}$ d	$3{,}10 \times 10^{-7}$ d
30		$3{,}80 \times 10^{-6}$ b	$2{,}06 \times 10^{-6}$ c	$1{,}21 \times 10^{-6}$ c	$6{,}94 \times 10^{-7}$ d	$2{,}65 \times 10^{-7}$ d
33		$3{,}46 \times 10^{-6}$ b	$1{,}85 \times 10^{-6}$ c	$1{,}06 \times 10^{-6}$ c	$5{,}94 \times 10^{-7}$ d	$2{,}30 \times 10^{-7}$ d
36		$3{,}17 \times 10^{-6}$ b	$1{,}67 \times 10^{-6}$ c	$9{,}39 \times 10^{-7}$ d	$5{,}16 \times 10^{-7}$ d	$2{,}01 \times 10^{-7}$ d
39		$2{,}93 \times 10^{-6}$ c	$1{,}53 \times 10^{-6}$ c	$8{,}40 \times 10^{-7}$ d	$4{,}53 \times 10^{-7}$ d	$1{,}78 \times 10^{-7}$ d
43		$2{,}65 \times 10^{-6}$ c	$1{,}37 \times 10^{-6}$ c	$7{,}34 \times 10^{-7}$ d	$3{,}87 \times 10^{-7}$ d	$1{,}54 \times 10^{-7}$ d
47		$2{,}43 \times 10^{-6}$ c	$1{,}24 \times 10^{-6}$ c	$6{,}49 \times 10^{-7}$ d	$3{,}35 \times 10^{-7}$ d	$1{,}34 \times 10^{-7}$ d
51		$2{,}24 \times 10^{-6}$ c	$1{,}13 \times 10^{-6}$ c	$5{,}80 \times 10^{-7}$ d	$2{,}93 \times 10^{-7}$ d	$1{,}19 \times 10^{-7}$ d
56		$2{,}04 \times 10^{-6}$ c	$1{,}02 \times 10^{-6}$ c	$5{,}10 \times 10^{-7}$ d	$2{,}52 \times 10^{-7}$ d	$1{,}03 \times 10^{-7}$ d

Emergency Stop

ISO 13849-1:2023, figure 12 with an added red line for 1.8 X 10-7:



UR robots comply with ISO 10218-1:2011 and the applicable portions of ISO/TS 15066. It is important to understand that most of ISO/TS 15066 is directed towards the integrator and not the robot manufacturer. ISO 10218-1:2011, clause 5.10 details 4 collaborative techniques as explained below. It is important to note this is the APPLICATION when in AUTOMATIC mode.

UR robots comply with ISO 10218-1:2025, clause 5.10.4 Power and force limiting (PFL) and ISO 10218-1:2011, 5.10.6.

#	ISO 10218-1	Technique	Explanation	UR e-Series & UR series Robots
1	**2011, 5.10.2** Collaborative Operation[12]	Safety-rated monitored stop	Stop condition where position is held at a standstill and is monitored as a safety function. Category 2 stop is permitted to auto reset. In the case of resetting and restarting operation after a safety-rated monitored stop, see ISO 10218-2 and ISO/TS 15066 as resumption shall not cause hazardous conditions. NOTE: ISO 10218-2:2025 changed this a Stop Category 2 followed by a monitored-standstill safety function.	**UR robots' safeguard stop is a safety-rated monitored stop.** See SF2. *In ISO 10218-1:2025, the term "safety-rated monitored stop" was eliminated. There are only 3 "capabilities for collaborative applications": hand-guided controls (HGC), speed and separation monitoring (SSM) and power and force limiting (PFL).*
2	**2011, 5.10.3** Collaborative Operation[12]	Hand-guiding	This is essentially individual and direct personal control while the robot is in automatic mode. Hand guiding equipment shall be located close to the end-effector and shall have: — an Emergency Stop pushbutton; and — a 3-position enabling device; and — a safety-rated monitored stop function; and — a settable safety-rated monitored speed function. *See ISO 10218-2:2025, 5.14, for requirements including use of hold-to-run or 3-position enabling.*	**UR robots do not provide hand-guiding for collaborative applications**. Hand-guided teach (free drive) is provided with UR robots but this is for **programming in manual mode**. *ISO 10218-1:2025, 5.10.2 requires safety functions: monitored-speed, software-based limiting, monitored-standstill, hold-to-run or 3 position enabling, single-point-of control, direct control.*
3	**2011, 5.10.4** Collaborative Operation[12]	Speed & separation monitoring (SSM) safety functions	SSM is the robot maintaining a separation distance from any operator (human). This is done by monitoring of the distance between the robot system and intrusions to ensure that the MINIMUM PROTECTIVE DISTANCE is assured. Currently, this is done using Sensitive Protective Equipment (SPE), typically a safety laser scanner, to detect intrusion(s) towards the robot application. This SPE causes **1)** dynamic changing of the parameters for the limiting safety functions; or **2)** a safety-rated monitored stop condition. Upon detection of the intrusion exiting the protective device's detection zone, the robot is permitted to **a)** resume the "higher" normal safety function limits in the case of **1)** above; **b)** resume operation in the case of **2)** above. In the case of **2) b)** restarting operation after a safety -rated monitored stop, see ISO 10218-2:2011 and ISO/TS 15066 or ISO 10218-2:2025, 5.14, Annex M, and Annex N.	**To facilitate SSM, UR robots have the capability of switching between two sets of parameters for safety functions with configurable limits.** **See Reduced Mode.** Normal operation can be when no intrusion is detected. Reduced can be activated by safety planes/safety boundaries. Multiple safety zones can be readily used with UR robots. For example, one safety zone can be used for "reduced settings" and another zone boundary is used as a safeguard stop input to the UR robot. Reduced limits can also include a reduced setting for the stop time and stop distance limits – to reduce the work area and floorspace. *ISO 10218-1:2025, 5.10.3 UR robots comply when used with a protective device. Speed can be limited by the UR speed limiting safety function.*
4	**2011, 5.10.5** Collaborative Operation[12]	Power and force limiting (PFL)	The robot design and/or safety functions will limit the **energy transfer** from the robot to a person. If a parameter limit is exceeded, a stop happens. PFL applications require assessing the ROBOT APPLICATION (including the end-effector and workpiece(s), so that contact will not cause injury. The study performed evaluated pressures to the ONSET of pain, not injury. See ISO/TS 15066, ISO/TR 20218-1 and ISO 10218-2:2025, 5.9 & 5.14.	UR robots are PFL robots that comply with both the 2011 & 2025 editions. UR robots have safety functions that can be used to limit motion, speed, momentum, force, power and more of the robot. This is used in the robot application to lessen contact pressures and forces caused by the end-effector & workpiece(s)

[12] *ISO 10218:2025 removed the term "collaborative operation" and removed the term "collaborative robot".*