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CE TECHNICAL DOCUMENTATION

Sample project: CE marking robotic welding cell RSZ-2600

Robotic welding cell RSZ-2600 (assembly of machinery)

Project no.	MUSTER-2026-001-EN
Customer	Andrea Bergmann, Beispiel Stahlbau GmbH
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MACHINE DESCRIPTION

Robotic MAG welding cell RSZ-2600 for arc welding of steel assemblies up to 40 kg workpiece weight in series production. Special-purpose machine, single unit. Configuration as an assembly of machinery: (1) Articulated-arm industrial robot, 6 axes, reach 2600 mm, payload 12 kg, supplied by the robot manufacturer as partly completed machinery with an EU declaration of incorporation in accordance with Annex V Part B and assembly instructions in accordance with Annex XI. …

Excerpt: the full description is at the start of module 1.

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1. Risk assessment

according to EN ISO 12100

Machine description

Robotic MAG welding cell RSZ-2600 for arc welding of steel assemblies up to 40 kg workpiece weight in series production. Special-purpose machine, single unit.

Configuration as an assembly of machinery: (1) Articulated-arm industrial robot, 6 axes, reach 2600 mm, payload 12 kg, supplied by the robot manufacturer as partly completed machinery with an EU declaration of incorporation in accordance with Annex V Part B and assembly instructions in accordance with Annex XI. (2) Two-station turntable with vertical axis of rotation and 180-degree rotation, fixed dividing centre wall with welding curtain, pneumatic workpiece clamps. (3) MAG welding power source 400 A at 60 per cent duty cycle, CE-marked, with wire feed unit and torch cleaning station. (4) Welding fume extraction 1800 m³/h with filter cartridge. All components are controlled jointly and placed on the market as a single unit.

Protection concept: perimeter guard (safety fence) 2200 mm high with welding-light-opaque infill panels and welding protection viewing windows; one maintenance door as an interlocking guard with guard locking based on the de-energised principle, with an escape release on the inside and a lockout device for personal padlocks; Type 4 light curtain with 30 mm resolution at the loading station, safety distance calculated in accordance with EN ISO 13855; safety PLC; emergency stop devices at the control desk, at the maintenance door and on the teach pendant, acting on all part-machines of the cell; lockable operating mode selector switch with the operating modes Automatic and Set-up; in set-up mode safely reduced speed of 250 mm/s and enabling device.

Operation: manual loading and unloading at the respective front station by trained skilled personnel, cycle time approximately 90 seconds. No personnel access to the robot working area in automatic mode.

Hazards: crushing and impact by the robot and turntable, arc radiation in the UV and IR range, welding fume and welding gases, hot surfaces and weld spatter, noise, electrical hazard, stored pneumatic energy.

Technical data: rated voltage 400 V AC 50 Hz, connected load 32 kVA, compressed air 6 bar, emission sound pressure level at the loading station 84 dB(A) with measurement uncertainty K equal to 2.5 dB, A-weighted sound power level 96 dB(A). Stationary installation in a production hall indoors.

Data connections: the cell controller is linked to the robot, the turntable and the welding power source via PROFINET with PROFIsafe. Through an OPC UA interface the cell receives orders from the user's MES and reports production data back. The manufacturer's remote maintenance runs through a VPN gateway that the user enables at the control desk. The HMI panel has a USB port for backups.

First placing on the market: March 2027. Complete machinery.

Robotic welding cell RSZ-2600 (assembly of machinery)

Intended use: automated MAG welding of steel assemblies up to 40 kg workpiece weight in series production. The operator manually places the workpieces at the respective front station of the two-station turntable, clamps them pneumatically and removes the welded assemblies; the welding process is carried out fully automatically by the robot behind the fixed dividing centre wall. The cell is intended for stationary use in a production hall (indoors) and may only be operated by instructed skilled personnel in the operating modes Automatic and Set-up. Permitted materials: uncoated structural steels in accordance with the approved welding procedure specification (WPS). Any other use, in particular the welding of coated or galvanised parts, is considered not to be the intended use.

Limits of the machinery: Use limits: workpieces up to 40 kg, maximum dimensions 800 x 600 x 400 mm; workpieces over 15 kg are loaded using a lifting aid provided by the user on site (load capacity at least 40 kg). MAG welding (process 135) of uncoated structural steel S235 to S355, solid wire 1.0 to 1.2 mm, shielding gas M21 (argon-CO2 mixture), cycle time approximately 90 seconds.

Spatial limits: floor area of the cell approximately 6.5 x 4.0 m plus a maintenance aisle at least 1.0 m wide all round the safety fence; personnel access only via the loading station with the light curtain and the interlocked maintenance door.

Time limits: designed for two-shift operation (16 h per working day); maintenance intervals in accordance with the operating instructions; intended service life 12 years.

Environmental limits: indoors, +5 to +40 degrees C, relative humidity up to 70 per cent non-condensing, level load-bearing industrial floor, adequate hall ventilation.

Energy limits and interfaces: 400 V AC 50 Hz, connected load 32 kVA; compressed air 6 bar (+/- 0.5 bar); shielding gas supply via user-side ring main or cylinder bank; welding fume extraction 1800 m³/h with filter cartridge, return of the cleaned air to the hall.

Reasonably foreseeable misuse: Bypassing or manipulating guards: climbing over the safety fence, reaching through or over the light curtain, manipulating the guard locking of the maintenance door or the enabling device. Presence of a second person in the cell in set-up mode outside the field of view of the set-up personnel. Reaching into the turntable during rotation, for example to reposition a slipped workpiece. Loading of impermissible workpieces: too heavy, too large, oily, coated or galvanised (increased hazardous substance emission). Manual lifting of workpieces over 15 kg without a lifting aid. Operation with a saturated filter cartridge or with the extraction switched off. Cleaning, maintenance and fault-clearing work without isolation and securing against re-energisation (electrical energy, residual pneumatic energy). Operation by uninstructed personnel. Unprotected viewing of the arc by bystanders when the maintenance door is open in set-up mode.

Operating modes: Automatic mode, Setting / inching, Maintenance mode, Transport and installation, Cleaning, Fault clearance, Decommissioning / dismantling

Risk assessment method applied

Record of the risk assessment

- Date of the risk assessment: 18/08/2026
- Revision level: Rev. 2
- Participants: M. Beispiel, CE coordinator (moderation); Jonas Weber, commissioning inspector; Mechanical design; Electrical design and control engineering; Production and assembly

The assessment follows EN ISO 12100:2010: determine the limits of the machinery (clause 5.3), identify hazards (5.4), estimate the risk (5.5), evaluate the risk (5.6) and reduce the risk in three steps (clause 6).

Risk score (RS) = severity (S) × probability of occurrence (O) (2D matrix based on EN ISO 12100, max. 25).

In accordance with EN ISO 12100 clause 5.5.2.2, the severity (S) describes the extent of the possible harm: reversible or irreversible, and the number of persons affected.

In accordance with EN ISO 12100 clause 5.5.2.3, the probability of occurrence (O) combines three elements: frequency and duration of exposure, probability of occurrence of a hazardous event, and the possibility of avoiding or limiting the harm.

Severity of the possible harm (S)

- S 1 (Minor injury): reversible, treated with first aid, no medical treatment and no lost time (graze, light bruise)
- S 2 (Moderate injury): reversible, medical treatment required, healing without lasting effects, lost time of up to a few days (cut, sprain)
- S 3 (Serious injury): reversible, but in-patient treatment and prolonged healing, lost time of more than a week (fracture, deep cut, second-degree burn)
- S 4 (Very serious injury): irreversible: permanent damage, loss or permanent loss of function of a body part, occupational disease (amputation, blindness, noise-induced hearing loss)
- S 5 (Fatal): irreversible: death of one or more persons, including death occurring some time after the event

Probability of occurrence (O)

- O 1 (Unlikely): exposure rare and brief; the hazardous event requires several independent faults; the harm can as a rule be avoided
- O 2 (Rare): exposure occasional (less than monthly); the hazardous event requires a component failure or incorrect behaviour; the harm is usually avoidable
- O 3 (Occasional): exposure regular (monthly to weekly); a single fault already leads to the hazardous event; the harm is avoidable only under favourable conditions
- O 4 (Frequent): exposure frequent (daily) or over long periods; the hazardous event is to be expected in normal operation; the harm is barely avoidable
- O 5 (Very frequent): exposure continuous or in every work cycle; without a protective measure the hazardous event occurs regularly; the harm cannot be avoided

Evaluation and acceptance of the residual risk

- Acceptance criterion: a residual risk counts as adequately reduced when all life phases and operating modes have been considered, the order of the three steps has been observed, no further step 1 or step 2 measure is practicable according to the state of the art, the measures do not create new hazards, and the remaining residual risks are stated in the information for use (EN ISO 12100 clause 5.6.2).
- low (RS ≤ 4): residual risk acceptable; state residual risks in the information for use.
- medium (RS ≤ 9): acceptance only with a written justification of why no further step 1 or step 2 measure is practicable according to the state of the art; information for use is mandatory.
- high (RS ≤ 15): not acceptable; further step 1 or step 2 measures are required before the residual risk is evaluated.
- very high (RS ≤ 25): not acceptable; the machine must not be placed on the market in this condition.

Risk levels: ≤4 low · ≤9 medium · ≤15 high · ≥16 very high. Measure steps to EN ISO 12100: step 1 = inherently safe design (clause 6.2) · step 2 = safeguarding and complementary protective measures (clause 6.3) · step 3 = information for use (clause 6.4).

Protection against corruption (security for safety)

Threat analysis according to prEN 50742 (draft) route A as part of this risk assessment; 9 scenarios of the hazard type “Corruption/security” assessed, legal basis per scenario in square brackets (MR (EU) 2023/1230 Annex III No. 1.1.9, 1.2.1, 1.2.6). IEC 62443-3-3 is cited per scenario as the reference for route B. No presumption of conformity as long as there is no OJ reference.

Interface inventory: Network / fieldbus / line integration; Remote access / remote maintenance; USB / removable media; Operator panel (HMI) with user and parameter management; Engineering / programming access

Life-phase coverage:
Disposal: no hazards identified

Standards cited without presumption of conformity: EN 149 (filtering half masks to protect against particles; legal framework: Regulation (EU) 2016/425 on personal protective equipment), EN 169 (welding filters), EN 388 (protective gloves against mechanical risks; legal framework: Regulation (EU) 2016/425 on personal protective equipment), EN 407 (protective gloves against thermal risks; legal framework: Regulation (EU) 2016/425 on personal protective equipment), EN 60903 (insulating gloves for live working; legal framework: Regulation (EU) 2016/425 on personal protective equipment), EN ISO 11611 (protective clothing for welding and allied processes; legal framework: Regulation (EU) 2016/425 on personal protective equipment), EN ISO 16321 (eye and face protection at work; legal framework: Regulation (EU) 2016/425 on personal protective equipment), EN ISO 20345 (safety footwear; legal framework: Regulation (EU) 2016/425 on personal protective equipment), EN ISO 25980 (transparent welding curtains, strips and screens), ISO 7010 (registered safety signs). These standards are not listed in the Official Journal of the EU as harmonised standards for the Machinery Directive or the Machinery Regulation and therefore do not confer a presumption of conformity; applying them as recognised state of the art is permitted.

Hazards per sub-machine

Sub-machine / interface	Hazards	Highest initial risk	Highest residual risk
Communication network	1	RS 12 (High)	RS 4 (Low)
Control / logging	1	RS 9 (Medium)	RS 3 (Low)
Control / network	1	RS 12 (High)	RS 4 (Low)
Electrical installation (control cabinet / welding power source)	1	RS 10 (High)	RS 5 (Medium)
HMI / parameterisation	1	RS 12 (High)	RS 4 (Low)
Interface: turntable / welding robot	1	RS 10 (High)	RS 5 (Medium)
Interfaces to third-party equipment	1	RS 8 (Medium)	RS 4 (Low)
Loading station	1	RS 15 (High)	RS 6 (Medium)
Loading station (light curtain interface)	1	RS 10 (High)	RS 5 (Medium)
Loading station (operating station)	1	RS 16 (Very high)	RS 8 (Medium)
Loading station (removal side)	1	RS 12 (High)	RS 6 (Medium)
Loading station / maintenance aisle	2	RS 9 (Medium)	RS 6 (Medium)
MES / cloud data connection	1	RS 9 (Medium)	RS 3 (Low)
Overall installation (control / safety control)	1	RS 10 (High)	RS 5 (Medium)
Overall installation (dismantling / disposal)	1	RS 8 (Medium)	RS 4 (Low)
Overall installation (EMC interface)	1	RS 8 (Medium)	RS 4 (Low)
Overall installation (emergency stop coordination)	1	RS 10 (High)	RS 5 (Medium)
Overall installation (extraction / welding area)	1	RS 16 (Very high)	RS 8 (Medium)
Overall installation (installation)	1	RS 8 (Medium)	RS 4 (Low)
Overall installation (restart coordination)	1	RS 15 (High)	RS 5 (Medium)
Overall installation (system integration)	1	RS 10 (High)	RS 5 (Medium)
Overall installation (transport / installation)	1	RS 10 (High)	RS 5 (Medium)
Overall installation (welding area / turntable)	1	RS 16 (Very high)	RS 8 (Medium)
Overall installation (zone access)	1	RS 10 (High)	RS 5 (Medium)

Sub-machine / interface	Hazards	Highest initial risk	Highest residual risk
Pneumatic clamping device (turntable)	1	RS 12 (High)	RS 4 (Low)
Pneumatic clamping device / compressed air system	1	RS 12 (High)	RS 3 (Low)
Remote maintenance gateway / cell controller	1	RS 12 (High)	RS 4 (Low)
Safety control / engineering	1	RS 10 (High)	RS 5 (Medium)
Shielding gas supply / piping system	1	RS 8 (Medium)	RS 4 (Low)
Software / Documentation	1	RS 9 (Medium)	RS 3 (Low)
Turntable (rotary unit)	1	RS 15 (High)	RS 5 (Medium)
Welding fume extraction (filter unit)	2	RS 9 (Medium)	RS 3 (Low)
Welding power source / fixture	1	RS 8 (Medium)	RS 4 (Low)
Welding power source / welding cables	1	RS 8 (Medium)	RS 4 (Low)
Welding robot	2	RS 15 (High)	RS 5 (Medium)
Welding robot / welding area	2	RS 12 (High)	RS 4 (Low)
Welding torch	1	RS 9 (Medium)	RS 3 (Low)
Welding torch / wire feed	1	RS 12 (High)	RS 6 (Medium)

42 hazards in total. A hazard that concerns several life phases appears under each of them, which results in 106 entries.

Transport (1 hazard)

No. 28 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Hazard from falling parts during transport and installation of the cell: During crane or forklift truck transport of cell components (safety fence segments, control cabinet, robot base frame), parts may fall due to rigging errors or load swing and strike persons.

Sub-machine: Overall installation (transport / installation) · also in: Assembly · Suggested with AI assistance

Step 1 · Inherently safe design measures	All cell components (safety fence segments, control cabinet, robot base frame) are provided with permanently integrated lifting points designed in accordance with applicable standards (e.g. eye bolts in accordance with DIN 580 or eye nuts in accordance with DIN 582) with a clearly marked working load limit (WLL) per lifting point. The centre of gravity of each component is positioned by design or documented by marking on the component such that stable attachment without load swing, with a sling angle of no more than 60 degrees to the vertical (β ≤ 60°), can be maintained (design based on German DGUV Rule 109-017 as a planning reference). This reduces the probability of a rigging error through the design itself.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk from load swing and persons present in the hazard zone: (1) Technical transport documentation: For each component, a rigging plan (drawing with lifting points, centre of gravity position, selection of lifting accessories and WLL) is to be provided as part of the assembly documents ((EU) 2023/1230 Annex III, section 1.7.4.2, information on transport and handling). (2) Cordoning off the hazard zone: During all crane lifts, the area below and to the side of the load is to be secured by physical barriers (barrier tape, barrier fencing) so that no unintended access by persons is possible. (3) Lifting accessories: Selection and use of tested lifting accessories (chains, lifting slings, shackles) with a sufficient WLL and a valid test certificate in accordance with the German Ordinance on Industrial Safety and Health (BetrSichV). A safety function within the meaning of EN ISO 13849-1 is not applicable to this transport phase; a PLr is not to be assigned.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4.2): (1) Include rigging plans with lifting points, centre of gravity position and WLL per component in Chapters 5.2 and 5.3. (2) Qualification requirement: crane operations and load rigging may only be carried out by instructed and authorised riggers (qualification in accordance with German DGUV Information 209-013). (3) Warning labelling on each component: warning sign 'Warning; Overhead load' (W015 in accordance with EN ISO 7010:2020), indication of the mass and the WLL per lifting point directly on the component. (4) PPE specification: safety helmet, safety footwear (S3) and high-visibility vest are mandatory during all transport operations. (5) Note: remaining beneath suspended loads is prohibited.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) during transport and installation. The severity remains 5 because assemblies of up to approximately 1,900 kg (turntable) are lifted. In step 1, all transport units have permanently integrated, marked lifting points with permissible working load and a documented centre of gravity for slinging at no more than 60 degrees to the vertical. Hoists, forklift trucks and lifting accessories are not part of the machine; the manufacturer can only influence the lifting operation itself through lifting points, slinging plan and marking, and these means are implemented (step 2: slinging plan for each component, barrier around the danger zone, requirement for tested lifting accessories in accordance with the German Industrial Safety Regulation BetrSichV). No further step 1 or step 2 measure on the machine that prevents slinging errors or swinging during crane lifting has been identified. The remaining risk consists of errors in slinging and persons standing under the load. Masses, lifting points, the prohibition of standing under suspended loads and the PPE are stated in the operating instructions (chapter 5) and on the components (sign W015, chapter 2.4).

Assembly (3 hazards)

No. 28 Mechanical — Risk before: S 5 · O 2 · **RS 10**

Hazard from falling parts during transport and installation of the cell: During crane or forklift truck transport of cell components (safety fence segments, control cabinet, robot base frame), parts may fall due to rigging errors or load swing and strike persons.

Sub-machine: Overall installation (transport / installation) · also in: Transport · Suggested with AI assistance

Step 1 · Inherently safe design measures	All cell components (safety fence segments, control cabinet, robot base frame) are provided with permanently integrated lifting points designed in accordance with applicable standards (e.g. eye bolts in accordance with DIN 580 or eye nuts in accordance with DIN 582) with a clearly marked working load limit (WLL) per lifting point. The centre of gravity of each component is positioned by design or documented by marking on the component such that stable attachment without load swing, with a sling angle of no more than 60 degrees to the vertical (β ≤ 60°), can be maintained (design based on German DGUV Rule 109-017 as a planning reference). This reduces the probability of a rigging error through the design itself.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk from load swing and persons present in the hazard zone: (1) Technical transport documentation: For each component, a rigging plan (drawing with lifting points, centre of gravity position, selection of lifting accessories and WLL) is to be provided as part of the assembly documents ((EU) 2023/1230 Annex III, section 1.7.4.2, information on transport and handling). (2) Cordoning off the hazard zone: During all crane lifts, the area below and to the side of the load is to be secured by physical barriers (barrier tape, barrier fencing) so that no unintended access by persons is possible. (3) Lifting accessories: Selection and use of tested lifting accessories (chains, lifting slings, shackles) with a sufficient WLL and a valid test certificate in accordance with the German Ordinance on Industrial Safety and Health (BetrSichV). A safety function within the meaning of EN ISO 13849-1 is not applicable to this transport phase; a PLr is not to be assigned.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4.2): (1) Include rigging plans with lifting points, centre of gravity position and WLL per component in Chapters 5.2 and 5.3. (2) Qualification requirement: crane operations and load rigging may only be carried out by instructed and authorised riggers (qualification in accordance with German DGUV Information 209-013). (3) Warning labelling on each component: warning sign 'Warning; Overhead load' (W015 in accordance with EN ISO 7010:2020), indication of the mass and the WLL per lifting point directly on the component. (4) PPE specification: safety helmet, safety footwear (S3) and high-visibility vest are mandatory during all transport operations. (5) Note: remaining beneath suspended loads is prohibited.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) during transport and installation. The severity remains 5 because assemblies of up to approximately 1,900 kg (turntable) are lifted. In step 1, all transport units have permanently integrated, marked lifting points with permissible working load and a documented centre of gravity for slinging at no more than 60 degrees to the vertical. Hoists, forklift trucks and lifting accessories are not part of the machine; the manufacturer can only influence the lifting operation itself through lifting points, slinging plan and marking, and these means are implemented (step 2: slinging plan for each component, barrier around the danger zone, requirement for tested lifting accessories in accordance with the German Industrial Safety Regulation BetrSichV). No further step 1 or step 2 measure on the machine that prevents slinging errors or swinging during crane lifting has been identified. The remaining risk consists of errors in slinging and persons standing under the load. Masses, lifting points, the prohibition of standing under suspended loads and the PPE are stated in the operating instructions (chapter 5) and on the components (sign W015, chapter 2.4).

No. 29 Mechanical — Risk before: S 4 · O 2 · **RS 8**

Hazard from insufficient stability of the cell during installation: if the cell is installed on an uneven or non-load-bearing floor, or if the heavy-duty anchors are not set and tightened as specified, the system may tip over or shift; persons in the vicinity may be struck.

Sub-machine: Overall installation (installation) · also in: Commissioning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Stability assured by design, by means of an adequately dimensioned, torsionally rigid base frame (welded frame structure or structural steel frame) with a wide base area and low centre of gravity in accordance with EN ISO 12100:2010 section 6.2.6 (stability). Fixing bores in the base frame for floor anchoring with 2 × 4 heavy-duty anchors M16 to be provided so that anchoring is possible without reworking; the anchoring is designed so that it cannot work loose by itself and can be released only with a tool. The centre of gravity position and tipping resistance are to be verified by calculation as part of the design (stability verification in accordance with EN ISO 12100:2010 section 6.2.6).
Step 2 · Safeguarding and/or complementary protective measures	(1) Provision of a machine-specific installation plan (dimensional drawing with a minimum floor load-bearing capacity of 10 kN/m², flatness tolerance of the substrate and anchor point positions) as part of the delivery documentation, which is to be approved by the user before assembly commences. (2) Marking of the anchor points on the base frame by means of permanent markings (arrow or labelling) so that assembly personnel can identify the positions unambiguously. (3) For the assembly state before the anchors are set: verification of stability without anchoring (tipping resistance verification, ratio of stabilising moments to tipping moments of at least 1.5 as specified by the manufacturer). These measures are not safety functions within the meaning of EN ISO 13849-1 and do not require a PLr.
Step 3 · Information for use	(1) Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Chapter 7 (Installation conditions) and Chapter 8 (Assembly and installation) with binding specifications for: minimum floor load-bearing capacity (at least 10 kN/m²), required flatness of the substrate, obligation to anchor to the floor with 2 × 4 heavy-duty anchors M16 (tightening torque 110 Nm) with specification of the anchor type and embedment depth, and reference to the installation plan. (2) Warning marking on the base frame: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Risk of tipping before anchoring' on at least two opposite sides of the base frame, visible during assembly. (3) Qualification requirement: installation and anchoring may only be carried out by qualified specialist personnel (industrial mechanics or fitters with experience in machine installation); requirement to be stated in the operating instructions. (4) PPE notice: safety footwear (EN ISO 20345, protection class S3) and protective gloves during assembly; specification in the operating instructions.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 39 Corruption/security — Risk before: S 4 · O 2 · **RS 8**

Connection of external devices creates a hazardous situation: A connected external device (the user's higher-level line control system or MES, remote maintenance gateway, user-side signals from the extraction system or the gas supply) sends unexpected signals, writes to control variables or occupies resources. The machine starts, changes the operating mode or ignores stop conditions because the functions of the external device were not taken into account in the risk assessment. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 1, 1.2.1 lit. h, 1.2.4.4]

Sub-machine: Interfaces to third-party equipment · also in: Commissioning, Operation

Step 1 · Inherently safe design measures	Design interfaces to external devices as defined signal interfaces with specified semantics (no enabling of movements by external signals alone), route safety-relevant signals only via safe inputs/outputs, assign the stop and emergency stop chain of the external device unambiguously.
Step 2 · Safeguarding and/or complementary protective measures	Whitelist of approved participants and variables, plausibility check of incoming commands, interlock of operating mode changes via external interfaces, diagnostics for missing or unknown participants. Evidence reference route B: IEC 62443-3-3 SR 1.2, SR 2.1, SR 3.5, SR 5.2, SR 7.7.
Step 3 · Information for use	Operating instructions and interface description for the integrator (signals, states, requirements for the assembly of machinery in accordance with Annex III, section 1.2.4.4), note that the connection of non-approved devices requires a new risk assessment.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

Commissioning (9 hazards)

No. 12 Electrical — Risk before: S 5 · O 2 · **RS 10**

Hazard from direct or indirect contact with live parts of the welding power source, the robot control cabinet and the cell control system (400 V AC, 32 kVA): Contact with terminals, cables or the interior of the control cabinet when the cabinet is open without isolation can lead to electric shock with ventricular fibrillation or burns.

Sub-machine: Electrical installation (control cabinet / welding power source) · also in: Maintenance, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	All live parts inside the control cabinet (terminals, busbars, power terminals of the welding power source) are designed with touch-proof covers (degree of protection at least IP 2X or IPXXB in accordance with EN 60204-1:2018 section 6.2.2), so that contact with live parts is prevented by the enclosure form itself without the need for a guard. In addition, minimum clearances between live and accessible parts are designed such that the degree of protection IP 2X is maintained even with the cabinet door open (protective caps, insulating covers on terminal strips). This addresses (EU) 2023/1230 Annex III, section 1.5.1 (Electrical energy supply) by analogy, as well as EN 60204-1:2018 section 6.2.
Step 2 · Safeguarding and/or complementary protective measures	1. Isolation and de-energisation (LOTO): Main switch with lockable OFF position in accordance with EN 60204-1:2018 section 5.3 and EN ISO 14118:2018 (prevention of unexpected start-up / energy isolation). The main switch must disconnect the overall installation from the supply on all poles as an isolating device; residual voltage at the capacitors of the welding power source is to be limited to below 60 V DC within 5 s by means of a discharge time or active discharge circuit; where this is not achieved, a warning notice stating the discharge time is affixed to the enclosure (EN 60204-1:2018 section 6.2.4). Cabinet door interlock: The doors of the main control cabinets are fitted with a lock that can only be opened with a key and prevents unauthorised opening (EN 60204-1:2018 section 6.2.2). 2. Protective equipotential bonding and protective conductor: All control cabinet enclosures, the welding power source and the robot control cabinet are connected via a continuous protective conductor (PE) of adequate cross-section (EN 60204-1:2018 section 8.2), so that in the event of an insulation fault the fault current is safely dissipated and the protective device (circuit breaker / RCD) trips. 3. Residual current device (RCD): Use of an RCD (Type B, since DC fault currents from frequency inverters and the welding power source are possible) with a rated residual operating current of 30 mA for circuits on which persons are working; in circuits where an RCD is not compatible with the welding process, insulation monitoring is used instead (EN 60204-1:2018 sections 6.3.3 and 7.7). Not a safety function with a PLr requirement; the measures act passively and by design (warning labelling: see Step 3).
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Document the isolation procedure (LOTO) with a step-by-step instruction, including the discharge time of the capacitors of the welding power source and verification of the absence of voltage using a suitable measuring instrument (voltage tester Category CAT III 600 V). Qualification requirement: Work on the electrical installation may only be carried out by electrically skilled persons (ESP) in accordance with the German accident prevention regulation DGUV Regulation 3, or under the supervision of an ESP by electrically instructed persons. PPE specification: Insulating gloves (in accordance with EN 60903, class 00 for voltages up to 500 V AC), safety goggles (arc flash protection) and electrically insulating footwear are to be worn when working in an open cabinet. Warning labelling: Warning sign W012 'Warning; Electricity' in accordance with EN ISO 7010:2020 to be affixed permanently and clearly visible to all cabinet doors and to the welding power source. Residual risk note in the operating instructions: After operation of the main switch, capacitors in the welding power source and in the frequency inverter of the robot may still carry dangerous voltages (waiting time of at least 1 minute for the welding power source, for the robot drive as specified by the robot manufacturer); absence of voltage must always be verified by measurement.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to electrical voltage of 400 V AC. In step 1, the live parts are covered finger-safe (IP 2X in accordance with EN 60204-1:2018 section 6.2.2), also with the cabinet door open. After step 2, the lockable main switch disconnects all poles, the cabinet doors can only be opened with a key, the DC link of the welding power source discharges to no more than 60 V in a measured 1.9 s, protective conductor (0.08 Ω), fault loop impedance (0.28 Ω) and insulation resistance (> 100 MΩ) have been tested, and fault protection is provided by a type B RCD or insulation monitoring. The remaining risk is the work of the qualified electrician, who has to take measurements on live parts in the open cabinet during commissioning and fault-finding. These measurements cannot be carried out without voltage; for these life cycle phases no further step 1 or step 2 measure is therefore practicable, and the severity remains 5. The isolation procedure including verification of the absence of voltage, the qualification as a qualified electrician, insulating PPE and sign W012 are stated in the operating instructions (chapters 2.4, 2.6, 8.1 and 10).

No. 29 Mechanical — Risk before: S 4 · O 2 · **RS 8**

Hazard from insufficient stability of the cell during installation: if the cell is installed on an uneven or non-load-bearing floor, or if the heavy-duty anchors are not set and tightened as specified, the system may tip over or shift; persons in the vicinity may be struck.

Sub-machine: Overall installation (installation) · also in: Assembly · Suggested with AI assistance

Step 1 · Inherently safe design measures	Stability assured by design, by means of an adequately dimensioned, torsionally rigid base frame (welded frame structure or structural steel frame) with a wide base area and low centre of gravity in accordance with EN ISO 12100:2010 section 6.2.6 (stability). Fixing bores in the base frame for floor anchoring with 2 × 4 heavy-duty anchors M16 to be provided so that anchoring is possible without reworking; the anchoring is designed so that it cannot work loose by itself and can be released only with a tool. The centre of gravity position and tipping resistance are to be verified by calculation as part of the design (stability verification in accordance with EN ISO 12100:2010 section 6.2.6).
Step 2 · Safeguarding and/or complementary protective measures	(1) Provision of a machine-specific installation plan (dimensional drawing with a minimum floor load-bearing capacity of 10 kN/m², flatness tolerance of the substrate and anchor point positions) as part of the delivery documentation, which is to be approved by the user before assembly commences. (2) Marking of the anchor points on the base frame by means of permanent markings (arrow or labelling) so that assembly personnel can identify the positions unambiguously. (3) For the assembly state before the anchors are set: verification of stability without anchoring (tipping resistance verification, ratio of stabilising moments to tipping moments of at least 1.5 as specified by the manufacturer). These measures are not safety functions within the meaning of EN ISO 13849-1 and do not require a PLr.
Step 3 · Information for use	(1) Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Chapter 7 (Installation conditions) and Chapter 8 (Assembly and installation) with binding specifications for: minimum floor load-bearing capacity (at least 10 kN/m²), required flatness of the substrate, obligation to anchor to the floor with 2 × 4 heavy-duty anchors M16 (tightening torque 110 Nm) with specification of the anchor type and embedment depth, and reference to the installation plan. (2) Warning marking on the base frame: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Risk of tipping before anchoring' on at least two opposite sides of the base frame, visible during assembly. (3) Qualification requirement: installation and anchoring may only be carried out by qualified specialist personnel (industrial mechanics or fitters with experience in machine installation); requirement to be stated in the operating instructions. (4) PPE notice: safety footwear (EN ISO 20345, protection class S3) and protective gloves during assembly; specification in the operating instructions.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 30 Combination

Risk before: S 5 · O 2 · **RS 10**

Hazard arising from incorrect parameterisation of the robot control system or the safety controller (e.g. incorrect safety distances, incorrect speed limits in set-up mode, incorrect zone releases): Erroneous parameters may result in safety functions not operating as intended, thereby endangering persons through robot movements or turntable movements.

Sub-machine: Overall installation (control / safety control) · also in: Setting up, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Safety-relevant parameters (speed limits, protection zones, zone releases) are stored exclusively in the safety controller (safety PLC) and are protected against unauthorised or inadvertent modification by a password-protected, role-based access concept. Parameter sets for safety functions SF-01 to SF-05 are stored in the safety controller as immutable, checksum-protected data records (e.g. CRC-32 or equivalent), so that any unintended modification is automatically detected at system start-up and a safe state is enforced. This principle corresponds to the inherently safe control principle in accordance with EN ISO 12100 section 6.2.11 (control principles that limit the occurrence of hazards) and reduces the possibility of erroneous parameters becoming effective at all.
Step 2 · Safeguarding and/or complementary protective measures	1. Validation requirement before release: Every change to safety-relevant parameters requires a documented acceptance test (functional test of all affected safety functions SF-01 to SF-05) carried out by two authorised persons (dual-control principle) before recommissioning. The safety controller may not release automatic operation until a positive acknowledgement has been given. Basis: EN ISO 13849-2:2012 (validation of safety functions) and EN ISO 11161:2007+A1:2010 (verification and validation for integrated manufacturing systems). 2. Parameter verification by the safety controller: The safety controller (PLr e for SF-02 and SF-04, PLr d for SF-01, SF-03 and SF-05 in accordance with EN ISO 13849-1:2023) checks the consistency of the safety-relevant parameters against stored reference values (checksum comparison) at start-up and cyclically. In the event of a discrepancy, stop category 1 in accordance with EN 60204-1:2018 is triggered and a restart is inhibited (no automatic restart in accordance with EN ISO 14118:2018). 3. Set-up mode SF-05: The safely reduced speed of 250 mm/s (SF-05, PLr d) is limited at hardware level in the safety controller and cannot be overridden by parameters of the robot control system. Monitoring is performed by an SRP/CS in accordance with EN ISO 13849-1:2023, category and PL in accordance with SF-05 (PLr d). 4. Zone release turntable SF-04: The release of the 180-degree rotary movement (SF-04, PLr e) is performed exclusively via the safety controller on the basis of verified sensor signals; a release caused by erroneous zone parameters in the robot control system alone is excluded by design. 5. Change management: All parameter changes are stored with a time stamp, user identification and predecessor/successor value in a tamper-proof change log (audit trail) of the safety controller. Basis: EN ISO 11161:2007+A1:2010.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the parameter change procedure with a step-by-step guide, listing of all safety-relevant parameters for each safety function (SF-01 to SF-05), obligation to carry out a validation test after each change, and documentation obligation in the change log. 2. Qualification requirement: Parameter changes to the safety controller may only be carried out by specialist personnel with demonstrated qualification in functional safety (e.g. TÜV certification as Functional Safety Engineer or equivalent) and knowledge of the system. This is to be set out in the operating instructions and in an operating procedure. 3. Warning labelling: The warning sign 'Warning; Electricity' (W012 in accordance with EN ISO 7010:2020) and the supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006) are to be affixed to the safety controller and the control cabinet. Additionally, an information sign stating: 'Parameter changes by authorised specialist personnel only; subsequent validation test required'. 4. Commissioning checklist: Before every initial commissioning and after every parameter change, a system-specific commissioning checklist is to be completed and signed (basis: EN ISO 11161:2007+A1:2010).

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to incorrect parameterisation. In step 1, the safety-relevant parameters are held only in the safety PLC, protected by a role-based access concept and checksum-protected parameter sets. After step 2, the safety PLC checks the parameters against the reference at start-up and cyclically and triggers a stop with restart interlock in the event of a deviation, the speed limit of SF-05 cannot be overwritten via the robot controller, the rotation enable SF-04 comes only from the safety PLC, and every change is logged and validated under the four-eyes principle in accordance with EN ISO 13849-2:2012 before release. The remaining risk is a parameter that is specified incorrectly by authorised personnel and not detected during validation. The parameters have to remain changeable for commissioning, modifications and new clamping fixtures; a measure that detects a technically incorrect but properly entered and validated value is not available according to the state of the art. Change procedure, qualification, commissioning checklist and the text sign on the validation obligation at the control cabinet: operating instructions chapters 2.4 and 2.6.

No. 31 Combination — Risk before: S 5 · O 2 · **RS 10**

Hazard from differing safety levels of the sub-machines from different manufacturers (robot, welding power source, turntable, extraction system): missing or incomplete interface interlocking between the sub-machines may result in one sub-machine starting up even though another is in an unsafe condition (EN ISO 11161).

Sub-machine: Overall installation (system integration) · also in: Operation, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	System architecture with a single, higher-level safety controller (Safety Master) as an inherently safe control principle in accordance with EN ISO 12100 section 6.2.11: All safety-relevant status signals of the sub-machines (robot operating mode, turntable end position, extraction system operation, welding power source ready) are routed exclusively via the safety controller. No sub-machine drive receives an enable signal unless the safety controller has assessed the overall state as safe. Through this centralisation, the possibility of an incomplete interface interlock is reduced to a minimum by design: there are no parallel, mutually independent enable paths between the sub-machines. The interface definition is carried out in accordance with EN ISO 11161:2007+A1:2010 (system integration, responsibilities, interface description) and is documented in the safety concept of the overall installation.
Step 2 · Safeguarding and/or complementary protective measures	1. Interlock matrix in accordance with EN ISO 11161:2007+A1:2010: For each sub-machine combination, a complete state matrix (operating mode x state of the other sub-machines) is created and implemented in the safety controller. Each enable signal is implemented as an AND-combination of all relevant safety states. 2. Safety function SF-04 (enable of the 180-degree rotary movement of the turntable only when the rotation range is clear, PLr e) ensures that the turntable only rotates when the protective field of the light curtain is clear, the clamps are closed and the robot is demonstrably outside the rotation range. The safety function is designed to PLr e in accordance with EN ISO 13849-1:2023 and validated in accordance with EN ISO 13849-2:2012. 3. Safety function SF-01 (safe stopping upon opening of the maintenance door, stop category 1, PLr d) and SF-02 (safe stopping upon interruption of the light curtain, PLr e) are coordinated across the overall installation: a stop signal from one sub-machine triggers the coordinated stop of all sub-machines via the safety controller. Stop category 1 in accordance with EN 60204-1:2018 section 9.2.2 applies to the robot and the turntable. 4. Emergency stop of the overall installation (SF-03, stop category 1, PLr d) in accordance with EN ISO 13850:2015 acts on all sub-machines simultaneously via the safety controller. Emergency stop devices are arranged at the control desk, at the maintenance door and on the teach pendant. 5. Prevention of unexpected start-up in accordance with EN ISO 14118:2018: After every stop (emergency stop, activation of a protective device, interruption of energy supply), a deliberate restart command is required; automatic restart is excluded. 6. Set-up mode with safely reduced speed (SF-05, 250 mm/s, PLr d) and enabling device in accordance with EN ISO 10218-2:2025 section 5.7.7; in this mode, the robot and the turntable move only with the enabling device actuated and at safely reduced speed, and the welding power source is safely switched off via SF-01 while the maintenance door is open.
Step 3 · Information for use	Operating instructions for the overall installation in accordance with (EU) 2023/1230 Annex III, section 1.7.4: The interface interlock logic (state matrix, enable conditions per sub-machine) is to be documented in full. For each sub-machine, the handover point of safety responsibility (sub-machine manufacturer up to the interface, integrator from the interface onwards) is defined in writing in the safety concept of the overall installation in accordance with EN ISO 11161:2007+A1:2010 and is to be stated in the operating instructions. Qualification requirement: commissioning, parameterisation and modifications to the safety controller may only be carried out by qualified specialist personnel with knowledge of EN ISO 13849-1:2023 and EN ISO 11161. Warning labelling at the control desk: warning sign 'Warning; Automatic start-up' (W018 in accordance with EN ISO 7010:2020). The operating instructions must describe procedures for fault-finding and commissioning, including the sequence in which sub-machines may be commissioned and the verification steps for checking the interface interlock prior to the first automatic operation.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) at the interfaces of sub-machines from different manufacturers. The robot (partly completed machinery with declaration of incorporation), welding power source and extraction unit have their own control systems, and their integration requires a higher-level logic. In step 1, all safety-relevant states are routed through a single safety PLC without parallel enabling paths. After step 2, an interlocking matrix of all operating modes and states is implemented as an AND logic, SF-01 to SF-05 act across the entire installation, every stop leads to a coordinated stop of all sub-machines, and validation is carried out in accordance with EN ISO 13849-2:2012 and EN ISO 11161:2007+A1:2010. The remaining risk is a systematic error in the specification of the matrix that remains undetected during validation. The internal safety of the purchased sub-machines is the responsibility of their respective manufacturers; at the interfaces for which the manufacturer of the assembly is responsible, no further step 1 or step 2 measure beyond the central interlocking and its validation has been identified. Transfer points of responsibility, commissioning sequence and test steps of the interface interlocking: operating instructions chapters 1.1, 2.6 and 8.3.

No. 37 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Unintentional corruption through misconfiguration or operator error: Incorrect recipe or parameter file loaded, roles and passwords not set up (default password active), configuration incompletely restored after a fault. Safety-relevant settings deviate from the approved configuration without being noticed. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 3, 1.2.1 lit. b, 1.2.1 lit. d, 1.2.1 lit. e]

Sub-machine: HMI / parameterisation · also in: Setting up, Operation

Step 1 · Inherently safe design measures	Separate safety-relevant settings from process recipes so that a recipe change cannot alter them; hard-limit value ranges in the safety controller (limits derived from the risk assessment, Annex III, section 1.2.1, point (d)).
Step 2 · Safeguarding and/or complementary protective measures	Forced password change on commissioning, role model with dual-control approval for safety-relevant changes, comparison of the active configuration with the approved reference (checksum) at start-up with display of any deviation, change log. Evidence reference route B: IEC 62443-3-3 SR 1.5, SR 2.1, SR 3.4, SR 7.6.
Step 3 · Information for use	Operating instructions: commissioning checklist (passwords, roles, saving of reference configuration), description of the data designated as safety-relevant, instruction for functional testing after configuration changes.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 38 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Failure or disruption of the communication network connection: Network failure, overload (broadcast storm, denial of service), cable break or change of network segment interrupts communication between control components or the safety-oriented communication (PROFIsafe). Upon restoration, an unexpected start-up occurs or outdated setpoint values are taken over in an uncontrolled manner. [MR (EU) 2023/1230 Annex III No. 1.2.6, 1.2.1 lit. a, 1.2.3]

Sub-machine: Communication network · also in: Operation

Step 1 · Inherently safe design measures	Design safety functions such that loss of communication leads to the safe state (watchdog, time monitoring of safe telegrams) and a restart only takes place after a deliberate acknowledgement (Annex III, section 1.2.3). Decouple safety-directed communication from standard communication.
Step 2 · Safeguarding and/or complementary protective measures	Network segmentation and load limiting (rate limiting, storm protection at switches), monitoring of network quality with diagnostic message, defined behaviour upon loss of connection in all operating modes tested and documented. Evidence reference route B: IEC 62443-3-3 SR 7.1, SR 7.2, SR 5.1, SR 5.2.
Step 3 · Information for use	Operating instructions: requirements for the user's network (segmentation, permitted participants, no external devices in the safety segment), description of the behaviour upon communication failure and the restart procedure.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 39 Corruption/security — Risk before: S 4 · O 2 · **RS 8**

Connection of external devices creates a hazardous situation: A connected external device (the user's higher-level line control system or MES, remote maintenance gateway, user-side signals from the extraction system or the gas supply) sends unexpected signals, writes to control variables or occupies resources. The machine starts, changes the operating mode or ignores stop conditions because the functions of the external device were not taken into account in the risk assessment. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 1, 1.2.1 lit. h, 1.2.4.4]

Sub-machine: Interfaces to third-party equipment · also in: Assembly, Operation

Step 1 · Inherently safe design measures	Design interfaces to external devices as defined signal interfaces with specified semantics (no enabling of movements by external signals alone), route safety-relevant signals only via safe inputs/outputs, assign the stop and emergency stop chain of the external device unambiguously.
Step 2 · Safeguarding and/or complementary protective measures	Whitelist of approved participants and variables, plausibility check of incoming commands, interlock of operating mode changes via external interfaces, diagnostics for missing or unknown participants. Evidence reference route B: IEC 62443-3-3 SR 1.2, SR 2.1, SR 3.5, SR 5.2, SR 7.7.
Step 3 · Information for use	Operating instructions and interface description for the integrator (signals, states, requirements for the assembly of machinery in accordance with Annex III, section 1.2.4.4), note that the connection of non-approved devices requires a new risk assessment.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 40 Corruption/security — Risk before: S 3 · O 3 · **RS 9**

Safety-relevant software not identifiable or labelled: The version status and checksum of the safety software cannot be retrieved at the machine, and safety-relevant software and data are not designated as such. After an intervention, update or device replacement, it cannot be determined whether the machine is still in the inspected state; operation with non-approved software remains undetected. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 3, 1.1.9 para. 4, 1.7.4.2]

Sub-machine: Software / Documentation · also in: Maintenance, Operation

Step 1 · Inherently safe design measures	Design safety-relevant software as a distinct unit with its own version number and checksum (separate from standard and visualisation software) so that unambiguous identification is technically possible.
Step 2 · Safeguarding and/or complementary protective measures	Information page on the HMI showing the version and checksum of all safety-relevant software components (always easily accessible without login, Annex III, section 1.1.9, fourth paragraph), labelling of safety-relevant data in file names, menus and exports, comparison with the acceptance report at start-up. Evidence reference route B: IEC 62443-3-3 SR 3.4.
Step 3 · Information for use	Operating instructions: list of safety-relevant software and data with versions (Annex III, section 1.7.4.2), instructions for retrieving version information, note on the significance for conformity and on the obligation to report deviations.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 43 Corruption/security

Risk before: S 5 · O 2 · **RS 10**

Unsecured engineering access to the safety controller: The programming access of the safety controller or safety PLC is reachable without a password or with the manufacturer's default credentials; the safety program can be overwritten or placed in a stopped state during operation, and forcing of inputs and outputs is possible. Protective functions are rendered ineffective or actuators are controlled directly. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 2, 1.1.9 para. 3, 1.2.1 lit. a]

Sub-machine: Safety control / engineering · also in: Maintenance, Troubleshooting

Step 1 · Inherently safe design measures	Programming access to the safety controller physically separated from the process network (dedicated port, inside a locked control cabinet), no forcing of safety-relevant signals in the as-delivered state, program changes only in the secured stop state of the machine.
Step 2 · Safeguarding and/or complementary protective measures	Individual password for the safety program access with mandatory password change at commissioning, write protection and access protection levels of the controller activated, logging of all accesses and program changes with version and checksum, display of the program status on the HMI. Evidence reference route B: IEC 62443-3-3 SR 1.1, SR 1.5, SR 2.1, SR 2.8, SR 3.4, SR 7.7.
Step 3 · Information for use	Operating instructions: Access protection and password management as a user obligation, prohibition of program changes without re-verification and documentation, reference to the requirements for substantial modification.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) via the engineering access to the safety controller. The access has to remain available for commissioning, maintenance and fault-finding. In step 1, the programming port is separated from the process network inside the locked control cabinet, forcing of safety-relevant signals is excluded in the as-delivered state, and program changes are only permitted in the secured stop state. After step 2, an individual password, write protection and access protection levels are active, every access and every program change is logged with version and checksum, and the program status can be retrieved on the HMI panel (evidence in accordance with IEC 62443-3-3 SR 1.1, 1.5, 2.1, 2.8, 3.4 and 7.7). The remaining risk is misuse or error by a person with a valid password and cabinet key. A technical measure that distinguishes authorised from improper changes is not available according to the state of the art; deviations become detectable by comparing version and checksum with the acceptance report. Password management as an obligation of the user and the prohibition of program changes without renewed testing and documentation are stated in the operating instructions (chapters 2.6 and 13).

Setting up (24 hazards)

No. 1 Mechanical — Risk before: S 5 · O 3 · **RS 15**

Crushing and shearing hazard from the turntable during the automatic rotation: Body parts of the operator (hands, arms) may be drawn in and crushed between the turntable and the fixed dividing centre wall or the safety fence, in particular when reaching into the turntable during rotation to reposition a displaced workpiece (reasonably foreseeable misuse).

Sub-machine: Turntable (rotary unit) · also in: Operation, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Design the gap dimensions between the turntable edge and the fixed dividing centre wall as well as the safety fence such that no crushing points arise: the gaps must not be smaller than the minimum gaps in EN ISO 13854:2019 Table 1 (25 mm for fingers, 100 mm for the hand, 120 mm for the arm, 500 mm for the body). Alternatively, keep the gap so small that no part of the body can enter it (opening sizes in accordance with EN ISO 13857:2019 Table 4). Where neither of the two gap sizes can be achieved, the geometry of the table frame must be configured so that no converging wedge shape is created (parallel or diverging flanks instead of a converging gap). In addition: reduce the mass and rotation speed of the turntable to the functionally necessary minimum (drive design) in order to limit the kinetic energy acting in the crushing gap.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk after Step 1: The rotation range remains a hazard zone that must not be entered while the drive is running. Technical protective measures: 1. Release of the rotary movement only when the rotation range is clear (SF-04, PLr e, EN ISO 13849-1:2023): ESPE (light curtain type 4 in accordance with EN IEC 61496-1:2020) monitors the rotation range completely; arrangement and safety distance in accordance with EN ISO 13855:2024. 2. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release (SF-01, PLr d; stop category 1 in accordance with EN 60204-1:2018). 3. Set-up mode: rotary movement only at safely reduced speed of 250 mm/s and with the enabling device actuated (SF-05, PLr d, stop category 1 in accordance with EN 60204-1:2018). 4. Emergency stop in the operator area in accordance with EN ISO 13850:2015, integrated into SF-03 (PLr d, stop category 1 in accordance with EN 60204-1:2018). 5. Energy isolation prior to interventions: isolating valve with mechanical latching (lockout) in accordance with EN ISO 4414:2010; lock the turntable positively in its end position (EN ISO 14118:2018).
Step 3 · Information for use	1. Operating instructions: entering the rotation range while the turntable is running or unsecured is prohibited. Before any intervention (e.g. repositioning a workpiece), the system must be completely switched off and secured (lockout/tagout). A separate procedure with an enabling device applies to set-up mode and is described in the operating instructions. 2. Warning signs on the machine: the following signs are affixed to the turntable: warning signs W019 'Warning; Crushing' and W024 'Warning; Crushing of hands' and prohibition sign P015 'No reaching in' (in accordance with EN ISO 7010:2020). 3. Who may intervene: set-up and fault rectification may only be carried out by trained personnel. Training must be repeated at least once a year and recorded in writing. 4. Personal protective equipment: protective gloves do not protect against crushing. Reach into the rotation range only when the turntable has been stopped. Safety footwear S3 in accordance with EN ISO 20345 is mandatory throughout the entire area of the installation.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Warning: crushing

Justification of acceptance: Residual risk RS 5 (S 5, O 1). The severity remains 5: the mass and drive of the turntable are required for the 180-degree rotation with a payload of up to 2 x 40 kg plus clamping fixtures in a cycle of around 90 seconds and have already been limited to the functionally necessary level in step 1; the gaps are designed in accordance with EN ISO 13854:2019 and EN ISO 13857:2019, and the table edges have no converging wedge shape. Any further reduction of the energy would prevent the rotation. After step 2, the table only rotates when the rotation range is clear (SF-04, PL e), the maintenance door is guard-locked (SF-01, PL d), set-up mode is limited to 250 mm/s with enabling device (SF-05), and the table is positively locked before any intervention. An accident therefore requires deliberate reaching into the rotating table while bypassing these devices; no additional step 1 or step 2 measure has been identified that would make this misuse more difficult without preventing the rotation. The prohibition and the obligation to isolate before every intervention are stated in the operating instructions (chapters 2.2, 2.6 and 9.1), and signs W019, W024 and P015 are affixed to the turntable.

No. 2 Mechanical — Risk before: S 5 · O 3 · **RS 15**

Crushing and drawing-in hazard from the welding robot (industrial robot) in set-up mode: at reduced speed (hold-to-run control), operators or set-up personnel may be crushed or drawn in between the robot arm and peripheral equipment (safety fence, turntable, welding fixture) by unexpected robot movements.

Sub-machine: Welding robot · Suggested with AI assistance

Step 1 · Inherently safe design measures	Speed limitation to a maximum of 250 mm/s (TCP speed) in set-up mode by the robot controller as an inherent design requirement for the robot (EN ISO 10218-1:2025 sections 5.2.7 and 5.5.3). In addition: minimum distances between the outermost robot positions in set-up mode and fixed peripheral equipment (safety fence, turntable, welding fixture) are to be maximised by design, to the extent that the cell layout permits, in order to geometrically reduce crushing and drawing-in points. Remaining crushing points that fall below a minimum distance of 500 mm (body) or 300 mm (head) in accordance with EN ISO 13854:2019 Table 1 and cannot be resolved by design are passed to Step 2 as residual risk.
Step 2 · Safeguarding and/or complementary protective measures	SF-05 'Safely reduced speed 250 mm/s with enabling device in set-up mode', PLr d in accordance with EN ISO 13849-1:2023: The safety function SLS (safely-limited speed, referred to in this document as safely reduced speed) is implemented via an SRP/CS PLr d. The enabling device (3-position, panic function) in accordance with EN ISO 10218-2:2025 section 5.7.7 must be continuously actuated; on release or full depression, a category 1 stop in accordance with EN 60204-1:2018 is initiated. The set-up personnel carry the teach pendant with them; the teach pendant must have sole authority to enable movement as long as persons are present within the safeguarded space (EN ISO 10218-2:2025 section 5.7.5). Access to the safeguarded space in set-up mode is only possible via the maintenance door with guard locking in accordance with EN ISO 14119:2025. The guard locking releases the door for set-up mode only once the operating mode 'Set-up' has been selected at the lockable operating mode selector switch. Isolation of energy before entering the safeguarded space without the teach pendant: safe isolation in accordance with EN ISO 14118:2018 (lockout/tagout preparation). The remaining crushing points were checked against the minimum gaps in accordance with EN ISO 13854:2019 Table 1 during the factory acceptance test.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): set-up mode exclusively by instructed and authorised set-up personnel with demonstrated robot operator qualification. Description of permissible body postures and movement areas in set-up mode. Warning marking at the maintenance door: warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020 and note 'Always carry the enabling device'. PPE specification: safety footwear S3 (EN ISO 20345), close-fitting protective clothing (no drawing-in risk from loose clothing). Note in the operating instructions that entering the safeguarded space without an active teach pendant and without an enabling device is prohibited.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Warning: automatic start-up

Justification of acceptance: Residual risk RS 5 (S 5, O 1) in set-up mode. Teaching and checking the welding paths requires the set-up person to observe the torch at the fixture from close by while the robot is moving; presence in the safeguarded space therefore cannot be excluded by design for this task. In step 1, the TCP speed is limited to 250 mm/s (EN ISO 10218-1:2025) and the distances to the peripheral equipment have been increased as far as the layout of the installation permits. After step 2, movements are only possible at safely monitored speed (SF-05, PL d) with the three-position enabling device held continuously, the hand-held pendant has sole control of motion, and the guard locking only releases the maintenance door in set-up mode selected at the lockable mode selector switch. The protective measures for set-up mode provided for in EN ISO 10218-2:2025 are thus implemented; no further step 1 or step 2 measure that still permits set-up close to the path is identifiable according to the state of the art. The remaining risk is crushing due to operating error despite the enabling device; qualification, permissible body postures and behaviour in the safeguarded space are specified in the operating instructions (chapters 2.3, 2.6 and 9.3).

No. 4 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Crushing hazard at the interface between the turntable and the welding robot (transfer area): During the rotation the loaded fixture moves into the working area of the robot; uncoordinated entry of the robot into the rotation range or missing interlock between the turntable movement and the robot enable can lead to collisions and crushing injuries.

Sub-machine: Interface: turntable / welding robot · also in: Operation, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	The rotation radius of the turntable and the working space boundary of the robot (TCP envelope) are coordinated with each other during the design phase such that the maximum rotation range of the fixture and the minimum robot working space maintain a geometric minimum distance of >= 500 mm (minimum gap to avoid crushing of the body in accordance with EN ISO 13854:2019 Table 1) from each other when both movements would be active simultaneously. This minimises the overlap zone by design; complete elimination of the overlap is not possible with this system topology due to functional constraints, so that the remaining residual overlap is safeguarded by Step 2.
Step 2 · Safeguarding and/or complementary protective measures	SF-04 'Enable of the 180-degree rotary movement of the turntable only when the rotation range is clear' with PLr e in accordance with EN ISO 13849-1:2023 (risk graph: S2/F2/P2). Implementation as an interlocked safety function in the safety PLC: (a) Robot standstill monitoring: the robot must be in a defined rest position outside the rotation range and must confirm this via a safe feedback signal (safe output of the robot controller in accordance with EN ISO 10218-2:2025 sections 5.4.7 and 5.5.8) before the turntable enable is granted. (b) Turntable enable to the robot: as long as the turntable is not in its end position and locked, the robot controller receives no enable signal for the entry area; the turntable is positively locked in its end position. (c) Guard locking of the maintenance door to the rotation range in accordance with EN ISO 14119:2025 with escape release, incorporated in SF-01 (PLr d). (d) Emergency stop of the overall installation in accordance with EN ISO 13850:2015, incorporated in SF-03 (PLr d), stop category 1 in accordance with EN 60204-1:2018. (e) In set-up mode SF-05 applies: safely reduced speed <= 250 mm/s with enabling device (PLr d); the set-up personnel may enter the rotation range only with the enabling device actuated and at reduced speed. The distance of the safety fence from the rotation range complies with EN ISO 13857:2019 Table 2; the safety fence is designed in accordance with EN ISO 14120:2015.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the interlock logic SF-04 and the operating modes Automatic and Set-up; explicit notice that entering the rotation range while the system is running is prohibited. Set-up mode: qualification requirement to be documented (only trained specialist personnel with knowledge of the enabling device). Warning labelling at the rotation range: warning signs W019 'Warning; Crushing' and W024 'Warning; Crushing of hands' in accordance with EN ISO 7010:2020; at the maintenance door additionally the supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006). PPE specification in the operating instructions: safety footwear S3 in accordance with EN ISO 20345; in set-up mode additionally close-fitting protective clothing (no entanglement risk from loose clothing). Note on residual risk in set-up mode and fault-finding: always keep the enabling device actuated, never enter the rotation range without the enabling device.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) at the transfer between turntable and robot. The robot has to reach the station that has just been rotated in; a complete geometric separation of the rotation range and the robot working space is therefore not possible for functional reasons with this installation layout. In step 1, the overlap has been reduced by a minimum distance of 500 mm between the rotation radius and the TCP envelope. The remaining overlap is mutually interlocked: the turntable only rotates when the robot controller confirms the rest position outside the rotation zone via a safe output, and the robot is only released when the table is locked in its end position (SF-04, PL e according to risk graph S2/F2/P2). An accident therefore requires a failure of this interlock or entry while the installation is running by defeating the guard locking (SF-01). The enabling is already implemented at the required performance level; a further step 1 or step 2 measure would not measurably reduce the probability of occurrence. In set-up mode SF-05 applies with 250 mm/s and enabling device. The interlocking logic, the prohibition of entry and the behaviour in set-up mode are described in the operating instructions (chapters 2.5, 2.6 and 9.3).

No. 5 Mechanical — Risk before: S 4 · O 3 · **RS 12**

Falling of workpieces or fixture parts due to failure of the pneumatic clamping device: In the event of compressed air failure or leakage, the clamping elements open in an uncontrolled manner; workpieces of up to 40 kg may fall from the turntable and strike persons at the loading station.

Sub-machine: Pneumatic clamping device (turntable) · also in: Operation, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Use of pneumatically closing clamps with a pilot-operated non-return valve (pressure-holding valve) in the clamping line directly at the clamping cylinder: in the event of compressed air failure or a leak in the supply line, the clamping pressure remains trapped in the cylinder and the workpiece remains clamped; the clamps open only when the valve is actively pilot-opened. The clamping force is designed for the maximum workpiece weight of 40 kg plus a safety factor in accordance with EN ISO 4414:2010. Additionally: limitation of the operating pressure to the level required for the clamping function, in order to minimise the stored pneumatic energy (EN ISO 4414:2010).
Step 2 · Safeguarding and/or complementary protective measures	1. Clamping pressure monitoring with safety function: a pressure switch in the clamping line monitors the clamping pressure; if the pressure falls below the minimum clamping pressure, the enable for the rotary movement of the turntable is inhibited (linked to SF-04, PLr e in accordance with EN ISO 13849-1:2023). As long as the clamping pressure has not been confirmed, the turntable does not rotate. 2. Mechanical interlock of the rotary motion: Positive locking of the turntable in the loading position, so that unintended rotation with a clamped or loose workpiece is prevented; the interlock is released only after the clamping pressure has been confirmed (interlocked with SF-04, PLr e). 3. Enclosure/catch device: Mechanical catch device (deflector plate) below the turntable, designed for the maximum workpiece weight of 40 kg and the maximum drop height, to keep falling parts away from the loading station; design in accordance with EN ISO 14120:2015. 4. Safety distance at the loading station: Arrangement of the loading station such that the hazard zone below the turntable is outside the regular area of presence.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the clamping principle (pneumatically closing clamps with pressure-holding valve) and the clamping pressure monitoring; prohibition of remaining beneath the turntable during operation and during fault-finding without secured standstill; procedure in the event of compressed air failure (shut down the machine, restore the compressed air supply, remove the workpiece only after a pressure check). 2. Energy isolation prior to interventions: Instruction for complete pressure relief of the pneumatic system prior to maintenance and servicing work in accordance with EN ISO 4414:2010 and EN ISO 14118:2018 (prevention of unexpected restart and unexpected energy release); because of the pressure-holding valve, the clamping pressure remains trapped in the clamping cylinders, so the clamps must be opened and depressurised before any work on the clamping device; provide a shut-off and exhaust valve with lockout facility. 3. Warning labelling: Attach warning signs W015 'Warning; Overhead load' and W024 'Warning; Crushing of hands' in accordance with EN ISO 7010:2020 to the turntable and at the loading station. 4. Qualification: Fault-finding and set-up work to be carried out by trained specialist personnel only; requirements to be specified in the operating instructions. 5. PPE: Prescribe the wearing of safety footwear (S3 in accordance with EN ISO 20345) at the loading station as residual risk protection.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 6 Mechanical — Risk before: S 5 · O 3 · **RS 15**

Hazard of crushing and impact due to unexpected restart of the turntable or the robot after an emergency stop or after fault clearance: if a coordinated restart prevention system (EN ISO 11161) is absent, individual sub-machines may start up automatically while persons are still present in the hazard zone.

Sub-machine: Overall installation (restart coordination) · also in: Troubleshooting, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: restart after an emergency stop or after fault clearance is a control-system event that cannot be eliminated by design, given the functional principle of the overall installation (coordinated automatic operation of robot and turntable) without cancelling the machine function. No geometric or energetic measure exists that would prevent the restart itself without abolishing the machine function. Protection must therefore be achieved entirely through Step 2 measures (control system and interlocking).
Step 2 · Safeguarding and/or complementary protective measures	1. Coordinated restart prevention in accordance with EN ISO 11161:2007+A1:2010: the overall installation control system shall not release the restart of a sub-machine (turntable, robot) until a deliberate, manual restart command has been issued from a safe position outside all hazard zones. The restart command shall not be triggered automatically following acknowledgement of the emergency stop or following fault clearance. 2. Safety function SF-01 (safe stop, stop category 1 on opening of the maintenance door, PLr d in accordance with EN ISO 13849-1:2023) and SF-03 (emergency stop of the overall installation, stop category 1, PLr d in accordance with EN ISO 13849-1:2023) ensure that all drives are safely brought to a standstill. The restart prevention is implemented as an integral part of safety functions SF-01, SF-03 and SF-04 and is executed at their respective PLr (SF-04: PLr e; SF-01 and SF-03: PLr d in accordance with EN ISO 13849-1:2023). 3. Safety function SF-04 (release of the 180-degree rotary movement of the turntable only when the rotation range is clear, PLr e in accordance with EN ISO 13849-1:2023): the turntable may only execute its rotary movement when the rotation range has been detected as clear by the Type 4 light curtain in accordance with EN IEC 61496-1:2020 (positioned in accordance with EN ISO 13855:2024). This function remains active after restart and prevents start-up in the presence of persons. 4. Safety function SF-05 (safely reduced speed of 250 mm/s with enabling device in set-up mode, PLr d in accordance with EN ISO 13849-1:2023): in set-up mode, restart shall be released exclusively via an enabling device (3-position in accordance with EN ISO 10218-2:2025 section 5.7.7), so that an unexpected restart at full speed is excluded. 5. De-energisation and energy isolation in accordance with EN ISO 14118:2018: before entering the hazard zone for fault-finding or maintenance, the energy supply to all relevant drives (electrical, pneumatic in accordance with EN ISO 4414:2010) shall be disconnected by means of a lockable isolating device and secured against unintentional re-energisation (lockout/tagout). Residual energy (stored pneumatic energy) shall be dissipated before any intervention; the turntable shall be positively locked in its end position. 6. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release: the guard locking keeps the maintenance door closed as long as hazardous movements have not been safely brought to a standstill (stop category 1 completed). Integration is carried out within the scope of SF-01 (PLr d).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the restart sequence after an emergency stop and after fault clearance; explicit statement that restart is permissible only after all hazard zones have been fully vacated and a manual acknowledgement command has been issued from outside. Description of the lockout/tagout procedure in accordance with EN ISO 14118:2018 for all maintenance and fault-finding activities. 2. Warning labelling at the maintenance door and at the acknowledgement units: warning of unexpected restart (warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020), notice of the obligation to acknowledge from outside. 3. Qualification requirement: set-up and maintenance activities may only be carried out by instructed specialist personnel who have been trained in the restart procedure and the lockout/tagout method (EN ISO 10218-2:2025 section 7.5.12). 4. PPE specification: safety footwear (S3 in accordance with EN ISO 20345) shall be worn when entering the hazard zone for fault-finding or maintenance; additional PPE as determined by the user's workplace risk assessment.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to unexpected restart. The restart is a control event of the coordinated automatic operation of robot and turntable; there is no design measure that prevents it without defeating the function of the cell (step 1). After step 2, the overall control system only enables the restart in accordance with EN ISO 11161:2007+A1:2010 upon a deliberate command from the control desk outside the danger zones, the restart interlock is part of SF-01, SF-03 (PL d) and SF-04 (PL e), the rotation enable checks the rotation range also after the restart, and the lockout device for personal padlocks prevents the maintenance door from being closed while a person is inside the cell. For fault-finding and maintenance, the lockable main switch and the lockable compressed air valve with exhaust function in accordance with EN ISO 14118:2018 are provided. The remaining risk is a start-up when a person neither attaches their padlock nor isolates the installation and the restart interlock fails at the same time. A technical measure that replaces isolation by the person is not available according to the state of the art. The restart sequence and the isolation procedure are described in the operating instructions (chapters 9.5 and 10.4).

No. 7 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Missing or uncoordinated emergency stop function between sub-machines (robot, turntable, welding power source, extraction system): an emergency stop at one sub-machine does not necessarily stop all other sub-machines; persons may be endangered by components that continue to run.

Sub-machine: Overall installation (emergency stop coordination) · also in: Operation, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the coordination of several independent controllers necessarily requires a higher-level control logic. A pure design measure (geometry, energy limitation, substitution) cannot replace the missing interconnection of the emergency stop circuits. The functional principle of the overall installation necessitates active control coordination.
Step 2 · Safeguarding and/or complementary protective measures	Higher-level emergency stop circuit (SF-03) in accordance with EN ISO 13850:2015 and EN ISO 11161:2007+A1:2010: all emergency stop devices of the overall installation are integrated into a common, higher-level safety circuit which, on actuation at any point, brings all hazardous sub-machines (robot, turntable, welding power source, pneumatics) to a coordinated standstill; the extraction system runs on for operational reasons. Stop category 1 in accordance with EN 60204-1:2018 (controlled stopping, followed by energy disconnection): the robot performs a controlled stop along its path, the turntable brakes actively, the welding power source is de-energised, and the clamps remain clamped by the pressure-holding valve. The run-on of the extraction system is not a safety function, but is operationally required. Safety function SF-03 is specified with PLr d in accordance with EN ISO 13849-1:2023 and implemented in Category 3 with PL d. Integration of the robot is carried out via the robot controller in accordance with EN ISO 10218-2:2025 section 5.3.3 (span of control of the emergency stop, safety interface to the higher-level controller). Emergency stop devices are to be designed in accordance with EN ISO 13850:2015 (mushroom-head pushbutton, yellow background, self-latching, release only by deliberate action). Emergency stop devices are to be positioned such that at least one emergency stop device is reachable from every operating station without exposure to a hazard (EN ISO 13850:2015). Restart interlock: after an emergency stop, a manual reset is required before the installation can restart (EN ISO 13850:2015 section 4.1.4), in order to prevent unexpected restart in accordance with EN ISO 14118:2018.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the emergency stop topology of the overall installation with a layout plan of all emergency stop devices and the area of effect of each emergency stop device. Clear instruction that after an emergency stop, the hazard zone of all sub-machines must be inspected before the reset is carried out. Set-up mode and fault-finding: instruction that intervention in the hazard zone is only permissible after all sub-machines have come to a complete standstill and the maintenance door has been secured against closing (personal padlock in the lockout device). Qualification requirement: set-up and fault-finding only by instructed specialist personnel who are familiar with the emergency stop topology. Marking at the control desk: text sign stating the area of effect of the emergency stop devices (the emergency stop acts on all sub-machines of the cell), supplemented by warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) in the coordination of the emergency stop. Linking the emergency stop circuits of several sub-machines is only possible by means of the control system; there is no step 1 measure for this. A higher-level emergency stop circuit SF-03 in category 3 with PL d is implemented, which stops robot, turntable, welding power source and pneumatics together from every emergency stop device (control desk, maintenance door, teach pendant), with manual reset in accordance with EN ISO 13850:2015 and scope of effect in accordance with EN ISO 11161:2007+A1:2010; the required performance level is achieved and the emergency stop test items have been passed. The remaining risk is the overrun during the controlled stop in stop category 1. This category has been chosen because the robot brakes under control along its path and the clamps hold the workpiece via the pressure-holding valve; a stop in category 0 would give up this control without eliminating the overrun. The emergency stop is a complementary protective measure and does not replace any safeguard. The arrangement and scope of effect of the emergency stop devices are stated in the operating instructions (chapters 2.5 and 9.5) and on the text sign at the control desk.

No. 8 Mechanical

Risk before: S 3 · O 4 · **RS 12**

Cutting and puncture hazard from the welding wire (solid wire 1.0 to 1.2 mm) at the welding torch: The wire protruding from the torch acts like a needle; during set-up, wire threading or torch cleaning, hands and fingers can be punctured or cut.

Sub-machine: Welding torch / wire feed · also in: Maintenance, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Automatic wire retraction after the end of welding: The wire feed control automatically retracts the wire by a defined amount (5 to 10 mm) into the torch after each welding cycle, so that the sharp wire tip is recessed within the contact tip and no longer protrudes freely. By design, this minimises the hazard point (free-standing wire tip) for the set-up and cleaning life-cycle phases. In addition: selection of a wire feed system that, in inching mode (set-up), advances the wire only when the button is continuously pressed (dead man's principle), so that the wire is not advanced in an uncontrolled manner.
Step 2 · Safeguarding and/or complementary protective measures	1. Mechanical wire length limitation: An adjustable wire length stop (torch protection cap with a defined opening) is provided at the torch neck, limiting the maximum protruding wire to the minimum dimension necessary for the process. 2. Inhibit of automatic wire feed: Automatic wire feed is inhibited as soon as the maintenance door is opened; with the door open, the wire can be fed only in inching mode at reduced threading speed. 3. Inching mode of the wire feed: inching mode at reduced threading speed is a function of the welding power source, not a safety function; it is designed to prevent unintended rapid wire feed. 4. Marking of the hazard point on the torch and wire feed with warning sign W022 'Warning; Sharp element' in accordance with EN ISO 7010:2020.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Explicit note that the welding wire presents a sharp tip that can pierce the skin even when stationary. Description of the safe procedure for threading wire (feed the wire only in inching mode at reduced threading speed, cut the wire end cleanly with side cutters, never probe with the bare hand). 2. Warning marking on the torch holder and on the wire feed unit: warning sign W022 'Warning; Sharp element' in accordance with EN ISO 7010:2020. 3. Qualification requirement: activities on the torch and wire feed (threading wire, cleaning) may only be carried out by instructed specialist personnel; requirement to be documented in the operating instructions. 4. PPE specification: cut-resistant protective gloves (in accordance with EN 388, puncture resistance of at least performance level 2) must be worn when threading wire and when cleaning the torch; specification to be included in the operating instructions and on the notice posted at the workplace. 5. Note on safe cutting of the wire tip: before any manual activity on the torch, the wire tip must be cut cleanly and burr-free with a suitable pair of side cutters; the tool is to be made available at the workplace.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) from the wire tip. The wire has to protrude from the contact tube for the arc. The automatic retraction after each cycle and the inching mode on the hold-to-run principle (step 1), the length limitation by the torch protection cap, the lock-out of the automatic wire feed when the maintenance door is open and the wire cutter of the torch cleaning station (step 2) limit the exposed wire length to the process dimension. Threading the wire when changing the wire and working on the torch remain manual tasks in which the hand necessarily works at the wire; a protective device between hand and wire cannot be applied for these tasks, so a further step 1 or step 2 measure is not practicable. The remaining puncture or cut injury is reversible. It is countered in step 3 by cut-resistant gloves in accordance with EN 388, cleanly cutting off the wire tip before any manual task, restriction to instructed personnel and sign W022 on the torch holder and the wire feed unit (operating instructions chapters 2.4 and 2.6).

No. 9 Mechanical

Risk before: S 4 · O 4 · **RS 16**

Ergonomic hazard and crushing hazard during manual loading and unloading of workpieces up to 40 kg: Workpieces up to 15 kg are loaded by hand, workpieces above 15 kg with the user-supplied lifting aid; in the event of reasonably foreseeable misuse (lifting without the lifting aid), musculoskeletal strain arises together with the risk of losing grip, with the subsequent falling of the workpiece onto feet or hands.

Sub-machine: Loading station (operating station) · also in: Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	Limitation of the manually handled workpiece mass to a maximum of 15 kg. The threshold is set by the manufacturer for around 40 lifts per hour and is derived from the reference mass in accordance with EN 1005-2:2003+A1:2008. For workpieces above 15 kg and up to 40 kg, the workpiece fixture at the loading station is designed so that loading from above with the user-supplied lifting aid is possible without re-gripping (unobstructed access, insertion depth, geometry of the locating stops).
Step 2 · Safeguarding and/or complementary protective measures	1. The loading station is prepared for a user-supplied lifting aid (lifting aid not included in the scope of supply, load capacity at least 40 kg, operating radius covering the entire loading zone). Access from above is unobstructed, so that the operator can reach the loading position without re-gripping or releasing the workpiece. 2. Floor marking (yellow/black in accordance with German ASR A1.3) of the set-down and slewing area of the lifting aid at the loading station, so that the operator is not standing beneath the suspended load during loading. 3. The light curtain at the loading station (SF-02, PLr e) safeguards the hazard zone of the machine opening; it does not protect against the falling of the workpiece itself, but it does limit the area in which hands may be located during loading.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Clear specification of the handling rule (up to 15 kg by hand, above 15 kg with the user-supplied lifting aid, load capacity at least 40 kg) and of the correct attachment points on the workpiece. Specification of body posture during loading in accordance with EN 1005-4. 2. Warning labelling at the loading station: Warning signs W015 'Warning; Overhead load' and W024 'Warning; Crushing of hands' and mandatory sign M008 'Wear safety footwear' in accordance with EN ISO 7010:2020. Text sign 'Manual handling up to 15 kg only, use the lifting aid above this' directly at the loading station. 3. Qualification requirement: Operators must be instructed in the use of the lifting aid and in ergonomically correct handling before commencing work (documented instruction). 4. PPE specification: Safety footwear S3 in accordance with EN ISO 20345 and protective gloves (cut-resistant, secure grip) are to be stipulated as minimum PPE for all loading and unloading activities.

Risk after: S 4 · O 2 · **RS 8 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 8 (S 4, O 2) during loading and unloading. Workpieces up to 40 kg are part of the intended use, and manual loading is the concept of the machine (operating instructions chapter 2.1); automatic loading would defeat this concept. In step 1, manual handling is limited to 15 kg (manufacturer's specification derived from the reference mass of EN 1005-2:2003+A1:2008), and the fixture is designed so that heavier parts are loaded from above with the lifting aid without re-gripping. After step 2, the loading station is prepared for the lifting aid provided by the user and its slewing area is marked on the floor. The machine cannot determine whether a workpiece over 15 kg is lifted without the lifting aid; the remaining risk is this misuse with overloading of the musculoskeletal system or a falling workpiece. No further step 1 or step 2 measure that prevents this misuse without defeating manual loading has been identified. The text sign "Manual handling up to 15 kg only, use the lifting aid above this", S3 safety footwear, the instruction of personnel and the user's obligation to provide the lifting aid are stated in the operating instructions (chapters 1.2, 2.4 and 9.1).

No. 10 Mechanical — Risk before: S 3 · O 3 · **RS 9**

Hazard of tripping, slipping and falling in the area of the loading station and the maintenance aisle due to weld spatter on the floor, cables, hoses (compressed air, shielding gas) and wet areas during cleaning work.

Sub-machine: Loading station / maintenance aisle · also in: Operation, Maintenance, Cleaning, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Keep cables and hoses (compressed air, shielding gas) out of the floor area of the loading station and maintenance aisle by design, by routing them in cable ducts, energy chain systems or ceiling-suspended cable management systems, so that no trip hazards arise. Design connections at the loading station as ceiling pendants or wall-mounted socket panels. Reduce weld-spatter exposure on the floor by means of design-integrated shielding plates (spatter-protection shields) at the welding station, so that discharge into the operator area is minimised. The hall floor is not part of the scope of supply; the requirement for the installation site (anti-slip floor covering) is passed on to the user in Step 3.
Step 2 · Safeguarding and/or complementary protective measures	Limit the residual risk from remaining trip and slip hazards by means of the following technical measures: (1) Floor markings (yellow/black in accordance with German ASR A1.3) to identify traffic routes and hazard zones in accordance with (EU) 2023/1230 Annex III, section 1.5.15. (2) Adequate fixed lighting of the loading station and maintenance aisle in accordance with (EU) 2023/1230 Annex III, section 1.1.4, so that obstacles and wet areas can be detected at an early stage; the machine-integrated lighting in accordance with EN 1837 provides 500 lx at the loading station and 200 lx in the maintenance aisle. (3) Spatter-protection mats in the immediate welding area that are easy to remove and clean.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): (1) Reference to the hazard of tripping and slipping due to weld spatter, hoses and wet conditions; prescribe cleaning intervals and cleaning procedures for the floor area. (2) Qualification requirement: all persons entering the loading station and maintenance aisle must have been instructed in the hazards and the traffic-route layout. (3) PPE specification: safety footwear with anti-slip soles (S3 in accordance with EN ISO 20345) shall be worn when entering the loading station and maintenance aisle. (4) Warning labelling at the access to the loading station and maintenance aisle: affix warning sign W011 'Warning; Slippery surface' and mandatory sign M008 'Wear safety footwear' in accordance with EN ISO 7010:2020. (5) Requirement for the installation site: anti-slip floor covering at the loading station and in the maintenance aisle, slip resistance rating of at least R 11 in accordance with German DGUV Rule 108-003.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) due to tripping, slipping and falling. In step 1, cables and hoses have been routed out of the floor area, and spatter guards reduce the spatter carried out of the cell. What remains is welding spatter that reaches the floor through the opening, which is open for loading, and wet areas during cleaning. The opening has to remain open for loading, and the hall floor is not part of the scope of supply; further design measures on the machine do not reach these causes. After step 2, the traffic routes are marked, the loading station is lit with 500 lx and the maintenance aisle with 200 lx, and removable spatter mats are provided in the welding area; the test of trip and slip points has been passed. Any further technical measure would only replace the floor cleaning, which is specified as a daily task. The daily cleaning (operating instructions chapter 10.2), slip-resistant S3 safety footwear, signs W011 and W007 (chapter 2.4) and the requirement for a slip-resistant floor covering at the installation site (overview of residual risks, chapter 2.6) form the information for use.

No. 11 Mechanical — Risk before: S 5 · O 2 · **RS 10**

Hazard arising from simultaneous access by several persons to different zones of the cell (EN ISO 11161): a second person is present inside the cell without the set-up personnel being aware of this; when the robot or the turntable starts up, the second person is struck.

Sub-machine: Overall installation (zone access) · also in: Maintenance, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the functional principle of the overall installation requires accessible zones for set-up, maintenance and fault-finding work. The hazard arises from the simultaneous presence of several persons in different zones, which cannot be resolved by geometry, distance or energy limitation alone without defeating the operational purpose. A reduction of the robot or turntable energy to a level that safely excludes injury is not technically realisable with this type of installation.
Step 2 · Safeguarding and/or complementary protective measures	1. Protection of persons when several persons enter the cell, in accordance with EN ISO 11161:2007+A1:2010: the maintenance door has a lockout device for personal padlocks. Each person entering the cell attaches their personal padlock to the lockout device of the opened door. As long as a padlock is attached, the door cannot be closed and automatic mode cannot be started. Movements are then possible only in set-up mode, with the enabling device actuated and at safely reduced speed. Acknowledgement is possible only from outside, at the control desk. 2. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release from the inside in accordance with EN ISO 14119:2025 section 6.9.1, so that persons trapped inside can leave the cell at any time. 3. The enabling of automatic start-up (robot and turntable) is implemented as a safety function: automatic start-up is possible only when the maintenance door is closed and held closed by the guard locking and acknowledgement has been given from outside. The access function is SF-01 (safe stop on opening of the maintenance door) with PLr d in accordance with EN ISO 13849-1:2023. Independently of this, the release of the turntable rotation remains safeguarded by SF-04 (PLr e). 4. In set-up mode, SF-05 applies (safely reduced speed of 250 mm/s with enabling device, PLr d in accordance with EN ISO 13849-1:2023). The enabling device is person-specific. The cell has exactly one enabling device, on the teach pendant; movements in set-up mode are therefore permitted only when nobody other than the person holding the enabling device is inside the cell (for the procedural instruction, see Step 3). 5. The safety distances between the robot working space and areas where persons are present comply with EN ISO 13857:2019 Table 2 and EN ISO 10218-2:2025 sections 5.4.6 and 5.8.9.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the protection of persons at the maintenance door (one personal padlock per person in the lockout device, escape release from the inside), and of the obligation to attach the padlock before entering and to remove it only after leaving the cell. Procedural instruction for multi-person operations (setting up, maintenance, fault-finding) with clear role assignment (responsible person, coordination). 2. Warning signs at the maintenance door: warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020, text sign 'Attach your personal padlock before entering'. 3. Qualification requirement: Set-up and maintenance personnel must be instructed in the multi-person access concept and the use of the lockout device for personal padlocks and of the escape release. The instruction must be documented. 4. PPE specification in the operating instructions: Safety footwear S3 in accordance with EN ISO 20345, close-fitting protective clothing (no entanglement risk from loose clothing) when inside the cell.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) when several persons have access. Set-up, maintenance and fault-finding work require accessible zones; the hazard to a second person cannot be resolved by geometry or energy limitation (step 1). After step 2, every person entering attaches their personal padlock to the lockout device of the maintenance door; as long as a padlock is attached, the door cannot be closed and automatic mode cannot be started, and acknowledgement is only possible from outside (SF-01, PL d). Movements are then only possible in set-up mode with the single, person-bound enabling device and 250 mm/s (SF-05, PL d), and the escape release allows persons to leave from the inside at any time. This protection of persons follows EN ISO 11161:2007+A1:2010. The remaining risk is a person entering the cell without their own padlock while the set-up person initiates movements; even then, the installation only moves at reduced speed under the enabling device of the set-up person. Attaching the padlock remains an action of each individual person; no further step 1 or step 2 measure that prevents this misuse without restricting the set-up work has been identified. Procedure for work involving several persons, text sign at the door and instruction of personnel: operating instructions chapters 2.4, 2.5, 2.6 and 9.3.

No. 13 Electrical — Risk before: S 4 · O 2 · **RS 8**

Hazard from welding current at the workpiece and at the fixture: the welding circuit carries high currents (typically 100 to 350 A); in the event of a faulty earth connection or damaged insulation, persons who touch the workpiece or the fixture may receive an electric shock.

Sub-machine: Welding power source / fixture · also in: Operation, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Design the fixture frame and workpiece holders such that touchable conductive surfaces that lie within the welding current circuit are galvanically isolated from the machine frame by design, using insulation (insulating plates made of glass-fibre epoxy between the fixture base plate and the machine table, as well as insulating clamping jaw inserts). By design, this interrupts the unintentional current path via the frame and touchable external surfaces. In addition: define the earth cable connection point directly on the workpiece or at a designated location on the fixture that is not touchable by the operator, and integrate it by means of shaping (recess, cable routing channel) in such a way that incorrect positioning of the earth clamp is impeded by design.
Step 2 · Safeguarding and/or complementary protective measures	1. Welding power source: The welding power source has protection class I and degree of protection IP23S in accordance with EN IEC 60974-1; integration into the protective conductor chain of the overall installation shall be carried out in accordance with EN 60204-1:2018 section 8 (protective conductor cross-sections, connection points). 2. Monitoring of the earth connection: The earth current monitoring of the welding power source is activated; in the event of interruption or an impermissibly high contact resistance, the welding process is inhibited. The function is an operational interlock without a PL requirement (not a safety function within the meaning of EN ISO 13849-1:2023); no risk reduction is credited for it. 3. Equipotential bonding: All conductive parts of the fixture that are not deliberately insulated are included in the protective equipotential bonding of the installation (EN 60204-1:2018 section 8.2). 4. Access restriction during the welding process: The loading station is safeguarded by the light curtain (SF-02, PLr e in accordance with EN ISO 13849-1:2023); during active welding, access to the welding area is prevented by the interlocked maintenance door (SF-01, PLr d) and the enable logic of the turntable (SF-04, PLr e), so that contact with live parts in automatic mode is prevented by both design and control-engineering means. 5. Cable management: Welding cables and earth cables are routed in enclosed cable ducts or protective conduits (protection against mechanical damage); minimum bending radii as specified by the manufacturer shall be observed; cables shall be secured with strain relief.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the correct connection of the earth clamp (position, cleaning of the contact surface, permissible clamping areas); notice that touching the workpiece and the fixture during the welding process is prohibited; inspection intervals for insulation and cable condition (visual inspection every working day, six-monthly insulation measurement by an electrically skilled person, see Chapter 10.2). 2. Qualification requirement: Setting up, fault-finding and maintenance on the welding power source and its connections may only be carried out by an electrically skilled person or an electrically instructed person under the supervision of an electrically skilled person (terms as defined in EN 60204-1:2018 section 3.1). 3. Warning labelling on the fixture and in the welding area: Attach warning sign W012 'Warning; Electricity' in accordance with EN ISO 7010:2020 at a clearly visible location; attach a text sign 'Check earth clamp before commencing welding'. 4. PPE specification in the operating instructions: When setting up and fault-finding in the welding area, insulating gloves (protection class suitable for low voltage) and welding protective clothing shall be worn.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 14 Electrical — Risk before: S 4 · O 2 · **RS 8**

EMC interference between welding power source and safety controller (robot controller, light curtain evaluation unit, guard locking controller): high-frequency interference pulses from the MAG arc can influence safety functions and lead to spurious triggering or, more critically, to undetected failure of safety functions (EN ISO 11161).

Sub-machine: Overall installation (EMC interface) · also in: Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	Spatial and galvanic separation of welding circuits from safety circuits by design specification: (1) Route the welding current return conductor as a dedicated return conductor close to the workpiece, directly back from the welding fixture, so that no large-area current loops are created that act as antennas. (2) Route welding current cables and safety signal/control cables in separate cable ducts with a minimum separation of 200 mm (separation distances in accordance with EN 50174-2 and EN 60204-1:2018 Annex H); crossings at right angles only. (3) Earth the welding power source and safety controller on separate equipotential bonding busbars connected with low impedance to the system protective conductor, in order to avoid common impedance paths. These measures reduce coupling at the source without requiring a protective device.
Step 2 · Safeguarding and/or complementary protective measures	For the remaining residual risk of conducted and radiated interference: (1) Execute all safety signal and control cables (light curtain SF-02, guard locking SF-01, rotary release SF-04, emergency stop SF-03) as screened cables; connect the screen at both ends with low impedance to the equipotential bonding busbar. (2) Use mains filters (interference suppression filters) at the supply feed of the safety controller and the light curtain evaluation unit, designed in accordance with EN IEC 61000-6-2:2019 (immunity requirements for industrial environments). (3) Install the robot controller, light curtain evaluation unit and guard locking controller only in control cabinets with continuous shielding (metal enclosures, EMC-compliant cable entries). (4) The safety controller and all components of safety functions SF-01 to SF-05 shall demonstrably comply with the immunity requirements of EN IEC 61000-6-2:2019 (the component manufacturers' evidence is on file). (5) Safety functions SF-01 (PLr d), SF-02 (PLr e), SF-03 (PLr d), SF-04 (PLr e) and SF-05 (PLr d) shall be validated in accordance with EN ISO 13849-1:2023 and EN ISO 13849-2:2012; the validation shall demonstrate the immunity of the SRP/CS in accordance with EN ISO 13849-1:2023 Annex L and the CCF measures (Annex F). (6) Welding power source: CE-marked equipment with an EU declaration of conformity that also covers the EMC Directive 2014/30/EU; emissions of the power source in accordance with EN IEC 60974-10 (EMC of arc welding equipment), emissions of the overall installation in accordance with EN IEC 61000-6-4:2019 (test report RSZ-2600-EMV-001). (7) Overall installation: carry out an EMC acceptance test in accordance with EN IEC 61000-6-2:2019 in the operating state with the welding process active, in order to verify the immunity of the safety functions under real operating conditions.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): (1) Note that modifications to cable routing (welding current cables, control cables) may only be carried out by qualified skilled personnel with EMC expertise. (2) Maintenance instruction: visual inspection of screen terminations, equipotential bonding connections and cable duct separation; inspection interval six months (see Chapter 10.2). (3) Note that after every replacement of the welding power source, robot controller or safety components, a renewed EMC functional check of the safety functions is required. (4) Qualification requirement: set-up personnel (operating mode Set-up, SF-05 active) shall be instructed in EMC-related fault patterns on safety controllers. (5) Marking on the control cabinet of the safety controller: text sign 'Change cable routing only in accordance with electrical circuit diagram RSZ-2600-EPL-001'.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 15 Thermal

Risk before: S 3 · O 4 · **RS 12**

Burn hazard from hot workpieces and weld seams: Freshly welded assemblies reach several hundred degrees Celsius in the seam area; serious burns may result from removal without suitable protective gloves or from contact with the seam.

Sub-machine: Loading station (removal side) · also in: Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: The operating principle of arc/gas-shielded welding necessarily requires heat input into the workpiece; the resulting seam temperature cannot physically be reduced to a safe level without suppressing the welding process itself. Substitution of the joining process (e.g. adhesive bonding, bolting) is not provided for and would not meet the product requirements. A geometric measure (distance from the seam by means of shaping) cannot be realised by design at the removal grip point, as the operator must grip the assembly.
Step 2 · Safeguarding and/or complementary protective measures	1. Forced cooling time: A control-side lockout period after the end of welding (timer in the system control), during which the release for removal at the loading station (removal side) remains locked. The lockout period is stored for each welding program; it depends on the workpiece geometry and the heat input. This function is not a safety function within the meaning of EN ISO 13849-1 (no PLr assigned), but a process-related interlock; it reduces the probability of occurrence but does not replace the obligation to use PPE. 2. Warning light / signalling device: Optical indicator (red signal light at the removal station) that is active during the cooling lockout period and extinguishes as soon as the release is granted. 3. Thermal shielding: The fixed dividing centre wall with welding curtain between the welding area and the removal station shields the operator from radiant heat (design in accordance with EN ISO 13732-1:2008 with regard to contact temperature limits as a design reference for surfaces that may be touched inadvertently).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Reference to the risk of burns from hot workpieces and weld seams; specification of the required cooling time before removal; obligation to wear heat-protective gloves (PPE Category II, suitable for contact heat in accordance with EN 407, performance level at least contact heat Level 3) and, where applicable, forearm protection. 2. Warning labelling at the removal station: Warning sign W017 'Warning; Hot surface' and mandatory sign M009 'Wear protective gloves' in accordance with EN ISO 7010:2020 to be affixed permanently and clearly visible at the loading station (removal side) ((EU) 2023/1230 Annex III, section 1.7.1). 3. Qualification and instruction: Operators and set-up personnel are to be instructed in the risk of burns, the cooling times and the obligation to use PPE before commencing work; the instruction is to be documented. 4. Provision of PPE: The operating instructions must instruct the user to provide suitable heat-protective gloves (EN 407) and to monitor their use.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) from hot workpieces. The heat input is inherent to the welding process and cannot be reduced to a harmless level, and the operator has to grip the assembly (step 1 exhausted). After step 2, the control system locks the removal for a cooling time stored for each welding program, the red signal light at the removal station indicates the lock, and the dividing centre wall shields the radiant heat. Waiting until the seam falls below the contact temperature limits in accordance with EN ISO 13732-1:2008 would considerably exceed the cycle time of around 90 seconds and defeat series production in accordance with the intended use; a further step 1 or step 2 measure is therefore not practicable. The remaining risk is touching seam areas that are still warm after the lockout period has elapsed, which results in a reversible burn. This is countered by heat protection gloves in accordance with EN 407, signs W017 and M009 on the removal side and the instruction of personnel (operating instructions chapters 2.4, 2.6 and 9.1).

No. 16 Thermal

Risk before: S 4 · O 3 · **RS 12**

Burn and fire hazard from welding spatter (flying sparks): During MAG welding, spatter is generated at temperatures above 1500 degrees C; it can land on combustible materials (packaging, oils, clothing) in the surrounding area and cause fires or burns.

Sub-machine: Welding robot / welding area · also in: Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	Welding parameter optimisation to minimise spatter: Use of a low-spatter arc process (e.g. pulsed arc or CMT-type short arc) instead of the conventional short arc, to the extent permitted by the joining task. By specifically reducing the transferred spatter energy and quantity, the probability of ignition-capable spatter reaching combustible materials is reduced by design. Additionally: position the welding area such that no combustible operating materials (oils, lubricants, packaging) are stored or routed within the spatter protection radius of 1 m around the welding area. Lines carrying combustible media shall be routed out of the spatter area or provided with non-combustible shields.
Step 2 · Safeguarding and/or complementary protective measures	1. Guard: The welding area is enclosed by the safety fence with welding-light-opaque infill panels and welding protection viewing windows (EN ISO 14120:2015) and by the dividing centre wall of the turntable; the infill panels and the dividing centre wall are non-combustible and resistant to welding spatter. This enclosure prevents spatter from escaping into the general working area. Towards the loading station, the dividing centre wall of the turntable with its welding curtain in accordance with EN ISO 25980 shields the welding area. 2. Extraction system in the welding area: capture of welding fumes and particles directly at the point of origin in accordance with EN ISO 21904-1:2020, in order to extract glowing particles and reduce the thermal load on the surrounding area. 3. Secure the exclusion zone of 1 m around the safety fence: permanent yellow and black floor marking in accordance with the German workplace rule ASR A1.3 and, where possible, physical barriers; no storage or depositing areas within the zone. 4. Fire protection: provide a bracket for a fire extinguisher (CO2 or powder, no water due to the electrical installation) at the cell; provision and inspection of extinguishing agents are the responsibility of the user (note in the operating instructions, Step 3). 5. Safety functions: the maintenance door is integrated into the safety controller via SF-01 (PLr d) and the loading opening via SF-02 (PLr e); welding takes place only with the maintenance door closed and locked.
Step 3 · Information for use	1. Operating instructions (pursuant to (EU) 2023/1230 Annex III, section 1.7.4): Reference to the spatter protection radius and prohibition of storing combustible materials in the welding area. Specification of the permissible welding parameter ranges (current, voltage, wire feed) to minimise spatter. Instructions for the regular cleaning of spatter from machine surfaces and the welding area (reduction of fire load). Procedural instructions for the event of fire (alerting, first-response extinguishing, evacuation). 2. Warning signs on the safety fence in accordance with EN ISO 7010:2020: general warning sign W001 with the supplementary text 'Fire hazard from welding spatter'. 'Warning; Hot surface' (W017) in the welding area. Mandatory sign M010 'Wear protective clothing' at the maintenance door. 3. Qualification requirement: Set-up personnel and operators must be trained in the operation of the welding system and in the handling of fire protection equipment. Set-up personnel require a qualification as a welding specialist or equivalent documented instruction. 4. PPE specification: During set-up work in the welding area, the following PPE must be worn: flame-retardant welding protective clothing (in accordance with EN ISO 11611), welder's gloves (in accordance with EN 12477), welding face shield or welding helmet with a welding filter in accordance with EN ISO 16321-2 (formerly EN 169). In automatic mode with the maintenance door closed, no welder PPE is required; however, entering the welding area during operation is prohibited (operating instructions).

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 17 Thermal

Risk before: S 3 · O 3 · **RS 9**

Risk of burns from the hot welding torch and torch neck: The torch neck and the contact tip are strongly heated after the welding process; when changing the torch, during cleaning or during set-up without a cooling period, hands and fingers may be burned.

Sub-machine: Welding torch · also in: Maintenance, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Use of active torch cooling (water-cooled torch instead of an air-cooled torch): The continuous water cooling limits the thermal energy in the torch neck and at the contact tip by design to a significantly lower temperature level. Additionally: The torch holder and the change system are designed such that the operator, when changing the torch, touches only thermally decoupled grip areas (plastic or ceramic handle, no direct metal contact with the torch neck). Design in accordance with EN ISO 13732-1:2008 (burn threshold for bare metal around 51 °C for a contact period of 1 min and 48 °C for 10 min).
Step 2 · Safeguarding and/or complementary protective measures	1. Cooling-time monitoring: a temperature sensor on the torch neck reports to the machine control system; the HMI indicates the release for torch changes and cleaning only once the temperature has fallen below the limit value. The function is an operational interlock without a PL requirement under EN ISO 13849-1; no risk reduction is credited to it. 2. Guard: the welding area is enclosed by the safety fence with welding-light-opaque infill panels and welding protection viewing windows (EN ISO 14120:2015); access to the torch for maintenance and cleaning is provided exclusively via the secured maintenance door (SF-01, PLr d). Unintentional access to the hot torch during automatic operation is thereby excluded by design. 3. Provision of a torch rest with a thermally insulated receptacle (ceramic or silicone pad) immediately at the welding station, so that the torch is placed down in a defined manner after the process and is not set down on conductive metal surfaces.
Step 3 · Information for use	1. Operating instructions: state the cooling time after the end of welding explicitly before any torch change, cleaning or set-up work on the torch (reference value as specified by the torch manufacturer); include a procedure for torch changes with the step 'wait for cooling time or check temperature'. 2. Warning labelling: permanently and clearly affix the warning sign 'Warning; Hot surface' (W017 in accordance with EN ISO 7010:2020) to the torch area and to the maintenance door. 3. Qualification: only instructed persons may carry out torch changes and cleaning; instruction covers the risk of burns, cooling times and correct use of PPE. 4. PPE specification: heat-protection gloves (suitable for contact heat, protection class in accordance with EN 407) are mandatory during torch changes, cleaning and set-up work on the torch; this requirement shall be stated in the operating instructions and indicated by the mandatory sign 'Wear protective gloves' (M009 in accordance with EN ISO 7010:2020) at the maintenance door.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 18 Radiation

Risk before: S 4 · O 3 · **RS 12**

Hazard from optical radiation of the MAG arc (UV, visible, IR): the arc emits intense ultraviolet, visible and infrared radiation; unprotected viewing of the arc (including through an open maintenance door in set-up mode) can cause eye injuries (keratoconjunctivitis, retinal damage) and skin burns.

Sub-machine: Welding robot / welding area · also in: Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the functional principle of MAG welding necessarily requires an open arc with high radiation intensity; current, voltage and arc energy cannot be reduced to a level at which the radiation hazard is eliminated without interrupting the welding process. Geometric relocation of the hazard point is not possible in a robot welding system with changing welding positions.
Step 2 · Safeguarding and/or complementary protective measures	1. Enclosure of the welding area: safety fence with welding-light-opaque infill panels and welding protection viewing windows as a fixed guard in accordance with EN ISO 14120:2015; infill panels and coating (matt black, light-absorbing surface) to be designed such that no relevant UV/IR reflection escapes to the outside. Viewing windows and welding curtains to be designed in accordance with EN ISO 25980. 2. Maintenance door: The maintenance door shall be equipped with guard locking in accordance with EN ISO 14119:2025 (interlock with guard locking, escape release in accordance with EN ISO 14119:2025 section 6.9.1). The safety function 'SF-01 Safe stop (stop category 1) upon opening of the maintenance door' shall be implemented with PLr d in accordance with EN ISO 13849-1:2023: the guard locking releases the door only once the arc has been extinguished and the robot is at a standstill; a safety distance in accordance with EN ISO 13855:2024 therefore does not have to be calculated. 3. Set-up mode with the maintenance door open: While the maintenance door is open, the welding power source is safely switched off via SF-01 (shutdown path of the safety PLC as for SF-03, PLr d in accordance with EN ISO 13849-1:2023), so that no arc can be ignited with the door open. The additional inhibit of the welding enable in the standard controller (welding enable only when the maintenance door is closed and locked) is an operational interlock without a PL requirement. The function 'SF-05 Safely reduced speed 250 mm/s with enabling device in set-up mode' (PLr d) applies to the movements of the robot and the turntable. With the maintenance door closed, the guard locking (SF-01) protects against arc radiation. 4. Radiation protection at the loading opening: the dividing centre wall of the turntable with its welding curtain in accordance with EN ISO 25980 shields the loading station, so that no direct radiation can reach the operator.
Step 3 · Information for use	1. Operating instructions: Note on the radiation hazard from the MAG arc (UV, visible, IR) in accordance with (EU) 2023/1230 Annex III, sections 1.7.4.1 and 1.7.4.2; statement that the welding power source is safely switched off via SF-01 while the maintenance door is open; description of the PPE requirements for set-up and maintenance activities in the vicinity of the welding area. 2. Qualification requirement: Set-up and maintenance personnel must have knowledge of the radiation hazard associated with arc welding; instruction in accordance with the German Occupational Safety Ordinance on Artificial Optical Radiation (OStrV) is to be identified in the operating instructions as a user obligation. 3. PPE specification: For activities where a residual risk from stray radiation (e.g. reflections during set-up in the immediate vicinity) cannot be completely excluded: welding goggles or welding face shield with a welding filter in accordance with EN ISO 16321-2 (formerly EN 169), UV-resistant protective clothing and protective gloves. 4. Warning labelling: Warning sign 'Warning; Optical radiation' (W027 in accordance with EN ISO 7010:2020) at the maintenance door and at the loading opening; mandatory signs 'Wear eye protection' (M004) and 'Wear protective clothing' (M010) in accordance with EN ISO 7010:2020 to be affixed at the maintenance door. 5. Emission data: Information on the optical radiation of the arc in the operating instructions in accordance with (EU) 2023/1230 Annex III, sections 1.5.10 and 1.7.4.2; the basis is the manufacturer's data for the welding power source and the assessment of radiation emission in accordance with EN 12198 (radiation from machinery).

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 19 Radiation

Risk before: S 4 · O 2 · **RS 8**

Hazard from electromagnetic fields (EMF) generated by the welding power source and the welding cables: High welding currents generate strong magnetic fields; persons with active implants (cardiac pacemakers, insulin pumps) may be endangered by the fields.

Sub-machine: Welding power source / welding cables · also in: Operation, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Route and bundle the welding cables (current conductor and return conductor) so that the forward and return conductors are brought into close spatial proximity (twisted or parallel-routed cable pairs with minimum distance between them): The magnetic fields of both conductors partially cancel each other out, which significantly reduces the resultant field strength in the surrounding area. Keep cables as short as technically possible and avoid unnecessary coiling or routing in loops, as loops increase field strength. Install the welding power source at a distance from the loading station and the control desk.
Step 2 · Safeguarding and/or complementary protective measures	Secure access to the welding area (welding cell) during operation by means of the existing fixed guard (safety fence in accordance with EN ISO 14120:2015), so that persons cannot enter the immediate vicinity of the active welding cables during automatic operation. Design the maintenance door with guard locking in accordance with EN ISO 14119:2025 (SF-01, PLr d), which permits entry only after the welding current has been switched off. During set-up mode and during maintenance work in the vicinity of cables: switch off the welding current before entering the hazard zone and secure it against being switched on again (energy isolation and standstill in accordance with EN ISO 14118:2018). The welding cables run entirely inside the safety fence, so that persons outside the cell keep their distance from the active cables.
Step 3 · Information for use	Operating instructions: Explicit statement that operation of the welding machine generates strong electromagnetic fields. Persons with active or passive metallic implants (cardiac pacemakers, insulin pumps, cochlear implants, metal implants) must not enter the immediate vicinity of the welding cables and the welding power source. Before commencing set-up or maintenance activities in the vicinity of cables, the welding current must be switched off. Qualification requirement: Set-up and maintenance personnel must be instructed regarding the EMF hazard; persons with known implants must be excluded from activities in the immediate vicinity of active welding cables. Warning labelling: Attach the warning sign 'Warning; Magnetic field' (W006 in accordance with EN ISO 7010:2020) at the maintenance door, at the loading station and on the welding power source. Additionally, attach the prohibition sign 'No access for people with active implanted cardiac devices' (P007 in accordance with EN ISO 7010:2020) at the same locations. EMF emissions are to be described qualitatively in the operating instructions; the basis for assessment is the manufacturer's data for the welding power source in accordance with EN IEC 62822-2 (assessment of arc welding equipment with regard to EMF exposure of persons).

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 20 Materials/substances — Risk before: S 4 · O 4 · **RS 16**

Hazard from inhaling welding fumes and vapours (metal oxides, manganese, iron oxides): MAG welding of structural steel generates harmful particles and gases; when extraction is inadequate (saturated filter cartridge, system switched off), concentrations in the operator's breathing zone exceed the workplace exposure limits.

Sub-machine: Overall installation (extraction / welding area) · also in: Operation, Maintenance, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Substitution of the welding consumable: Use of solid-wire electrodes with a demonstrably reduced manganese content (low-Mn alloy, e.g. Mn content < 1.0 % in accordance with the safety data sheet) instead of flux-cored wire electrodes or high-manganese wires, to the extent that the welding task (structural steel, weld quality) permits this. In addition: optimisation of welding parameters (arc voltage, wire feed speed, shielding gas composition) to a low-fume setting in accordance with the welding power source manufacturer's recommendation, in order to minimise fume generation at source. Both measures reduce the emitted pollutant mass and thereby the probability of a harmful exposure; the severity of the possible harm remains unchanged.
Step 2 · Safeguarding and/or complementary protective measures	Technical ventilation and extraction in accordance with EN ISO 21904-1:2020 (welding fume extraction): Capture of the welding fume by the capture hood above the welding area with a volumetric flow rate of 1800 m³/h, which ensures the capture velocity at the point of generation. The extraction system must be equipped with filter monitoring (differential-pressure switch) that triggers an alarm when the filter cartridge is saturated or the extraction is faulty; the cell stops in a controlled manner and can be restarted only after the fault has been rectified (operational interlock without a PL requirement under EN ISO 13849-1, no risk reduction is credited to it). Shielding of the welding area by the safety fence with welding-light-opaque infill panels (EN ISO 14120:2015) and the dividing centre wall of the turntable, in order to minimise fume escape into the operator area. Ambient air monitoring for welding fume concentration at the loading station is recommended as an additional measure by the user.
Step 3 · Information for use	Operating instructions (in accordance with (EU) 2023/1230 Annex III, section 1.7.4): Specification of the welding fume types emitted and reference to the workplace exposure limits to be observed in accordance with TRGS 900 and TRGS 528; instruction for regular inspection and replacement of filter cartridges (maintenance interval in accordance with manufacturer's specification EN ISO 21904-1:2020); prohibition of welding operation when the extraction system has failed or is switched off. Warning signs at the welding area: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Harmful welding fume' and mandatory sign 'Wear respiratory protection' (M017) as residual risk marking. PPE requirement: FFP3 particle filtering half mask in accordance with EN 149 or powered air-purifying respirator for set-up, maintenance and cleaning work in the welding area when the extraction system is switched off. Qualification requirement: operators and set-up personnel must be instructed in the hazards of welding fumes and the correct operation of the extraction system (TRGS 528 section 5).

Risk after: S 4 · O 2 · **RS 8 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 8 (S 4, O 2) from welding fumes. The severity results from the properties of the welding fumes (metal oxides, manganese) and remains unchanged; the MAG process is the purpose of the machine and cannot be substituted. In step 1, low-manganese solid wire, as far as the welding task permits, and low-fume parameters are provided. After step 2, the hood above the welding area captures the fumes at 1,800 m³/h, the cell stops in a controlled manner if the extraction is faulty or the filter cartridge is saturated (fault alarm threshold 1,400 m³/h), separation takes place in class W3, and the safety fence and dividing centre wall shield the loading station; capture, effectiveness and separation class have been tested. A complete enclosure is not possible because the loading opening has to remain open for manual loading, and the extraction is switched off during work in the welding area; no further step 1 or step 2 measure for this residual exposure has been identified. The remaining risk consists of residual emissions at the loading station and exposure during set-up, maintenance and cleaning work. FFP3 respiratory protection for this work, the prohibition of welding without effective extraction, filter maintenance and the user's obligations under TRGS 528 are stated in the operating instructions (chapters 1.2, 2.6, 9.1 and 10.2).

No. 24 Noise — Risk before: S 4 · O 4 · **RS 16**

Hazard from noise during the MAG welding process and from the turntable drive: The welding process (arc noise, spatter) and mechanical drives generate relevant sound pressure levels at the loading station; during continuous operation (two-shift operation, 16 h), the daily noise exposure level LEX,8h may reach or exceed the action values of the German Noise and Vibration Occupational Safety and Health Ordinance (LärmVibrationsArbSchV).

Sub-machine: Overall installation (welding area / turntable) · also in: Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	Noise reduction at source by design measures in accordance with EN ISO 11688-1: (1) Welding process optimisation: selection of low-emission welding parameters (pulsed arc instead of short arc where technically feasible in terms of the process), as the short arc generates higher spatter and noise emissions. (2) Drive encapsulation and structure-borne noise isolation of the turntable drive: elastic mounting of the drive motor and gearbox on the machine frame in order to reduce structure-borne noise transmission to radiating surfaces. (3) Machine frame using sound-absorbing or damped profiles (e.g. sheet metal cladding lined with bituminous damping mats) instead of undamped steel sheet surfaces, in order to reduce sound radiation. Measurement and declaration of noise emission values will be carried out in Step 2 and Step 3.
Step 2 · Safeguarding and/or complementary protective measures	(1) Acoustic shielding of the welding area by the dividing centre wall of the turntable and the closed infill panels of the safety fence between the welding area and the loading station. (2) Encapsulation or cladding of the turntable drive with sound-absorbing material, provided that maintenance accessibility is ensured (cladding to be designed as a guard in accordance with EN ISO 14120:2015). (3) Noise measurement at the loading station in accordance with EN ISO 11202:2010 under representative operating conditions (automatic mode, MAG welding active, turntable in operation) in order to determine the emission sound pressure level LpA (measured: 84 dB(A), K = 2.5 dB). The daily noise exposure level LEX,8h is determined by the user in accordance with the German Noise and Vibration Occupational Safety and Health Ordinance (LärmVibrationsArbSchV). Note: No safety function in accordance with EN ISO 13849-1 is affected; PLr determination does not apply to this hazard.
Step 3 · Information for use	(1) Operating instructions (MR (EU) 2023/1230 Annex III, section 1.7.4.2, point (u)): Statement of the measured emission sound pressure level LpA at the loading station in accordance with EN ISO 11202:2010 and EN ISO 4871:2009 (with measurement uncertainty K); where LpA exceeds 80 dB(A), additional statement of the sound power level LWA in accordance with EN ISO 3746:2010. Note on the user's obligations under the German Noise and Vibration Occupational Safety and Health Ordinance (LärmVibrationsArbSchV): risk assessment, noise reduction programme from the upper action value LEX,8h 85 dB(A), obligation to provide hearing protection from 80 dB(A), obligation to wear hearing protection from 85 dB(A). (2) Warning labelling at the loading station: Mandatory sign 'Wear ear protection' (M003 in accordance with EN ISO 7010:2020), to be affixed in a clearly visible location. (3) Qualification and instruction: Operating personnel are to be instructed by the user on the noise hazard, the action values and the correct use of hearing protection. (4) PPE specification: Suitable hearing protection (earmuffs or earplugs) with a sufficient attenuation value (SNR) corresponding to the LEX,8h determined by the user is to be provided by the user; selection in accordance with EN 458.

Risk after: S 4 · O 2 · **RS 8 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 8 (S 4, O 2) from noise; severity 4 because noise-induced hearing loss is irreversible. The arc noise originates in the welding process itself; in step 1, low-emission welding parameters, structure-borne noise isolation of the turntable drive and damped cladding are provided. After step 2, the centre wall and the closed fence infill panels shield the loading station, and the drive is clad. The measured values at the loading station are LpA = 84 dB(A) with K = 2.5 dB in accordance with EN ISO 11202:2010 and LWA = 96 dB(A) in accordance with EN ISO 3746:2010. The loading opening towards the operator has to remain open, so further enclosure on this side is not possible, and the arc noise cannot be reduced further without changing the process; a further step 1 or step 2 measure is not practicable. The daily noise exposure level is determined by the user's work organisation. The noise emission declaration in accordance with EN ISO 4871:2009, the obligations regarding hearing protection from 80 and 85 dB(A) and sign M003 are stated in the operating instructions (chapters 2.4 and 3).

No. 27 Ergonomic

Risk before: S 2 · O 3 · **RS 6**

Insufficient lighting at the loading station and in the maintenance aisle: inadequate illuminance makes it difficult to load and unload workpieces safely and to carry out maintenance work, and increases the risk of errors and accidents.

Sub-machine: Loading station / maintenance aisle · also in: Operation, Maintenance, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Machine-integrated workplace lighting at the loading station and in the maintenance aisle to be provided as part of the design: luminaires are permanently integrated into the machine structure (built into the frame of the safety fence) so that the illuminance at the loading station and in the maintenance aisle is permanently ensured independently of the hall lighting. The design is carried out in accordance with EN ISO 12100:2010 section 6.2.8 (ergonomics) in conjunction with EN 1837 (machine-integrated lighting); the lighting as built provides 500 lx at the loading station, 200 lx in the maintenance aisle. The integration into the design eliminates dependence on external lighting sources that may be inadequate.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk from failure or shadowing of the integrated luminaires: monitoring of the operational readiness of the workplace lighting by the machine control system (notification in the event of lamp failure). In addition, maintenance aisle areas to be marked with retroreflective yellow and black floor markings in accordance with the German workplace rule ASR A1.3 (trip hazards, aisle boundaries) and with the warning sign W007 'Warning; Floor-level obstacle' in accordance with EN ISO 7010:2020 at trip hazards. A safety function within the meaning of EN ISO 13849-1 is not required for lighting monitoring; in the event of a lighting failure, work is to be discontinued (Step 3).
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): specification of the illuminance of the workplace lighting: 500 lx at the loading station and 200 lx in the maintenance aisle; notice that work is to be discontinued in the event of failure of the integrated lighting until the lighting has been restored. Text sign on the maintenance door: 'Stop work if the lighting fails'. Qualification requirement: maintenance personnel must be instructed in checking the lighting function before commencing work. Use suitable portable luminaires for brief inspections in the event of a lighting failure; resume regular work only after the lighting has been restored.

Risk after: S 2 · O 1 · **RS 2 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 30 Combination

Risk before: S 5 · O 2 · **RS 10**

Hazard arising from incorrect parameterisation of the robot control system or the safety controller (e.g. incorrect safety distances, incorrect speed limits in set-up mode, incorrect zone releases): Erroneous parameters may result in safety functions not operating as intended, thereby endangering persons through robot movements or turntable movements.

Sub-machine: Overall installation (control / safety control) · also in: Commissioning, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Safety-relevant parameters (speed limits, protection zones, zone releases) are stored exclusively in the safety controller (safety PLC) and are protected against unauthorised or inadvertent modification by a password-protected, role-based access concept. Parameter sets for safety functions SF-01 to SF-05 are stored in the safety controller as immutable, checksum-protected data records (e.g. CRC-32 or equivalent), so that any unintended modification is automatically detected at system start-up and a safe state is enforced. This principle corresponds to the inherently safe control principle in accordance with EN ISO 12100 section 6.2.11 (control principles that limit the occurrence of hazards) and reduces the possibility of erroneous parameters becoming effective at all.
Step 2 · Safeguarding and/or complementary protective measures	1. Validation requirement before release: Every change to safety-relevant parameters requires a documented acceptance test (functional test of all affected safety functions SF-01 to SF-05) carried out by two authorised persons (dual-control principle) before recommissioning. The safety controller may not release automatic operation until a positive acknowledgement has been given. Basis: EN ISO 13849-2:2012 (validation of safety functions) and EN ISO 11161:2007+A1:2010 (verification and validation for integrated manufacturing systems). 2. Parameter verification by the safety controller: The safety controller (PLr e for SF-02 and SF-04, PLr d for SF-01, SF-03 and SF-05 in accordance with EN ISO 13849-1:2023) checks the consistency of the safety-relevant parameters against stored reference values (checksum comparison) at start-up and cyclically. In the event of a discrepancy, stop category 1 in accordance with EN 60204-1:2018 is triggered and a restart is inhibited (no automatic restart in accordance with EN ISO 14118:2018). 3. Set-up mode SF-05: The safely reduced speed of 250 mm/s (SF-05, PLr d) is limited at hardware level in the safety controller and cannot be overridden by parameters of the robot control system. Monitoring is performed by an SRP/CS in accordance with EN ISO 13849-1:2023, category and PL in accordance with SF-05 (PLr d). 4. Zone release turntable SF-04: The release of the 180-degree rotary movement (SF-04, PLr e) is performed exclusively via the safety controller on the basis of verified sensor signals; a release caused by erroneous zone parameters in the robot control system alone is excluded by design. 5. Change management: All parameter changes are stored with a time stamp, user identification and predecessor/successor value in a tamper-proof change log (audit trail) of the safety controller. Basis: EN ISO 11161:2007+A1:2010.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the parameter change procedure with a step-by-step guide, listing of all safety-relevant parameters for each safety function (SF-01 to SF-05), obligation to carry out a validation test after each change, and documentation obligation in the change log. 2. Qualification requirement: Parameter changes to the safety controller may only be carried out by specialist personnel with demonstrated qualification in functional safety (e.g. TÜV certification as Functional Safety Engineer or equivalent) and knowledge of the system. This is to be set out in the operating instructions and in an operating procedure. 3. Warning labelling: The warning sign 'Warning; Electricity' (W012 in accordance with EN ISO 7010:2020) and the supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006) are to be affixed to the safety controller and the control cabinet. Additionally, an information sign stating: 'Parameter changes by authorised specialist personnel only; subsequent validation test required'. 4. Commissioning checklist: Before every initial commissioning and after every parameter change, a system-specific commissioning checklist is to be completed and signed (basis: EN ISO 11161:2007+A1:2010).

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to incorrect parameterisation. In step 1, the safety-relevant parameters are held only in the safety PLC, protected by a role-based access concept and checksum-protected parameter sets. After step 2, the safety PLC checks the parameters against the reference at start-up and cyclically and triggers a stop with restart interlock in the event of a deviation, the speed limit of SF-05 cannot be overwritten via the robot controller, the rotation enable SF-04 comes only from the safety PLC, and every change is logged and validated under the four-eyes principle in accordance with EN ISO 13849-2:2012 before release. The remaining risk is a parameter that is specified incorrectly by authorised personnel and not detected during validation. The parameters have to remain changeable for commissioning, modifications and new clamping fixtures; a measure that detects a technically incorrect but properly entered and validated value is not available according to the state of the art. Change procedure, qualification, commissioning checklist and the text sign on the validation obligation at the control cabinet: operating instructions chapters 2.4 and 2.6.

No. 32 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Hazard from reaching over or under the light curtain at the loading station (reasonably foreseeable misuse): Persons reach around the side of the light curtain or under the light curtain into the rotation range without the protective function being triggered; the turntable or the robot may start up and trap hands or arms.

Sub-machine: Loading station (light curtain interface) · also in: Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: The loading station requires a permanently open access opening for manual workpiece infeed. Complete geometric closure of this opening by design would render the machine non-functional. Minimum distances in accordance with EN ISO 13854:2019 cannot, as a design measure, prevent lateral bypassing of a light curtain as long as the opening must remain available for operator access. Limitation of force or energy at the turntable or robot to a non-hazardous level (Step 1) is not technically feasible at the masses and torques involved without impairing the function.
Step 2 · Safeguarding and/or complementary protective measures	1. Protective field and under-reach guarding: Position the light curtain (Type 4 in accordance with EN IEC 61496-1:2020, SF-02, PLr e) such that the protective field covers the loading opening completely. Remaining openings below and beside the protective field are closed with fixed guards (EN ISO 14120:2015) in accordance with EN ISO 13857:2019 Table 4, so that reaching under or around the protective field is not possible. 2. Lateral flank guarding: Fixed guards (side panels or channel guides) in accordance with EN ISO 14120:2015 must be fitted on both sides of the light curtain to prevent lateral bypassing by design. The depth of these flanks must be determined in accordance with EN ISO 13857:2019 Table 4 (safety distance as a function of the opening size) so that the hazard zone cannot be reached from the lateral direction. 3. Light curtain specification: The light curtain must be selected as Type 4 in accordance with EN IEC 61496-1:2020 and integrated into safety function SF-02 (PLr e). The safety distance between the light curtain and the nearest hazard zone must be calculated and maintained in accordance with EN ISO 13855:2024 (reaching through, resolution 30 mm for hand detection). Integration into the control system is carried out in accordance with EN ISO 13849-1:2023, PLr e (SF-02).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Explicit statement that lateral bypassing or reaching under the light curtain is prohibited and overrides safety function SF-02. Description of the correct loading action (insert workpiece from the front through the light curtain). Note on the hazard posed by the turntable and the robot when the protective function has not been triggered. 2. Warning signs (EN ISO 7010:2020): 'Warning; Crushing of hands' (W024) to be affixed on both sides of the flank panels and on the light curtain frame. Prohibition sign 'No reaching in' (P015) at the access opening. 3. Qualification requirement: In set-up mode (SF-05, PLr d, safely reduced speed 250 mm/s with enabling device) only instructed specialist personnel who are familiar with the function and limitations of the light curtain may work. This requirement must be recorded in the operating instructions and in the instruction documentation. 4. PPE: Protective gloves provide no protection against crushing and entanglement hazards from the turntable or robot and are not suitable as a protective measure for this hazard. This notice must be included in the operating instructions to avoid incorrect assumptions.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to reaching around or under the light curtain. The loading opening has to be permanently open for loading in a cycle of around 90 seconds, and limiting the force or energy of turntable and robot is not feasible (step 1). After step 2, a type 4 light curtain with 30 mm resolution (SF-02, PL e, category 4) covers the opening without muting, the flanks and openings below and beside the protective field are closed by fixed guards in accordance with EN ISO 13857:2019 Table 4, and the safety distance is calculated in accordance with EN ISO 13855:2024; the measured overrun distance of the turntable of 45 mm is below the permissible value of 60 mm. A movable guard at the opening would have to open and close in every cycle and would create its own crushing point at the closing edge; it does not reduce the risk compared with the solution implemented. The remaining risk is deliberate bridging, for example by taping over the protective field. The prohibition, the daily check with the test rod, signs W024 and P015 at the opening and the note that gloves do not protect against crushing are stated in the operating instructions (chapters 2.2, 2.4, 9.1 and 9.4).

No. 36 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Manipulation of safety-relevant parameters via the network: Unauthorised write access via fieldbus, OPC UA or MES interface alters safety-relevant parameters (e.g. monitoring of the maintenance door, parameters of the light curtain, speed limit in set-up mode). The protective function becomes ineffective or the machine operates outside the limits defined in the risk assessment. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 1, 1.1.9 para. 3, 1.2.1 lit. a, 1.2.1 lit. d]

Sub-machine: Control / network · also in: Operation

Step 1 · Inherently safe design measures	Safety-relevant parameters are to be held only in the safety controller and must not be writable via the process network under any circumstances (write access physically or architecturally separated, safety network segmented from standard communication). Limit values derived from the risk assessment are to be stored as constants in the safety program, not as recipe data.
Step 2 · Safeguarding and/or complementary protective measures	Authentication and authorisation for every write access (roles, no default passwords), integrity checking of safety-relevant configuration (checksum/CRC with release procedure), plausibility checking of incoming values against the permissible limits, logging of every parameter change with timestamp and user. Evidence reference route B: IEC 62443-3-3 SR 1.1, SR 2.1, SR 3.4, SR 3.5, SR 5.1, SR 2.8.
Step 3 · Information for use	Operating instructions: network requirements for the user (segmentation, firewall, no direct internet connection of the controller), list of safety-relevant parameters with a note that changes are only permissible by authorised personnel and with a subsequent functional check of the safety functions.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 37 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Unintentional corruption through misconfiguration or operator error: Incorrect recipe or parameter file loaded, roles and passwords not set up (default password active), configuration incompletely restored after a fault. Safety-relevant settings deviate from the approved configuration without being noticed. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 3, 1.2.1 lit. b, 1.2.1 lit. d, 1.2.1 lit. e]

Sub-machine: HMI / parameterisation · also in: Operation, Commissioning

Step 1 · Inherently safe design measures	Separate safety-relevant settings from process recipes so that a recipe change cannot alter them; hard-limit value ranges in the safety controller (limits derived from the risk assessment, Annex III, section 1.2.1, point (d)).
Step 2 · Safeguarding and/or complementary protective measures	Forced password change on commissioning, role model with dual-control approval for safety-relevant changes, comparison of the active configuration with the approved reference (checksum) at start-up with display of any deviation, change log. Evidence reference route B: IEC 62443-3-3 SR 1.5, SR 2.1, SR 3.4, SR 7.6.
Step 3 · Information for use	Operating instructions: commissioning checklist (passwords, roles, saving of reference configuration), description of the data designated as safety-relevant, instruction for functional testing after configuration changes.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

Operation (29 hazards)

No. 1 Mechanical

Risk before: S 5 · O 3 · **RS 15**

Crushing and shearing hazard from the turntable during the automatic rotation: Body parts of the operator (hands, arms) may be drawn in and crushed between the turntable and the fixed dividing centre wall or the safety fence, in particular when reaching into the turntable during rotation to reposition a displaced workpiece (reasonably foreseeable misuse).

Sub-machine: Turntable (rotary unit) · also in: Setting up, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Design the gap dimensions between the turntable edge and the fixed dividing centre wall as well as the safety fence such that no crushing points arise: the gaps must not be smaller than the minimum gaps in EN ISO 13854:2019 Table 1 (25 mm for fingers, 100 mm for the hand, 120 mm for the arm, 500 mm for the body). Alternatively, keep the gap so small that no part of the body can enter it (opening sizes in accordance with EN ISO 13857:2019 Table 4). Where neither of the two gap sizes can be achieved, the geometry of the table frame must be configured so that no converging wedge shape is created (parallel or diverging flanks instead of a converging gap). In addition: reduce the mass and rotation speed of the turntable to the functionally necessary minimum (drive design) in order to limit the kinetic energy acting in the crushing gap.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk after Step 1: The rotation range remains a hazard zone that must not be entered while the drive is running. Technical protective measures: 1. Release of the rotary movement only when the rotation range is clear (SF-04, PLr e, EN ISO 13849-1:2023): ESPE (light curtain type 4 in accordance with EN IEC 61496-1:2020) monitors the rotation range completely; arrangement and safety distance in accordance with EN ISO 13855:2024. 2. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release (SF-01, PLr d; stop category 1 in accordance with EN 60204-1:2018). 3. Set-up mode: rotary movement only at safely reduced speed of 250 mm/s and with the enabling device actuated (SF-05, PLr d, stop category 1 in accordance with EN 60204-1:2018). 4. Emergency stop in the operator area in accordance with EN ISO 13850:2015, integrated into SF-03 (PLr d, stop category 1 in accordance with EN 60204-1:2018). 5. Energy isolation prior to interventions: isolating valve with mechanical latching (lockout) in accordance with EN ISO 4414:2010; lock the turntable positively in its end position (EN ISO 14118:2018).
Step 3 · Information for use	1. Operating instructions: entering the rotation range while the turntable is running or unsecured is prohibited. Before any intervention (e.g. repositioning a workpiece), the system must be completely switched off and secured (lockout/tagout). A separate procedure with an enabling device applies to set-up mode and is described in the operating instructions. 2. Warning signs on the machine: the following signs are affixed to the turntable: warning signs W019 'Warning; Crushing' and W024 'Warning; Crushing of hands' and prohibition sign P015 'No reaching in' (in accordance with EN ISO 7010:2020). 3. Who may intervene: set-up and fault rectification may only be carried out by trained personnel. Training must be repeated at least once a year and recorded in writing. 4. Personal protective equipment: protective gloves do not protect against crushing. Reach into the rotation range only when the turntable has been stopped. Safety footwear S3 in accordance with EN ISO 20345 is mandatory throughout the entire area of the installation.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Warning: crushing

Justification of acceptance: Residual risk RS 5 (S 5, O 1). The severity remains 5: the mass and drive of the turntable are required for the 180-degree rotation with a payload of up to 2 x 40 kg plus clamping fixtures in a cycle of around 90 seconds and have already been limited to the functionally necessary level in step 1; the gaps are designed in accordance with EN ISO 13854:2019 and EN ISO 13857:2019, and the table edges have no converging wedge shape. Any further reduction of the energy would prevent the rotation. After step 2, the table only rotates when the rotation range is clear (SF-04, PL e), the maintenance door is guard-locked (SF-01, PL d), set-up mode is limited to 250 mm/s with enabling device (SF-05), and the table is positively locked before any intervention. An accident therefore requires deliberate reaching into the rotating table while bypassing these devices; no additional step 1 or step 2 measure has been identified that would make this misuse more difficult without preventing the rotation. The prohibition and the obligation to isolate before every intervention are stated in the operating instructions (chapters 2.2, 2.6 and 9.1), and signs W019, W024 and P015 are affixed to the turntable.

No. 3 Mechanical — Risk before: S 5 · O 2 · **RS 10**

Impact and crushing hazard from the welding robot during automatic operation in the event of unauthorised access: persons who climb over the safety fence or tamper with the maintenance door are struck by the robot axis moving at full speed and force or are pressed against fixed parts.

Sub-machine: Welding robot · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the functional principle of the welding robot requires the free, rapid movement of the robot arm with full payload within the working space. Limiting force or speed to a level that is harmless to persons (impact force below the pain threshold) is technically incompatible with the required process parameters in automatic operation and would prevent the welding process. Geometric resolution of the hazard zone by shaping alone is not possible with a 6-axis industrial robot.
Step 2 · Safeguarding and/or complementary protective measures	1. Fixed guard: fixed safety fence with welding-light-opaque infill panels and viewing windows with welding protection filters in accordance with EN ISO 14120:2015 around the entire robot working space, height 2200 mm. Height and distance from the hazard zone to be designed in accordance with EN ISO 13857:2019 Table 2 so that neither reaching over nor climbing over without aids is possible. Remaining openings to be designed in accordance with EN ISO 13857:2019 Table 4 so that reaching under or through into the hazard zone is not possible. 2. Interlocked maintenance door with guard locking (SF-01): the maintenance door is an interlocking guard with guard locking in accordance with EN ISO 14119:2025. Opening the door triggers SF-01 'Safe stop, stop category 1'. The guard locking keeps the door closed until the robot has come to a safe standstill. Escape release to be provided in accordance with EN ISO 14119:2025 section 6.9.1. SF-01 is specified with PLr d; integration into the safety controller in accordance with EN ISO 13849-1:2023. 3. Tamper protection of the protective devices: the interlocking device of the maintenance door is protected against defeat in accordance with EN ISO 14119:2025 section 8: high-level coded actuator in accordance with EN ISO 14119:2025, switch and actuator mounted with non-detachable fasteners. In addition: safety fence panels to be fastened so that they can only be released using a tool (no quick-release fasteners), so that unauthorised opening without a tool is not possible. 4. Emergency stop devices (SF-03): emergency stop devices at the control desk, at the maintenance door and on the teach pendant in accordance with EN ISO 13850:2015, integrated into SF-03 'Emergency stop of the overall installation, stop category 1', PLr d. 5. Protection against unexpected restart: energy isolation and restart prevention in accordance with EN ISO 14118:2018 to be ensured; restart after door opening only by deliberate acknowledgement at a control desk located outside the hazard zone. 6. Set-up mode (SF-05): in set-up mode, robot movement only at safely reduced speed of 250 mm/s and with enabling device in accordance with SF-05, PLr d; integration in accordance with EN ISO 10218-2:2025 sections 5.5.6 and 5.7.7 and EN ISO 13849-1:2023.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the access rules for the robot working space, prohibition of climbing over the safety fence, procedure for energy isolation prior to entry (lockout/tagout in accordance with EN ISO 14118:2018), qualification requirements for operators and set-up personnel (robot safety instruction in accordance with EN ISO 10218-2:2025). 2. Warning marking on the safety fence and at the maintenance door: warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020 and supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006). Marking to be affixed so that it is clearly visible and permanent. 3. Instruction: operating personnel and set-up personnel are to be instructed before initial commissioning and thereafter at regular intervals. Unauthorised access is to be prevented by organisational measures (access control, key-operated switch for operating mode selection in accordance with EN ISO 10218-2:2025 section 5.7.2). 4. Residual risk notice in the operating instructions: despite all protective measures, a residual risk exists in the event of tampering with the protective devices; notice of the criminal law and liability consequences of tampering.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) in the event of unauthorised access during automatic operation. Limiting the force or speed of the robot to a level that is harmless to persons is not compatible with the welding process parameters (step 1), so the severity remains 5. The robot working space is enclosed on all sides by a 2200 mm high safety fence in accordance with EN ISO 14120:2015 with distances in accordance with EN ISO 13857:2019, the panels can only be removed with a tool, and the only door is interlocked and guard-locked (SF-01, PL d) and protected against defeat in accordance with EN ISO 14119:2025 section 8 by a high-coded actuator and non-removable fixings. Access therefore requires deliberate climbing over with aids or tampering with tools. Against deliberate defeat with tools, a further protective device provides no fundamentally different protection, because it can be defeated with comparable effort; the measures against reasonably foreseeable defeat are implemented. The prohibition and consequences of tampering, the access rules and the instruction of personnel are stated in the operating instructions (chapters 2.2, 2.5 and 2.6), and signs W018 and D-P006 are affixed to the fence and the door.

No. 4 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Crushing hazard at the interface between the turntable and the welding robot (transfer area): During the rotation the loaded fixture moves into the working area of the robot; uncoordinated entry of the robot into the rotation range or missing interlock between the turntable movement and the robot enable can lead to collisions and crushing injuries.

Sub-machine: Interface: turntable / welding robot · also in: Setting up, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	The rotation radius of the turntable and the working space boundary of the robot (TCP envelope) are coordinated with each other during the design phase such that the maximum rotation range of the fixture and the minimum robot working space maintain a geometric minimum distance of >= 500 mm (minimum gap to avoid crushing of the body in accordance with EN ISO 13854:2019 Table 1) from each other when both movements would be active simultaneously. This minimises the overlap zone by design; complete elimination of the overlap is not possible with this system topology due to functional constraints, so that the remaining residual overlap is safeguarded by Step 2.
Step 2 · Safeguarding and/or complementary protective measures	SF-04 'Enable of the 180-degree rotary movement of the turntable only when the rotation range is clear' with PLr e in accordance with EN ISO 13849-1:2023 (risk graph: S2/F2/P2). Implementation as an interlocked safety function in the safety PLC: (a) Robot standstill monitoring: the robot must be in a defined rest position outside the rotation range and must confirm this via a safe feedback signal (safe output of the robot controller in accordance with EN ISO 10218-2:2025 sections 5.4.7 and 5.5.8) before the turntable enable is granted. (b) Turntable enable to the robot: as long as the turntable is not in its end position and locked, the robot controller receives no enable signal for the entry area; the turntable is positively locked in its end position. (c) Guard locking of the maintenance door to the rotation range in accordance with EN ISO 14119:2025 with escape release, incorporated in SF-01 (PLr d). (d) Emergency stop of the overall installation in accordance with EN ISO 13850:2015, incorporated in SF-03 (PLr d), stop category 1 in accordance with EN 60204-1:2018. (e) In set-up mode SF-05 applies: safely reduced speed <= 250 mm/s with enabling device (PLr d); the set-up personnel may enter the rotation range only with the enabling device actuated and at reduced speed. The distance of the safety fence from the rotation range complies with EN ISO 13857:2019 Table 2; the safety fence is designed in accordance with EN ISO 14120:2015.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the interlock logic SF-04 and the operating modes Automatic and Set-up; explicit notice that entering the rotation range while the system is running is prohibited. Set-up mode: qualification requirement to be documented (only trained specialist personnel with knowledge of the enabling device). Warning labelling at the rotation range: warning signs W019 'Warning; Crushing' and W024 'Warning; Crushing of hands' in accordance with EN ISO 7010:2020; at the maintenance door additionally the supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006). PPE specification in the operating instructions: safety footwear S3 in accordance with EN ISO 20345; in set-up mode additionally close-fitting protective clothing (no entanglement risk from loose clothing). Note on residual risk in set-up mode and fault-finding: always keep the enabling device actuated, never enter the rotation range without the enabling device.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) at the transfer between turntable and robot. The robot has to reach the station that has just been rotated in; a complete geometric separation of the rotation range and the robot working space is therefore not possible for functional reasons with this installation layout. In step 1, the overlap has been reduced by a minimum distance of 500 mm between the rotation radius and the TCP envelope. The remaining overlap is mutually interlocked: the turntable only rotates when the robot controller confirms the rest position outside the rotation zone via a safe output, and the robot is only released when the table is locked in its end position (SF-04, PL e according to risk graph S2/F2/P2). An accident therefore requires a failure of this interlock or entry while the installation is running by defeating the guard locking (SF-01). The enabling is already implemented at the required performance level; a further step 1 or step 2 measure would not measurably reduce the probability of occurrence. In set-up mode SF-05 applies with 250 mm/s and enabling device. The interlocking logic, the prohibition of entry and the behaviour in set-up mode are described in the operating instructions (chapters 2.5, 2.6 and 9.3).

No. 5 Mechanical — Risk before: S 4 · O 3 · **RS 12**

Falling of workpieces or fixture parts due to failure of the pneumatic clamping device: In the event of compressed air failure or leakage, the clamping elements open in an uncontrolled manner; workpieces of up to 40 kg may fall from the turntable and strike persons at the loading station.

Sub-machine: Pneumatic clamping device (turntable) · also in: Setting up, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Use of pneumatically closing clamps with a pilot-operated non-return valve (pressure-holding valve) in the clamping line directly at the clamping cylinder: in the event of compressed air failure or a leak in the supply line, the clamping pressure remains trapped in the cylinder and the workpiece remains clamped; the clamps open only when the valve is actively pilot-opened. The clamping force is designed for the maximum workpiece weight of 40 kg plus a safety factor in accordance with EN ISO 4414:2010. Additionally: limitation of the operating pressure to the level required for the clamping function, in order to minimise the stored pneumatic energy (EN ISO 4414:2010).
Step 2 · Safeguarding and/or complementary protective measures	1. Clamping pressure monitoring with safety function: a pressure switch in the clamping line monitors the clamping pressure; if the pressure falls below the minimum clamping pressure, the enable for the rotary movement of the turntable is inhibited (linked to SF-04, PLr e in accordance with EN ISO 13849-1:2023). As long as the clamping pressure has not been confirmed, the turntable does not rotate. 2. Mechanical interlock of the rotary motion: Positive locking of the turntable in the loading position, so that unintended rotation with a clamped or loose workpiece is prevented; the interlock is released only after the clamping pressure has been confirmed (interlocked with SF-04, PLr e). 3. Enclosure/catch device: Mechanical catch device (deflector plate) below the turntable, designed for the maximum workpiece weight of 40 kg and the maximum drop height, to keep falling parts away from the loading station; design in accordance with EN ISO 14120:2015. 4. Safety distance at the loading station: Arrangement of the loading station such that the hazard zone below the turntable is outside the regular area of presence.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the clamping principle (pneumatically closing clamps with pressure-holding valve) and the clamping pressure monitoring; prohibition of remaining beneath the turntable during operation and during fault-finding without secured standstill; procedure in the event of compressed air failure (shut down the machine, restore the compressed air supply, remove the workpiece only after a pressure check). 2. Energy isolation prior to interventions: Instruction for complete pressure relief of the pneumatic system prior to maintenance and servicing work in accordance with EN ISO 4414:2010 and EN ISO 14118:2018 (prevention of unexpected restart and unexpected energy release); because of the pressure-holding valve, the clamping pressure remains trapped in the clamping cylinders, so the clamps must be opened and depressurised before any work on the clamping device; provide a shut-off and exhaust valve with lockout facility. 3. Warning labelling: Attach warning signs W015 'Warning; Overhead load' and W024 'Warning; Crushing of hands' in accordance with EN ISO 7010:2020 to the turntable and at the loading station. 4. Qualification: Fault-finding and set-up work to be carried out by trained specialist personnel only; requirements to be specified in the operating instructions. 5. PPE: Prescribe the wearing of safety footwear (S3 in accordance with EN ISO 20345) at the loading station as residual risk protection.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 7 Mechanical — Risk before: S 5 · O 2 · **RS 10**

Missing or uncoordinated emergency stop function between sub-machines (robot, turntable, welding power source, extraction system): an emergency stop at one sub-machine does not necessarily stop all other sub-machines; persons may be endangered by components that continue to run.

Sub-machine: Overall installation (emergency stop coordination) · also in: Setting up, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the coordination of several independent controllers necessarily requires a higher-level control logic. A pure design measure (geometry, energy limitation, substitution) cannot replace the missing interconnection of the emergency stop circuits. The functional principle of the overall installation necessitates active control coordination.
Step 2 · Safeguarding and/or complementary protective measures	Higher-level emergency stop circuit (SF-03) in accordance with EN ISO 13850:2015 and EN ISO 11161:2007+A1:2010: all emergency stop devices of the overall installation are integrated into a common, higher-level safety circuit which, on actuation at any point, brings all hazardous sub-machines (robot, turntable, welding power source, pneumatics) to a coordinated standstill; the extraction system runs on for operational reasons. Stop category 1 in accordance with EN 60204-1:2018 (controlled stopping, followed by energy disconnection): the robot performs a controlled stop along its path, the turntable brakes actively, the welding power source is de-energised, and the clamps remain clamped by the pressure-holding valve. The run-on of the extraction system is not a safety function, but is operationally required. Safety function SF-03 is specified with PLr d in accordance with EN ISO 13849-1:2023 and implemented in Category 3 with PL d. Integration of the robot is carried out via the robot controller in accordance with EN ISO 10218-2:2025 section 5.3.3 (span of control of the emergency stop, safety interface to the higher-level controller). Emergency stop devices are to be designed in accordance with EN ISO 13850:2015 (mushroom-head pushbutton, yellow background, self-latching, release only by deliberate action). Emergency stop devices are to be positioned such that at least one emergency stop device is reachable from every operating station without exposure to a hazard (EN ISO 13850:2015). Restart interlock: after an emergency stop, a manual reset is required before the installation can restart (EN ISO 13850:2015 section 4.1.4), in order to prevent unexpected restart in accordance with EN ISO 14118:2018.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the emergency stop topology of the overall installation with a layout plan of all emergency stop devices and the area of effect of each emergency stop device. Clear instruction that after an emergency stop, the hazard zone of all sub-machines must be inspected before the reset is carried out. Set-up mode and fault-finding: instruction that intervention in the hazard zone is only permissible after all sub-machines have come to a complete standstill and the maintenance door has been secured against closing (personal padlock in the lockout device). Qualification requirement: set-up and fault-finding only by instructed specialist personnel who are familiar with the emergency stop topology. Marking at the control desk: text sign stating the area of effect of the emergency stop devices (the emergency stop acts on all sub-machines of the cell), supplemented by warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) in the coordination of the emergency stop. Linking the emergency stop circuits of several sub-machines is only possible by means of the control system; there is no step 1 measure for this. A higher-level emergency stop circuit SF-03 in category 3 with PL d is implemented, which stops robot, turntable, welding power source and pneumatics together from every emergency stop device (control desk, maintenance door, teach pendant), with manual reset in accordance with EN ISO 13850:2015 and scope of effect in accordance with EN ISO 11161:2007+A1:2010; the required performance level is achieved and the emergency stop test items have been passed. The remaining risk is the overrun during the controlled stop in stop category 1. This category has been chosen because the robot brakes under control along its path and the clamps hold the workpiece via the pressure-holding valve; a stop in category 0 would give up this control without eliminating the overrun. The emergency stop is a complementary protective measure and does not replace any safeguard. The arrangement and scope of effect of the emergency stop devices are stated in the operating instructions (chapters 2.5 and 9.5) and on the text sign at the control desk.

No. 9 Mechanical

Risk before: S 4 · O 4 · **RS 16**

Ergonomic hazard and crushing hazard during manual loading and unloading of workpieces up to 40 kg: Workpieces up to 15 kg are loaded by hand, workpieces above 15 kg with the user-supplied lifting aid; in the event of reasonably foreseeable misuse (lifting without the lifting aid), musculoskeletal strain arises together with the risk of losing grip, with the subsequent falling of the workpiece onto feet or hands.

Sub-machine: Loading station (operating station) · also in: Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Limitation of the manually handled workpiece mass to a maximum of 15 kg. The threshold is set by the manufacturer for around 40 lifts per hour and is derived from the reference mass in accordance with EN 1005-2:2003+A1:2008. For workpieces above 15 kg and up to 40 kg, the workpiece fixture at the loading station is designed so that loading from above with the user-supplied lifting aid is possible without re-gripping (unobstructed access, insertion depth, geometry of the locating stops).
Step 2 · Safeguarding and/or complementary protective measures	1. The loading station is prepared for a user-supplied lifting aid (lifting aid not included in the scope of supply, load capacity at least 40 kg, operating radius covering the entire loading zone). Access from above is unobstructed, so that the operator can reach the loading position without re-gripping or releasing the workpiece. 2. Floor marking (yellow/black in accordance with German ASR A1.3) of the set-down and slewing area of the lifting aid at the loading station, so that the operator is not standing beneath the suspended load during loading. 3. The light curtain at the loading station (SF-02, PLr e) safeguards the hazard zone of the machine opening; it does not protect against the falling of the workpiece itself, but it does limit the area in which hands may be located during loading.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Clear specification of the handling rule (up to 15 kg by hand, above 15 kg with the user-supplied lifting aid, load capacity at least 40 kg) and of the correct attachment points on the workpiece. Specification of body posture during loading in accordance with EN 1005-4. 2. Warning labelling at the loading station: Warning signs W015 'Warning; Overhead load' and W024 'Warning; Crushing of hands' and mandatory sign M008 'Wear safety footwear' in accordance with EN ISO 7010:2020. Text sign 'Manual handling up to 15 kg only, use the lifting aid above this' directly at the loading station. 3. Qualification requirement: Operators must be instructed in the use of the lifting aid and in ergonomically correct handling before commencing work (documented instruction). 4. PPE specification: Safety footwear S3 in accordance with EN ISO 20345 and protective gloves (cut-resistant, secure grip) are to be stipulated as minimum PPE for all loading and unloading activities.

Risk after: S 4 · O 2 · **RS 8 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 8 (S 4, O 2) during loading and unloading. Workpieces up to 40 kg are part of the intended use, and manual loading is the concept of the machine (operating instructions chapter 2.1); automatic loading would defeat this concept. In step 1, manual handling is limited to 15 kg (manufacturer's specification derived from the reference mass of EN 1005-2:2003+A1:2008), and the fixture is designed so that heavier parts are loaded from above with the lifting aid without re-gripping. After step 2, the loading station is prepared for the lifting aid provided by the user and its slewing area is marked on the floor. The machine cannot determine whether a workpiece over 15 kg is lifted without the lifting aid; the remaining risk is this misuse with overloading of the musculoskeletal system or a falling workpiece. No further step 1 or step 2 measure that prevents this misuse without defeating manual loading has been identified. The text sign "Manual handling up to 15 kg only, use the lifting aid above this", S3 safety footwear, the instruction of personnel and the user's obligation to provide the lifting aid are stated in the operating instructions (chapters 1.2, 2.4 and 9.1).

No. 10 Mechanical — Risk before: S 3 · O 3 · **RS 9**

Hazard of tripping, slipping and falling in the area of the loading station and the maintenance aisle due to weld spatter on the floor, cables, hoses (compressed air, shielding gas) and wet areas during cleaning work.

Sub-machine: Loading station / maintenance aisle · also in: Setting up, Maintenance, Cleaning, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Keep cables and hoses (compressed air, shielding gas) out of the floor area of the loading station and maintenance aisle by design, by routing them in cable ducts, energy chain systems or ceiling-suspended cable management systems, so that no trip hazards arise. Design connections at the loading station as ceiling pendants or wall-mounted socket panels. Reduce weld-spatter exposure on the floor by means of design-integrated shielding plates (spatter-protection shields) at the welding station, so that discharge into the operator area is minimised. The hall floor is not part of the scope of supply; the requirement for the installation site (anti-slip floor covering) is passed on to the user in Step 3.
Step 2 · Safeguarding and/or complementary protective measures	Limit the residual risk from remaining trip and slip hazards by means of the following technical measures: (1) Floor markings (yellow/black in accordance with German ASR A1.3) to identify traffic routes and hazard zones in accordance with (EU) 2023/1230 Annex III, section 1.5.15. (2) Adequate fixed lighting of the loading station and maintenance aisle in accordance with (EU) 2023/1230 Annex III, section 1.1.4, so that obstacles and wet areas can be detected at an early stage; the machine-integrated lighting in accordance with EN 1837 provides 500 lx at the loading station and 200 lx in the maintenance aisle. (3) Spatter-protection mats in the immediate welding area that are easy to remove and clean.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): (1) Reference to the hazard of tripping and slipping due to weld spatter, hoses and wet conditions; prescribe cleaning intervals and cleaning procedures for the floor area. (2) Qualification requirement: all persons entering the loading station and maintenance aisle must have been instructed in the hazards and the traffic-route layout. (3) PPE specification: safety footwear with anti-slip soles (S3 in accordance with EN ISO 20345) shall be worn when entering the loading station and maintenance aisle. (4) Warning labelling at the access to the loading station and maintenance aisle: affix warning sign W011 'Warning; Slippery surface' and mandatory sign M008 'Wear safety footwear' in accordance with EN ISO 7010:2020. (5) Requirement for the installation site: anti-slip floor covering at the loading station and in the maintenance aisle, slip resistance rating of at least R 11 in accordance with German DGUV Rule 108-003.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) due to tripping, slipping and falling. In step 1, cables and hoses have been routed out of the floor area, and spatter guards reduce the spatter carried out of the cell. What remains is welding spatter that reaches the floor through the opening, which is open for loading, and wet areas during cleaning. The opening has to remain open for loading, and the hall floor is not part of the scope of supply; further design measures on the machine do not reach these causes. After step 2, the traffic routes are marked, the loading station is lit with 500 lx and the maintenance aisle with 200 lx, and removable spatter mats are provided in the welding area; the test of trip and slip points has been passed. Any further technical measure would only replace the floor cleaning, which is specified as a daily task. The daily cleaning (operating instructions chapter 10.2), slip-resistant S3 safety footwear, signs W011 and W007 (chapter 2.4) and the requirement for a slip-resistant floor covering at the installation site (overview of residual risks, chapter 2.6) form the information for use.

No. 13 Electrical — Risk before: S 4 · O 2 · **RS 8**

Hazard from welding current at the workpiece and at the fixture: the welding circuit carries high currents (typically 100 to 350 A); in the event of a faulty earth connection or damaged insulation, persons who touch the workpiece or the fixture may receive an electric shock.

Sub-machine: Welding power source / fixture · also in: Setting up, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Design the fixture frame and workpiece holders such that touchable conductive surfaces that lie within the welding current circuit are galvanically isolated from the machine frame by design, using insulation (insulating plates made of glass-fibre epoxy between the fixture base plate and the machine table, as well as insulating clamping jaw inserts). By design, this interrupts the unintentional current path via the frame and touchable external surfaces. In addition: define the earth cable connection point directly on the workpiece or at a designated location on the fixture that is not touchable by the operator, and integrate it by means of shaping (recess, cable routing channel) in such a way that incorrect positioning of the earth clamp is impeded by design.
Step 2 · Safeguarding and/or complementary protective measures	1. Welding power source: The welding power source has protection class I and degree of protection IP23S in accordance with EN IEC 60974-1; integration into the protective conductor chain of the overall installation shall be carried out in accordance with EN 60204-1:2018 section 8 (protective conductor cross-sections, connection points). 2. Monitoring of the earth connection: The earth current monitoring of the welding power source is activated; in the event of interruption or an impermissibly high contact resistance, the welding process is inhibited. The function is an operational interlock without a PL requirement (not a safety function within the meaning of EN ISO 13849-1:2023); no risk reduction is credited for it. 3. Equipotential bonding: All conductive parts of the fixture that are not deliberately insulated are included in the protective equipotential bonding of the installation (EN 60204-1:2018 section 8.2). 4. Access restriction during the welding process: The loading station is safeguarded by the light curtain (SF-02, PLr e in accordance with EN ISO 13849-1:2023); during active welding, access to the welding area is prevented by the interlocked maintenance door (SF-01, PLr d) and the enable logic of the turntable (SF-04, PLr e), so that contact with live parts in automatic mode is prevented by both design and control-engineering means. 5. Cable management: Welding cables and earth cables are routed in enclosed cable ducts or protective conduits (protection against mechanical damage); minimum bending radii as specified by the manufacturer shall be observed; cables shall be secured with strain relief.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the correct connection of the earth clamp (position, cleaning of the contact surface, permissible clamping areas); notice that touching the workpiece and the fixture during the welding process is prohibited; inspection intervals for insulation and cable condition (visual inspection every working day, six-monthly insulation measurement by an electrically skilled person, see Chapter 10.2). 2. Qualification requirement: Setting up, fault-finding and maintenance on the welding power source and its connections may only be carried out by an electrically skilled person or an electrically instructed person under the supervision of an electrically skilled person (terms as defined in EN 60204-1:2018 section 3.1). 3. Warning labelling on the fixture and in the welding area: Attach warning sign W012 'Warning; Electricity' in accordance with EN ISO 7010:2020 at a clearly visible location; attach a text sign 'Check earth clamp before commencing welding'. 4. PPE specification in the operating instructions: When setting up and fault-finding in the welding area, insulating gloves (protection class suitable for low voltage) and welding protective clothing shall be worn.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 14 Electrical — Risk before: S 4 · O 2 · **RS 8**

EMC interference between welding power source and safety controller (robot controller, light curtain evaluation unit, guard locking controller): high-frequency interference pulses from the MAG arc can influence safety functions and lead to spurious triggering or, more critically, to undetected failure of safety functions (EN ISO 11161).

Sub-machine: Overall installation (EMC interface) · also in: Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Spatial and galvanic separation of welding circuits from safety circuits by design specification: (1) Route the welding current return conductor as a dedicated return conductor close to the workpiece, directly back from the welding fixture, so that no large-area current loops are created that act as antennas. (2) Route welding current cables and safety signal/control cables in separate cable ducts with a minimum separation of 200 mm (separation distances in accordance with EN 50174-2 and EN 60204-1:2018 Annex H); crossings at right angles only. (3) Earth the welding power source and safety controller on separate equipotential bonding busbars connected with low impedance to the system protective conductor, in order to avoid common impedance paths. These measures reduce coupling at the source without requiring a protective device.
Step 2 · Safeguarding and/or complementary protective measures	For the remaining residual risk of conducted and radiated interference: (1) Execute all safety signal and control cables (light curtain SF-02, guard locking SF-01, rotary release SF-04, emergency stop SF-03) as screened cables; connect the screen at both ends with low impedance to the equipotential bonding busbar. (2) Use mains filters (interference suppression filters) at the supply feed of the safety controller and the light curtain evaluation unit, designed in accordance with EN IEC 61000-6-2:2019 (immunity requirements for industrial environments). (3) Install the robot controller, light curtain evaluation unit and guard locking controller only in control cabinets with continuous shielding (metal enclosures, EMC-compliant cable entries). (4) The safety controller and all components of safety functions SF-01 to SF-05 shall demonstrably comply with the immunity requirements of EN IEC 61000-6-2:2019 (the component manufacturers' evidence is on file). (5) Safety functions SF-01 (PLr d), SF-02 (PLr e), SF-03 (PLr d), SF-04 (PLr e) and SF-05 (PLr d) shall be validated in accordance with EN ISO 13849-1:2023 and EN ISO 13849-2:2012; the validation shall demonstrate the immunity of the SRP/CS in accordance with EN ISO 13849-1:2023 Annex L and the CCF measures (Annex F). (6) Welding power source: CE-marked equipment with an EU declaration of conformity that also covers the EMC Directive 2014/30/EU; emissions of the power source in accordance with EN IEC 60974-10 (EMC of arc welding equipment), emissions of the overall installation in accordance with EN IEC 61000-6-4:2019 (test report RSZ-2600-EMV-001). (7) Overall installation: carry out an EMC acceptance test in accordance with EN IEC 61000-6-2:2019 in the operating state with the welding process active, in order to verify the immunity of the safety functions under real operating conditions.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): (1) Note that modifications to cable routing (welding current cables, control cables) may only be carried out by qualified skilled personnel with EMC expertise. (2) Maintenance instruction: visual inspection of screen terminations, equipotential bonding connections and cable duct separation; inspection interval six months (see Chapter 10.2). (3) Note that after every replacement of the welding power source, robot controller or safety components, a renewed EMC functional check of the safety functions is required. (4) Qualification requirement: set-up personnel (operating mode Set-up, SF-05 active) shall be instructed in EMC-related fault patterns on safety controllers. (5) Marking on the control cabinet of the safety controller: text sign 'Change cable routing only in accordance with electrical circuit diagram RSZ-2600-EPL-001'.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 15 Thermal

Risk before: S 3 · O 4 · **RS 12**

Burn hazard from hot workpieces and weld seams: Freshly welded assemblies reach several hundred degrees Celsius in the seam area; serious burns may result from removal without suitable protective gloves or from contact with the seam.

Sub-machine: Loading station (removal side) · also in: Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: The operating principle of arc/gas-shielded welding necessarily requires heat input into the workpiece; the resulting seam temperature cannot physically be reduced to a safe level without suppressing the welding process itself. Substitution of the joining process (e.g. adhesive bonding, bolting) is not provided for and would not meet the product requirements. A geometric measure (distance from the seam by means of shaping) cannot be realised by design at the removal grip point, as the operator must grip the assembly.
Step 2 · Safeguarding and/or complementary protective measures	1. Forced cooling time: A control-side lockout period after the end of welding (timer in the system control), during which the release for removal at the loading station (removal side) remains locked. The lockout period is stored for each welding program; it depends on the workpiece geometry and the heat input. This function is not a safety function within the meaning of EN ISO 13849-1 (no PLr assigned), but a process-related interlock; it reduces the probability of occurrence but does not replace the obligation to use PPE. 2. Warning light / signalling device: Optical indicator (red signal light at the removal station) that is active during the cooling lockout period and extinguishes as soon as the release is granted. 3. Thermal shielding: The fixed dividing centre wall with welding curtain between the welding area and the removal station shields the operator from radiant heat (design in accordance with EN ISO 13732-1:2008 with regard to contact temperature limits as a design reference for surfaces that may be touched inadvertently).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Reference to the risk of burns from hot workpieces and weld seams; specification of the required cooling time before removal; obligation to wear heat-protective gloves (PPE Category II, suitable for contact heat in accordance with EN 407, performance level at least contact heat Level 3) and, where applicable, forearm protection. 2. Warning labelling at the removal station: Warning sign W017 'Warning; Hot surface' and mandatory sign M009 'Wear protective gloves' in accordance with EN ISO 7010:2020 to be affixed permanently and clearly visible at the loading station (removal side) ((EU) 2023/1230 Annex III, section 1.7.1). 3. Qualification and instruction: Operators and set-up personnel are to be instructed in the risk of burns, the cooling times and the obligation to use PPE before commencing work; the instruction is to be documented. 4. Provision of PPE: The operating instructions must instruct the user to provide suitable heat-protective gloves (EN 407) and to monitor their use.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) from hot workpieces. The heat input is inherent to the welding process and cannot be reduced to a harmless level, and the operator has to grip the assembly (step 1 exhausted). After step 2, the control system locks the removal for a cooling time stored for each welding program, the red signal light at the removal station indicates the lock, and the dividing centre wall shields the radiant heat. Waiting until the seam falls below the contact temperature limits in accordance with EN ISO 13732-1:2008 would considerably exceed the cycle time of around 90 seconds and defeat series production in accordance with the intended use; a further step 1 or step 2 measure is therefore not practicable. The remaining risk is touching seam areas that are still warm after the lockout period has elapsed, which results in a reversible burn. This is countered by heat protection gloves in accordance with EN 407, signs W017 and M009 on the removal side and the instruction of personnel (operating instructions chapters 2.4, 2.6 and 9.1).

No. 16 Thermal

Risk before: S 4 · O 3 · **RS 12**

Burn and fire hazard from welding spatter (flying sparks): During MAG welding, spatter is generated at temperatures above 1500 degrees C; it can land on combustible materials (packaging, oils, clothing) in the surrounding area and cause fires or burns.

Sub-machine: Welding robot / welding area · also in: Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Welding parameter optimisation to minimise spatter: Use of a low-spatter arc process (e.g. pulsed arc or CMT-type short arc) instead of the conventional short arc, to the extent permitted by the joining task. By specifically reducing the transferred spatter energy and quantity, the probability of ignition-capable spatter reaching combustible materials is reduced by design. Additionally: position the welding area such that no combustible operating materials (oils, lubricants, packaging) are stored or routed within the spatter protection radius of 1 m around the welding area. Lines carrying combustible media shall be routed out of the spatter area or provided with non-combustible shields.
Step 2 · Safeguarding and/or complementary protective measures	1. Guard: The welding area is enclosed by the safety fence with welding-light-opaque infill panels and welding protection viewing windows (EN ISO 14120:2015) and by the dividing centre wall of the turntable; the infill panels and the dividing centre wall are non-combustible and resistant to welding spatter. This enclosure prevents spatter from escaping into the general working area. Towards the loading station, the dividing centre wall of the turntable with its welding curtain in accordance with EN ISO 25980 shields the welding area. 2. Extraction system in the welding area: capture of welding fumes and particles directly at the point of origin in accordance with EN ISO 21904-1:2020, in order to extract glowing particles and reduce the thermal load on the surrounding area. 3. Secure the exclusion zone of 1 m around the safety fence: permanent yellow and black floor marking in accordance with the German workplace rule ASR A1.3 and, where possible, physical barriers; no storage or depositing areas within the zone. 4. Fire protection: provide a bracket for a fire extinguisher (CO2 or powder, no water due to the electrical installation) at the cell; provision and inspection of extinguishing agents are the responsibility of the user (note in the operating instructions, Step 3). 5. Safety functions: the maintenance door is integrated into the safety controller via SF-01 (PLr d) and the loading opening via SF-02 (PLr e); welding takes place only with the maintenance door closed and locked.
Step 3 · Information for use	1. Operating instructions (pursuant to (EU) 2023/1230 Annex III, section 1.7.4): Reference to the spatter protection radius and prohibition of storing combustible materials in the welding area. Specification of the permissible welding parameter ranges (current, voltage, wire feed) to minimise spatter. Instructions for the regular cleaning of spatter from machine surfaces and the welding area (reduction of fire load). Procedural instructions for the event of fire (alerting, first-response extinguishing, evacuation). 2. Warning signs on the safety fence in accordance with EN ISO 7010:2020: general warning sign W001 with the supplementary text 'Fire hazard from welding spatter'. 'Warning; Hot surface' (W017) in the welding area. Mandatory sign M010 'Wear protective clothing' at the maintenance door. 3. Qualification requirement: Set-up personnel and operators must be trained in the operation of the welding system and in the handling of fire protection equipment. Set-up personnel require a qualification as a welding specialist or equivalent documented instruction. 4. PPE specification: During set-up work in the welding area, the following PPE must be worn: flame-retardant welding protective clothing (in accordance with EN ISO 11611), welder's gloves (in accordance with EN 12477), welding face shield or welding helmet with a welding filter in accordance with EN ISO 16321-2 (formerly EN 169). In automatic mode with the maintenance door closed, no welder PPE is required; however, entering the welding area during operation is prohibited (operating instructions).

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 18 Radiation

Risk before: S 4 · O 3 · **RS 12**

Hazard from optical radiation of the MAG arc (UV, visible, IR): the arc emits intense ultraviolet, visible and infrared radiation; unprotected viewing of the arc (including through an open maintenance door in set-up mode) can cause eye injuries (keratoconjunctivitis, retinal damage) and skin burns.

Sub-machine: Welding robot / welding area · also in: Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the functional principle of MAG welding necessarily requires an open arc with high radiation intensity; current, voltage and arc energy cannot be reduced to a level at which the radiation hazard is eliminated without interrupting the welding process. Geometric relocation of the hazard point is not possible in a robot welding system with changing welding positions.
Step 2 · Safeguarding and/or complementary protective measures	1. Enclosure of the welding area: safety fence with welding-light-opaque infill panels and welding protection viewing windows as a fixed guard in accordance with EN ISO 14120:2015; infill panels and coating (matt black, light-absorbing surface) to be designed such that no relevant UV/IR reflection escapes to the outside. Viewing windows and welding curtains to be designed in accordance with EN ISO 25980. 2. Maintenance door: The maintenance door shall be equipped with guard locking in accordance with EN ISO 14119:2025 (interlock with guard locking, escape release in accordance with EN ISO 14119:2025 section 6.9.1). The safety function 'SF-01 Safe stop (stop category 1) upon opening of the maintenance door' shall be implemented with PLr d in accordance with EN ISO 13849-1:2023: the guard locking releases the door only once the arc has been extinguished and the robot is at a standstill; a safety distance in accordance with EN ISO 13855:2024 therefore does not have to be calculated. 3. Set-up mode with the maintenance door open: While the maintenance door is open, the welding power source is safely switched off via SF-01 (shutdown path of the safety PLC as for SF-03, PLr d in accordance with EN ISO 13849-1:2023), so that no arc can be ignited with the door open. The additional inhibit of the welding enable in the standard controller (welding enable only when the maintenance door is closed and locked) is an operational interlock without a PL requirement. The function 'SF-05 Safely reduced speed 250 mm/s with enabling device in set-up mode' (PLr d) applies to the movements of the robot and the turntable. With the maintenance door closed, the guard locking (SF-01) protects against arc radiation. 4. Radiation protection at the loading opening: the dividing centre wall of the turntable with its welding curtain in accordance with EN ISO 25980 shields the loading station, so that no direct radiation can reach the operator.
Step 3 · Information for use	1. Operating instructions: Note on the radiation hazard from the MAG arc (UV, visible, IR) in accordance with (EU) 2023/1230 Annex III, sections 1.7.4.1 and 1.7.4.2; statement that the welding power source is safely switched off via SF-01 while the maintenance door is open; description of the PPE requirements for set-up and maintenance activities in the vicinity of the welding area. 2. Qualification requirement: Set-up and maintenance personnel must have knowledge of the radiation hazard associated with arc welding; instruction in accordance with the German Occupational Safety Ordinance on Artificial Optical Radiation (OStrV) is to be identified in the operating instructions as a user obligation. 3. PPE specification: For activities where a residual risk from stray radiation (e.g. reflections during set-up in the immediate vicinity) cannot be completely excluded: welding goggles or welding face shield with a welding filter in accordance with EN ISO 16321-2 (formerly EN 169), UV-resistant protective clothing and protective gloves. 4. Warning labelling: Warning sign 'Warning; Optical radiation' (W027 in accordance with EN ISO 7010:2020) at the maintenance door and at the loading opening; mandatory signs 'Wear eye protection' (M004) and 'Wear protective clothing' (M010) in accordance with EN ISO 7010:2020 to be affixed at the maintenance door. 5. Emission data: Information on the optical radiation of the arc in the operating instructions in accordance with (EU) 2023/1230 Annex III, sections 1.5.10 and 1.7.4.2; the basis is the manufacturer's data for the welding power source and the assessment of radiation emission in accordance with EN 12198 (radiation from machinery).

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 19 Radiation

Risk before: S 4 · O 2 · **RS 8**

Hazard from electromagnetic fields (EMF) generated by the welding power source and the welding cables: High welding currents generate strong magnetic fields; persons with active implants (cardiac pacemakers, insulin pumps) may be endangered by the fields.

Sub-machine: Welding power source / welding cables · also in: Setting up, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Route and bundle the welding cables (current conductor and return conductor) so that the forward and return conductors are brought into close spatial proximity (twisted or parallel-routed cable pairs with minimum distance between them): The magnetic fields of both conductors partially cancel each other out, which significantly reduces the resultant field strength in the surrounding area. Keep cables as short as technically possible and avoid unnecessary coiling or routing in loops, as loops increase field strength. Install the welding power source at a distance from the loading station and the control desk.
Step 2 · Safeguarding and/or complementary protective measures	Secure access to the welding area (welding cell) during operation by means of the existing fixed guard (safety fence in accordance with EN ISO 14120:2015), so that persons cannot enter the immediate vicinity of the active welding cables during automatic operation. Design the maintenance door with guard locking in accordance with EN ISO 14119:2025 (SF-01, PLr d), which permits entry only after the welding current has been switched off. During set-up mode and during maintenance work in the vicinity of cables: switch off the welding current before entering the hazard zone and secure it against being switched on again (energy isolation and standstill in accordance with EN ISO 14118:2018). The welding cables run entirely inside the safety fence, so that persons outside the cell keep their distance from the active cables.
Step 3 · Information for use	Operating instructions: Explicit statement that operation of the welding machine generates strong electromagnetic fields. Persons with active or passive metallic implants (cardiac pacemakers, insulin pumps, cochlear implants, metal implants) must not enter the immediate vicinity of the welding cables and the welding power source. Before commencing set-up or maintenance activities in the vicinity of cables, the welding current must be switched off. Qualification requirement: Set-up and maintenance personnel must be instructed regarding the EMF hazard; persons with known implants must be excluded from activities in the immediate vicinity of active welding cables. Warning labelling: Attach the warning sign 'Warning; Magnetic field' (W006 in accordance with EN ISO 7010:2020) at the maintenance door, at the loading station and on the welding power source. Additionally, attach the prohibition sign 'No access for people with active implanted cardiac devices' (P007 in accordance with EN ISO 7010:2020) at the same locations. EMF emissions are to be described qualitatively in the operating instructions; the basis for assessment is the manufacturer's data for the welding power source in accordance with EN IEC 62822-2 (assessment of arc welding equipment with regard to EMF exposure of persons).

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 20 Materials/substances — Risk before: S 4 · O 4 · **RS 16**

Hazard from inhaling welding fumes and vapours (metal oxides, manganese, iron oxides): MAG welding of structural steel generates harmful particles and gases; when extraction is inadequate (saturated filter cartridge, system switched off), concentrations in the operator's breathing zone exceed the workplace exposure limits.

Sub-machine: Overall installation (extraction / welding area) · also in: Setting up, Maintenance, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Substitution of the welding consumable: Use of solid-wire electrodes with a demonstrably reduced manganese content (low-Mn alloy, e.g. Mn content < 1.0 % in accordance with the safety data sheet) instead of flux-cored wire electrodes or high-manganese wires, to the extent that the welding task (structural steel, weld quality) permits this. In addition: optimisation of welding parameters (arc voltage, wire feed speed, shielding gas composition) to a low-fume setting in accordance with the welding power source manufacturer's recommendation, in order to minimise fume generation at source. Both measures reduce the emitted pollutant mass and thereby the probability of a harmful exposure; the severity of the possible harm remains unchanged.
Step 2 · Safeguarding and/or complementary protective measures	Technical ventilation and extraction in accordance with EN ISO 21904-1:2020 (welding fume extraction): Capture of the welding fume by the capture hood above the welding area with a volumetric flow rate of 1800 m³/h, which ensures the capture velocity at the point of generation. The extraction system must be equipped with filter monitoring (differential-pressure switch) that triggers an alarm when the filter cartridge is saturated or the extraction is faulty; the cell stops in a controlled manner and can be restarted only after the fault has been rectified (operational interlock without a PL requirement under EN ISO 13849-1, no risk reduction is credited to it). Shielding of the welding area by the safety fence with welding-light-opaque infill panels (EN ISO 14120:2015) and the dividing centre wall of the turntable, in order to minimise fume escape into the operator area. Ambient air monitoring for welding fume concentration at the loading station is recommended as an additional measure by the user.
Step 3 · Information for use	Operating instructions (in accordance with (EU) 2023/1230 Annex III, section 1.7.4): Specification of the welding fume types emitted and reference to the workplace exposure limits to be observed in accordance with TRGS 900 and TRGS 528; instruction for regular inspection and replacement of filter cartridges (maintenance interval in accordance with manufacturer's specification EN ISO 21904-1:2020); prohibition of welding operation when the extraction system has failed or is switched off. Warning signs at the welding area: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Harmful welding fume' and mandatory sign 'Wear respiratory protection' (M017) as residual risk marking. PPE requirement: FFP3 particle filtering half mask in accordance with EN 149 or powered air-purifying respirator for set-up, maintenance and cleaning work in the welding area when the extraction system is switched off. Qualification requirement: operators and set-up personnel must be instructed in the hazards of welding fumes and the correct operation of the extraction system (TRGS 528 section 5).

Risk after: S 4 · O 2 · **RS 8 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 8 (S 4, O 2) from welding fumes. The severity results from the properties of the welding fumes (metal oxides, manganese) and remains unchanged; the MAG process is the purpose of the machine and cannot be substituted. In step 1, low-manganese solid wire, as far as the welding task permits, and low-fume parameters are provided. After step 2, the hood above the welding area captures the fumes at 1,800 m³/h, the cell stops in a controlled manner if the extraction is faulty or the filter cartridge is saturated (fault alarm threshold 1,400 m³/h), separation takes place in class W3, and the safety fence and dividing centre wall shield the loading station; capture, effectiveness and separation class have been tested. A complete enclosure is not possible because the loading opening has to remain open for manual loading, and the extraction is switched off during work in the welding area; no further step 1 or step 2 measure for this residual exposure has been identified. The remaining risk consists of residual emissions at the loading station and exposure during set-up, maintenance and cleaning work. FFP3 respiratory protection for this work, the prohibition of welding without effective extraction, filter maintenance and the user's obligations under TRGS 528 are stated in the operating instructions (chapters 1.2, 2.6, 9.1 and 10.2).

No. 21 Materials/substances — Risk before: S 4 · O 2 · **RS 8**

Hazard from shielding gas (argon-CO2 mixture M21) in the event of leakage: Argon and CO2 are heavier than air, so the shielding gas may accumulate near floor level; in the event of larger leakages in poorly ventilated areas, there is a risk of asphyxiation due to oxygen displacement.

Sub-machine: Shielding gas supply / piping system · also in: Maintenance, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Pressure limitation in the piping system: Limit the operating pressure of the shielding gas supply to the minimum level required for the welding process (pressure regulator at the supply connection of the cell). A lower system pressure reduces the quantity of gas escaping in the event of a fault and thus the potential for accumulation. Additionally: design the pipe routing and connection points so that leakages are minimised by design: use of cutting ring fittings or press fittings instead of hose clamps on fixed pipe sections; reduce hose lengths to the minimum operationally necessary; no routing of pipes near floor level in pits or enclosed chambers (route near the ceiling where possible). These measures address the energy source (stored pressurised gas) and the hazard location (accumulation zone) directly.
Step 2 · Safeguarding and/or complementary protective measures	1. Automatic shut-off of the gas supply: Solenoid valve (de-energised closed) in the shielding gas supply line, which automatically shuts off the gas supply upon machine stop, emergency stop (SF-03) and during operating pauses; additionally, a manual shut-off valve outside the cell. 2. Leak monitoring: Plausibility check of gas consumption via the machine control system (indication when gas flow occurs without an active welding process, as a leakage indicator); daily visual inspection of hose connections as a maintenance requirement. 3. Installation of the shielding gas supply provided on site (cylinder bank or withdrawal station) in a ventilated area of the hall, not in pits, basements or confined recesses. If installed in poorly ventilated areas, the user is required to provide an oxygen warning device (note in the operating instructions). A safety function with a PLr requirement is not necessary for this hazard; the risk is controlled by means of shut-off, installation location and ventilation.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Note on the risk of asphyxiation due to oxygen displacement in the event of larger leaks in poorly ventilated areas; requirement for adequate hall ventilation at the installation site; work on the gas supply only with the line shut off and depressurised (EN ISO 14118:2018). 2. Qualification: Work on compressed gas lines and fittings only by instructed specialist personnel; instruction in accordance with DGUV Rule 100-500 Chapter 2.26 and TRGS 528 (user's obligation). 3. Warning labelling: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Risk of asphyxiation from shielding gas' at the gas supply installation site; supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006) on locked supply areas. 4. When working in confined or poorly ventilated areas (e.g. cylinder changes in recesses): use a portable oxygen warning device; no lone working.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 24 Noise — Risk before: S 4 · O 4 · **RS 16**

Hazard from noise during the MAG welding process and from the turntable drive: The welding process (arc noise, spatter) and mechanical drives generate relevant sound pressure levels at the loading station; during continuous operation (two-shift operation, 16 h), the daily noise exposure level LEX,8h may reach or exceed the action values of the German Noise and Vibration Occupational Safety and Health Ordinance (LärmVibrationsArbSchV).

Sub-machine: Overall installation (welding area / turntable) · also in: Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Noise reduction at source by design measures in accordance with EN ISO 11688-1: (1) Welding process optimisation: selection of low-emission welding parameters (pulsed arc instead of short arc where technically feasible in terms of the process), as the short arc generates higher spatter and noise emissions. (2) Drive encapsulation and structure-borne noise isolation of the turntable drive: elastic mounting of the drive motor and gearbox on the machine frame in order to reduce structure-borne noise transmission to radiating surfaces. (3) Machine frame using sound-absorbing or damped profiles (e.g. sheet metal cladding lined with bituminous damping mats) instead of undamped steel sheet surfaces, in order to reduce sound radiation. Measurement and declaration of noise emission values will be carried out in Step 2 and Step 3.
Step 2 · Safeguarding and/or complementary protective measures	(1) Acoustic shielding of the welding area by the dividing centre wall of the turntable and the closed infill panels of the safety fence between the welding area and the loading station. (2) Encapsulation or cladding of the turntable drive with sound-absorbing material, provided that maintenance accessibility is ensured (cladding to be designed as a guard in accordance with EN ISO 14120:2015). (3) Noise measurement at the loading station in accordance with EN ISO 11202:2010 under representative operating conditions (automatic mode, MAG welding active, turntable in operation) in order to determine the emission sound pressure level LpA (measured: 84 dB(A), K = 2.5 dB). The daily noise exposure level LEX,8h is determined by the user in accordance with the German Noise and Vibration Occupational Safety and Health Ordinance (LärmVibrationsArbSchV). Note: No safety function in accordance with EN ISO 13849-1 is affected; PLr determination does not apply to this hazard.
Step 3 · Information for use	(1) Operating instructions (MR (EU) 2023/1230 Annex III, section 1.7.4.2, point (u)): Statement of the measured emission sound pressure level LpA at the loading station in accordance with EN ISO 11202:2010 and EN ISO 4871:2009 (with measurement uncertainty K); where LpA exceeds 80 dB(A), additional statement of the sound power level LWA in accordance with EN ISO 3746:2010. Note on the user's obligations under the German Noise and Vibration Occupational Safety and Health Ordinance (LärmVibrationsArbSchV): risk assessment, noise reduction programme from the upper action value LEX,8h 85 dB(A), obligation to provide hearing protection from 80 dB(A), obligation to wear hearing protection from 85 dB(A). (2) Warning labelling at the loading station: Mandatory sign 'Wear ear protection' (M003 in accordance with EN ISO 7010:2020), to be affixed in a clearly visible location. (3) Qualification and instruction: Operating personnel are to be instructed by the user on the noise hazard, the action values and the correct use of hearing protection. (4) PPE specification: Suitable hearing protection (earmuffs or earplugs) with a sufficient attenuation value (SNR) corresponding to the LEX,8h determined by the user is to be provided by the user; selection in accordance with EN 458.

Risk after: S 4 · O 2 · **RS 8 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 8 (S 4, O 2) from noise; severity 4 because noise-induced hearing loss is irreversible. The arc noise originates in the welding process itself; in step 1, low-emission welding parameters, structure-borne noise isolation of the turntable drive and damped cladding are provided. After step 2, the centre wall and the closed fence infill panels shield the loading station, and the drive is clad. The measured values at the loading station are LpA = 84 dB(A) with K = 2.5 dB in accordance with EN ISO 11202:2010 and LWA = 96 dB(A) in accordance with EN ISO 3746:2010. The loading opening towards the operator has to remain open, so further enclosure on this side is not possible, and the arc noise cannot be reduced further without changing the process; a further step 1 or step 2 measure is not practicable. The daily noise exposure level is determined by the user's work organisation. The noise emission declaration in accordance with EN ISO 4871:2009, the obligations regarding hearing protection from 80 and 85 dB(A) and sign M003 are stated in the operating instructions (chapters 2.4 and 3).

No. 27 Ergonomic

Risk before: S 2 · O 3 · **RS 6**

Insufficient lighting at the loading station and in the maintenance aisle: inadequate illuminance makes it difficult to load and unload workpieces safely and to carry out maintenance work, and increases the risk of errors and accidents.

Sub-machine: Loading station / maintenance aisle · also in: Setting up, Maintenance, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Machine-integrated workplace lighting at the loading station and in the maintenance aisle to be provided as part of the design: luminaires are permanently integrated into the machine structure (built into the frame of the safety fence) so that the illuminance at the loading station and in the maintenance aisle is permanently ensured independently of the hall lighting. The design is carried out in accordance with EN ISO 12100:2010 section 6.2.8 (ergonomics) in conjunction with EN 1837 (machine-integrated lighting); the lighting as built provides 500 lx at the loading station, 200 lx in the maintenance aisle. The integration into the design eliminates dependence on external lighting sources that may be inadequate.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk from failure or shadowing of the integrated luminaires: monitoring of the operational readiness of the workplace lighting by the machine control system (notification in the event of lamp failure). In addition, maintenance aisle areas to be marked with retroreflective yellow and black floor markings in accordance with the German workplace rule ASR A1.3 (trip hazards, aisle boundaries) and with the warning sign W007 'Warning; Floor-level obstacle' in accordance with EN ISO 7010:2020 at trip hazards. A safety function within the meaning of EN ISO 13849-1 is not required for lighting monitoring; in the event of a lighting failure, work is to be discontinued (Step 3).
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): specification of the illuminance of the workplace lighting: 500 lx at the loading station and 200 lx in the maintenance aisle; notice that work is to be discontinued in the event of failure of the integrated lighting until the lighting has been restored. Text sign on the maintenance door: 'Stop work if the lighting fails'. Qualification requirement: maintenance personnel must be instructed in checking the lighting function before commencing work. Use suitable portable luminaires for brief inspections in the event of a lighting failure; resume regular work only after the lighting has been restored.

Risk after: S 2 · O 1 · **RS 2 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 31 Combination — Risk before: S 5 · O 2 · **RS 10**

Hazard from differing safety levels of the sub-machines from different manufacturers (robot, welding power source, turntable, extraction system): missing or incomplete interface interlocking between the sub-machines may result in one sub-machine starting up even though another is in an unsafe condition (EN ISO 11161).

Sub-machine: Overall installation (system integration) · also in: Commissioning, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	System architecture with a single, higher-level safety controller (Safety Master) as an inherently safe control principle in accordance with EN ISO 12100 section 6.2.11: All safety-relevant status signals of the sub-machines (robot operating mode, turntable end position, extraction system operation, welding power source ready) are routed exclusively via the safety controller. No sub-machine drive receives an enable signal unless the safety controller has assessed the overall state as safe. Through this centralisation, the possibility of an incomplete interface interlock is reduced to a minimum by design: there are no parallel, mutually independent enable paths between the sub-machines. The interface definition is carried out in accordance with EN ISO 11161:2007+A1:2010 (system integration, responsibilities, interface description) and is documented in the safety concept of the overall installation.
Step 2 · Safeguarding and/or complementary protective measures	1. Interlock matrix in accordance with EN ISO 11161:2007+A1:2010: For each sub-machine combination, a complete state matrix (operating mode x state of the other sub-machines) is created and implemented in the safety controller. Each enable signal is implemented as an AND-combination of all relevant safety states. 2. Safety function SF-04 (enable of the 180-degree rotary movement of the turntable only when the rotation range is clear, PLr e) ensures that the turntable only rotates when the protective field of the light curtain is clear, the clamps are closed and the robot is demonstrably outside the rotation range. The safety function is designed to PLr e in accordance with EN ISO 13849-1:2023 and validated in accordance with EN ISO 13849-2:2012. 3. Safety function SF-01 (safe stopping upon opening of the maintenance door, stop category 1, PLr d) and SF-02 (safe stopping upon interruption of the light curtain, PLr e) are coordinated across the overall installation: a stop signal from one sub-machine triggers the coordinated stop of all sub-machines via the safety controller. Stop category 1 in accordance with EN 60204-1:2018 section 9.2.2 applies to the robot and the turntable. 4. Emergency stop of the overall installation (SF-03, stop category 1, PLr d) in accordance with EN ISO 13850:2015 acts on all sub-machines simultaneously via the safety controller. Emergency stop devices are arranged at the control desk, at the maintenance door and on the teach pendant. 5. Prevention of unexpected start-up in accordance with EN ISO 14118:2018: After every stop (emergency stop, activation of a protective device, interruption of energy supply), a deliberate restart command is required; automatic restart is excluded. 6. Set-up mode with safely reduced speed (SF-05, 250 mm/s, PLr d) and enabling device in accordance with EN ISO 10218-2:2025 section 5.7.7; in this mode, the robot and the turntable move only with the enabling device actuated and at safely reduced speed, and the welding power source is safely switched off via SF-01 while the maintenance door is open.
Step 3 · Information for use	Operating instructions for the overall installation in accordance with (EU) 2023/1230 Annex III, section 1.7.4: The interface interlock logic (state matrix, enable conditions per sub-machine) is to be documented in full. For each sub-machine, the handover point of safety responsibility (sub-machine manufacturer up to the interface, integrator from the interface onwards) is defined in writing in the safety concept of the overall installation in accordance with EN ISO 11161:2007+A1:2010 and is to be stated in the operating instructions. Qualification requirement: commissioning, parameterisation and modifications to the safety controller may only be carried out by qualified specialist personnel with knowledge of EN ISO 13849-1:2023 and EN ISO 11161. Warning labelling at the control desk: warning sign 'Warning; Automatic start-up' (W018 in accordance with EN ISO 7010:2020). The operating instructions must describe procedures for fault-finding and commissioning, including the sequence in which sub-machines may be commissioned and the verification steps for checking the interface interlock prior to the first automatic operation.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) at the interfaces of sub-machines from different manufacturers. The robot (partly completed machinery with declaration of incorporation), welding power source and extraction unit have their own control systems, and their integration requires a higher-level logic. In step 1, all safety-relevant states are routed through a single safety PLC without parallel enabling paths. After step 2, an interlocking matrix of all operating modes and states is implemented as an AND logic, SF-01 to SF-05 act across the entire installation, every stop leads to a coordinated stop of all sub-machines, and validation is carried out in accordance with EN ISO 13849-2:2012 and EN ISO 11161:2007+A1:2010. The remaining risk is a systematic error in the specification of the matrix that remains undetected during validation. The internal safety of the purchased sub-machines is the responsibility of their respective manufacturers; at the interfaces for which the manufacturer of the assembly is responsible, no further step 1 or step 2 measure beyond the central interlocking and its validation has been identified. Transfer points of responsibility, commissioning sequence and test steps of the interface interlocking: operating instructions chapters 1.1, 2.6 and 8.3.

No. 32 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Hazard from reaching over or under the light curtain at the loading station (reasonably foreseeable misuse): Persons reach around the side of the light curtain or under the light curtain into the rotation range without the protective function being triggered; the turntable or the robot may start up and trap hands or arms.

Sub-machine: Loading station (light curtain interface) · also in: Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: The loading station requires a permanently open access opening for manual workpiece infeed. Complete geometric closure of this opening by design would render the machine non-functional. Minimum distances in accordance with EN ISO 13854:2019 cannot, as a design measure, prevent lateral bypassing of a light curtain as long as the opening must remain available for operator access. Limitation of force or energy at the turntable or robot to a non-hazardous level (Step 1) is not technically feasible at the masses and torques involved without impairing the function.
Step 2 · Safeguarding and/or complementary protective measures	1. Protective field and under-reach guarding: Position the light curtain (Type 4 in accordance with EN IEC 61496-1:2020, SF-02, PLr e) such that the protective field covers the loading opening completely. Remaining openings below and beside the protective field are closed with fixed guards (EN ISO 14120:2015) in accordance with EN ISO 13857:2019 Table 4, so that reaching under or around the protective field is not possible. 2. Lateral flank guarding: Fixed guards (side panels or channel guides) in accordance with EN ISO 14120:2015 must be fitted on both sides of the light curtain to prevent lateral bypassing by design. The depth of these flanks must be determined in accordance with EN ISO 13857:2019 Table 4 (safety distance as a function of the opening size) so that the hazard zone cannot be reached from the lateral direction. 3. Light curtain specification: The light curtain must be selected as Type 4 in accordance with EN IEC 61496-1:2020 and integrated into safety function SF-02 (PLr e). The safety distance between the light curtain and the nearest hazard zone must be calculated and maintained in accordance with EN ISO 13855:2024 (reaching through, resolution 30 mm for hand detection). Integration into the control system is carried out in accordance with EN ISO 13849-1:2023, PLr e (SF-02).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Explicit statement that lateral bypassing or reaching under the light curtain is prohibited and overrides safety function SF-02. Description of the correct loading action (insert workpiece from the front through the light curtain). Note on the hazard posed by the turntable and the robot when the protective function has not been triggered. 2. Warning signs (EN ISO 7010:2020): 'Warning; Crushing of hands' (W024) to be affixed on both sides of the flank panels and on the light curtain frame. Prohibition sign 'No reaching in' (P015) at the access opening. 3. Qualification requirement: In set-up mode (SF-05, PLr d, safely reduced speed 250 mm/s with enabling device) only instructed specialist personnel who are familiar with the function and limitations of the light curtain may work. This requirement must be recorded in the operating instructions and in the instruction documentation. 4. PPE: Protective gloves provide no protection against crushing and entanglement hazards from the turntable or robot and are not suitable as a protective measure for this hazard. This notice must be included in the operating instructions to avoid incorrect assumptions.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to reaching around or under the light curtain. The loading opening has to be permanently open for loading in a cycle of around 90 seconds, and limiting the force or energy of turntable and robot is not feasible (step 1). After step 2, a type 4 light curtain with 30 mm resolution (SF-02, PL e, category 4) covers the opening without muting, the flanks and openings below and beside the protective field are closed by fixed guards in accordance with EN ISO 13857:2019 Table 4, and the safety distance is calculated in accordance with EN ISO 13855:2024; the measured overrun distance of the turntable of 45 mm is below the permissible value of 60 mm. A movable guard at the opening would have to open and close in every cycle and would create its own crushing point at the closing edge; it does not reduce the risk compared with the solution implemented. The remaining risk is deliberate bridging, for example by taping over the protective field. The prohibition, the daily check with the test rod, signs W024 and P015 at the opening and the note that gloves do not protect against crushing are stated in the operating instructions (chapters 2.2, 2.4, 9.1 and 9.4).

No. 34 Thermal

Risk before: S 3 · O 3 · **RS 9**

Fire hazard in the welding fume extraction system (filter fire): Sparks and glowing particles drawn in by the process can accumulate in the filter cartridge and ignite a smouldering fire or filter fire, including in a time-delayed manner after the end of a shift. Fire smoke can spread via the pipework system and the air recirculation into the hall.

Sub-machine: Welding fume extraction (filter unit) · also in: Maintenance

Step 1 · Inherently safe design measures	Spark reduction at the point of origin through the design of the welding parameters and the extraction geometry: Design the capture hood above the welding area and the duct routing so that sparks drawn in have cooled before they reach the filter cartridge. In addition, provide a pre-spark separator (baffle plate/cyclone separator) as an integrated component directly upstream of the filter cartridge, which separates coarse particles and sparks by inertia before they come into contact with the filter medium. This component is an integral part of the extraction system design, not a downstream protective device. Design in accordance with EN ISO 21904-1:2020 (requirements for welding fume extraction systems).
Step 2 · Safeguarding and/or complementary protective measures	The remaining residual risk of a filter fire is limited by the following technical protective measures: 1. Thermal monitoring of the filter cartridge: temperature sensor (thermostat or thermocouple) in the filter housing with a trigger threshold; upon exceedance, automatic shutdown of the extraction fan and closing of a motorised shut-off damper in the pipework system to prevent the supply of oxygen. Integration into the machine control system as an operational interlock without a PL requirement under EN ISO 13849-1, no risk reduction is credited to it; the cell stops in a controlled manner and can be restarted only after the fault has been rectified. 2. Extinguishing device at the filter housing: at least one closable extinguishing agent inlet opening (extinguishing lance) on the housing; an automatic extinguishing device is not part of the scope of supply and, if required, is added by the user in line with the user's fire protection concept. 3. Motorised shut-off damper in the air recirculation duct to the hall: automatic closure upon fire alarm to prevent the spread of smoke into the hall. Integration into the machine control system as an operational interlock without a PL requirement. 4. Smoke and CO detectors in the filter housing and in the exhaust air duct as a redundant detection level, with alarm forwarding to a permanently staffed location or to a fire alarm control panel (user's responsibility, to be agreed with the building fire protection concept). 5. Run-on time of the extraction fan after the end of welding: program a minimum run-on time of 10 minutes at the control system level so that glowing particles still present in the pipework are fully transported into the separator and cooled before the system is shut down. Design of the run-on time based on the pipework length and the volumetric flow rate.
Step 3 · Information for use	Operating instructions (in accordance with (EU) 2023/1230 Annex III, section 1.7.4): - Reference to the fire hazard from sparks and glowing particles in the filter system; description of the damage mechanism including time-delayed ignition. - The prescribed run-on time of the extraction fan after the end of welding (minimum value from the design) as a binding operating instruction. - Maintenance intervals for filter cartridges, pre-spark separators and temperature sensors; specification of the loading level at which the filter cartridge is to be replaced (manufacturer's specification EN ISO 21904-1:2020). - Prohibition on operating the extraction system with a defective temperature sensor or an ineffective shut-off damper. - Procedure in the event of a fire alarm: vacate the installation immediately, alert the fire brigade, do not attempt to deal with the filter housing independently (opening it can fan a smouldering fire). - Note that after the end of a shift, a visual inspection of the filter housing (temperature, odour) is to be carried out before the building is vacated. Warning labelling on the extraction system: - General warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Fire hazard from sparks in the filter' on the filter housing and maintenance opening. - Text sign 'Do not open in the event of a fire alarm' on the maintenance flap of the filter housing. Qualification and instruction: - Operating personnel and maintenance personnel are to be instructed before commencing work and thereafter at least annually on the fire hazard, the function of the protective devices and the correct behaviour in the event of a fire (user's obligation). - Maintenance work on the filter system only by instructed personnel wearing appropriate PPE (protective gloves, and where applicable respiratory protection during filter replacement due to welding fume exposure).

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 35 Ergonomic

Risk before: S 3 · O 5 · **RS 15**

Hazard from constrained postures and repetitive movements during loading and unloading of workpieces: The operator repeatedly performs gripping, lifting and clamping movements at a cycle of approximately 90 seconds; unfavourable body postures (bending, stretching) with varying workpiece geometries place strain on the spine, shoulders and wrists.

Sub-machine: Loading station

Step 1 · Inherently safe design measures	Height-adjustable loading station (height-adjustable standing platform for the operator), designed for the body height range P5 to P95 of the operating population in accordance with EN ISO 14738:2008 and EN 1005-4 (working height for assembly/handling: approximately 900 to 1100 mm above standing surface, individually adjustable). Design the workpiece carrier or clamping fixture so that all gripping points are within the recommended gripping zone (elbow height ±150 mm, horizontal reach max. 400 mm in front of the body), without bending or stretching. Workpiece weight and handling frequency have been assessed using the reference mass in accordance with EN 1005-2:2003+A1:2008: for around 40 lifts per hour, the manufacturer has set a threshold of 15 kg for manual handling; heavier workpieces of up to 40 kg are loaded using a lifting aid. Design the grip geometry of the clamping fixture for a neutral wrist position (no ulnar/radial deviation, no forced pronation) in accordance with EN ISO 12100:2010 section 6.2.8.
Step 2 · Safeguarding and/or complementary protective measures	For workpieces over 15 kg, a lifting aid (balancer, vacuum lifter or slewing jib crane) with a load capacity of at least 40 kg must be used at the loading station. The lifting aid is provided on site by the user and is not part of the scope of supply; the clearance required for its use is provided at the loading station. The machine control system does not impose a forced cycle: the next cycle starts only when the operator presses the cycle start pushbutton, so that micro-breaks are possible. Ensure illumination at the loading station of at least 500 lx (visual task: workpiece positioning) in order to avoid poor postures caused by inadequate visibility.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Specification of the workpiece mass/masses, of the assessment of manual handling of loads in accordance with EN 1005-2:2003+A1:2008 and of working postures in accordance with EN 1005-4; instructions on the correct adjustment of the working height with a setting guide. Ergonomic instruction for operators: correct lifting technique, use of the lifting aid, recognition of overload signals. Reference in the operating instructions to the user's obligation regarding occupational health surveillance in accordance with the German Ordinance on Occupational Health Care (ArbMedVV), that is, the offer of health surveillance for activities involving heavy physical work. Warning labelling at the loading station: text sign 'Manual handling up to 15 kg only, use the lifting aid above this'. Qualification requirement: Operators must be instructed in ergonomically correct operation and in the adjustment of the standing platform.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) from repeated gripping, lifting and clamping movements. Manual loading and unloading in a cycle of around 90 seconds is the intended task. In step 1, the working height can be adjusted via the standing platform for body heights P5 to P95, the gripping points are at elbow height, the handles are designed for a neutral wrist position, and manual handling is limited to 15 kg. After step 2, the lifting aid is available for heavier parts, the control system does not impose a forced cycle (start by the operator, micro-breaks possible), and the workstation is lit with 500 lx. The remaining load depends on shift length, breaks and job rotation, i.e. on the user's work organisation. A further step 1 or step 2 measure would only be effective with automatic loading, which would defeat the concept of the machine. Adjustment of the platform, ergonomic instruction and the note on occupational health care are part of the information for use (operating instructions chapters 2.6, 4.2 and 9.4).

No. 36 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Manipulation of safety-relevant parameters via the network: Unauthorised write access via fieldbus, OPC UA or MES interface alters safety-relevant parameters (e.g. monitoring of the maintenance door, parameters of the light curtain, speed limit in set-up mode). The protective function becomes ineffective or the machine operates outside the limits defined in the risk assessment. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 1, 1.1.9 para. 3, 1.2.1 lit. a, 1.2.1 lit. d]

Sub-machine: Control / network · also in: Setting up

Step 1 · Inherently safe design measures	Safety-relevant parameters are to be held only in the safety controller and must not be writable via the process network under any circumstances (write access physically or architecturally separated, safety network segmented from standard communication). Limit values derived from the risk assessment are to be stored as constants in the safety program, not as recipe data.
Step 2 · Safeguarding and/or complementary protective measures	Authentication and authorisation for every write access (roles, no default passwords), integrity checking of safety-relevant configuration (checksum/CRC with release procedure), plausibility checking of incoming values against the permissible limits, logging of every parameter change with timestamp and user. Evidence reference route B: IEC 62443-3-3 SR 1.1, SR 2.1, SR 3.4, SR 3.5, SR 5.1, SR 2.8.
Step 3 · Information for use	Operating instructions: network requirements for the user (segmentation, firewall, no direct internet connection of the controller), list of safety-relevant parameters with a note that changes are only permissible by authorised personnel and with a subsequent functional check of the safety functions.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 37 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Unintentional corruption through misconfiguration or operator error: Incorrect recipe or parameter file loaded, roles and passwords not set up (default password active), configuration incompletely restored after a fault. Safety-relevant settings deviate from the approved configuration without being noticed. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 3, 1.2.1 lit. b, 1.2.1 lit. d, 1.2.1 lit. e]

Sub-machine: HMI / parameterisation · also in: Setting up, Commissioning

Step 1 · Inherently safe design measures	Separate safety-relevant settings from process recipes so that a recipe change cannot alter them; hard-limit value ranges in the safety controller (limits derived from the risk assessment, Annex III, section 1.2.1, point (d)).
Step 2 · Safeguarding and/or complementary protective measures	Forced password change on commissioning, role model with dual-control approval for safety-relevant changes, comparison of the active configuration with the approved reference (checksum) at start-up with display of any deviation, change log. Evidence reference route B: IEC 62443-3-3 SR 1.5, SR 2.1, SR 3.4, SR 7.6.
Step 3 · Information for use	Operating instructions: commissioning checklist (passwords, roles, saving of reference configuration), description of the data designated as safety-relevant, instruction for functional testing after configuration changes.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 38 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Failure or disruption of the communication network connection: Network failure, overload (broadcast storm, denial of service), cable break or change of network segment interrupts communication between control components or the safety-oriented communication (PROFIsafe). Upon restoration, an unexpected start-up occurs or outdated setpoint values are taken over in an uncontrolled manner. [MR (EU) 2023/1230 Annex III No. 1.2.6, 1.2.1 lit. a, 1.2.3]

Sub-machine: Communication network · also in: Commissioning

Step 1 · Inherently safe design measures	Design safety functions such that loss of communication leads to the safe state (watchdog, time monitoring of safe telegrams) and a restart only takes place after a deliberate acknowledgement (Annex III, section 1.2.3). Decouple safety-directed communication from standard communication.
Step 2 · Safeguarding and/or complementary protective measures	Network segmentation and load limiting (rate limiting, storm protection at switches), monitoring of network quality with diagnostic message, defined behaviour upon loss of connection in all operating modes tested and documented. Evidence reference route B: IEC 62443-3-3 SR 7.1, SR 7.2, SR 5.1, SR 5.2.
Step 3 · Information for use	Operating instructions: requirements for the user's network (segmentation, permitted participants, no external devices in the safety segment), description of the behaviour upon communication failure and the restart procedure.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 39 Corruption/security — Risk before: S 4 · O 2 · **RS 8**

Connection of external devices creates a hazardous situation: A connected external device (the user's higher-level line control system or MES, remote maintenance gateway, user-side signals from the extraction system or the gas supply) sends unexpected signals, writes to control variables or occupies resources. The machine starts, changes the operating mode or ignores stop conditions because the functions of the external device were not taken into account in the risk assessment. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 1, 1.2.1 lit. h, 1.2.4.4]

Sub-machine: Interfaces to third-party equipment · also in: Assembly, Commissioning

Step 1 · Inherently safe design measures	Design interfaces to external devices as defined signal interfaces with specified semantics (no enabling of movements by external signals alone), route safety-relevant signals only via safe inputs/outputs, assign the stop and emergency stop chain of the external device unambiguously.
Step 2 · Safeguarding and/or complementary protective measures	Whitelist of approved participants and variables, plausibility check of incoming commands, interlock of operating mode changes via external interfaces, diagnostics for missing or unknown participants. Evidence reference route B: IEC 62443-3-3 SR 1.2, SR 2.1, SR 3.5, SR 5.2, SR 7.7.
Step 3 · Information for use	Operating instructions and interface description for the integrator (signals, states, requirements for the assembly of machinery in accordance with Annex III, section 1.2.4.4), note that the connection of non-approved devices requires a new risk assessment.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 40 Corruption/security — Risk before: S 3 · O 3 · **RS 9**

Safety-relevant software not identifiable or labelled: The version status and checksum of the safety software cannot be retrieved at the machine, and safety-relevant software and data are not designated as such. After an intervention, update or device replacement, it cannot be determined whether the machine is still in the inspected state; operation with non-approved software remains undetected. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 3, 1.1.9 para. 4, 1.7.4.2]

Sub-machine: Software / Documentation · also in: Commissioning, Maintenance

Step 1 · Inherently safe design measures	Design safety-relevant software as a distinct unit with its own version number and checksum (separate from standard and visualisation software) so that unambiguous identification is technically possible.
Step 2 · Safeguarding and/or complementary protective measures	Information page on the HMI showing the version and checksum of all safety-relevant software components (always easily accessible without login, Annex III, section 1.1.9, fourth paragraph), labelling of safety-relevant data in file names, menus and exports, comparison with the acceptance report at start-up. Evidence reference route B: IEC 62443-3-3 SR 3.4.
Step 3 · Information for use	Operating instructions: list of safety-relevant software and data with versions (Annex III, section 1.7.4.2), instructions for retrieving version information, note on the significance for conformity and on the obligation to report deviations.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 41 Corruption/security — Risk before: S 3 · O 3 · **RS 9**

Missing or incomplete records of interventions (logging): Interventions in safety-relevant hardware, software or configuration are not recorded, or are recorded without a timestamp and originator; logs overwrite themselves after a short period or are open to manipulation. Unauthorised interventions remain undetected and the audit trail is not available upon request by the authorities. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 2, 1.1.9 para. 5, 1.2.1 lit. f]

Sub-machine: Control / logging · also in: Maintenance, Troubleshooting

Step 1 · Inherently safe design measures	Provide event logging as a fixed function of the control system (not deactivatable by the operator), with a non-volatile memory of sufficient capacity.
Step 2 · Safeguarding and/or complementary protective measures	Logging of safety-relevant events with timestamp, user identity and content of the change (log-on, parameter and configuration change, software upload with version and checksum, opening of safety-relevant assemblies, remote-access sessions), protection against deletion and modification, export in readable form, retention of uploads and associated data for up to five years after uploading (Annex III, section 1.2.1, point (f)). Evidence reference route B: IEC 62443-3-3 SR 2.8, SR 2.9, SR 2.11, SR 3.9, SR 6.1.
Step 3 · Information for use	Operating instructions: Access to and export of logs, user's retention obligations when the machine is transferred, procedure in the event of a regulatory request, note on storage capacity and time synchronisation.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 42 Corruption/security — Risk before: S 3 · O 3 · **RS 9**

Falsified production or recipe data from MES or cloud: Order and recipe data taken from MES, ERP or cloud platform (e.g. welding parameters, program number or workpiece assignment) are falsified, outdated or intended for the wrong machine. The machine operates with specifications outside the safe limits or with an incorrect workpiece and program reference. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 3, 1.2.1 lit. b, 1.2.1 lit. d]

Sub-machine: MES / cloud data connection

Step 1 · Inherently safe design measures	Limit safety boundaries independently of transferred recipe data in the safety controller; recipe data shall control process parameters only within these limits (Annex III, section 1.2.1, point (d)).
Step 2 · Safeguarding and/or complementary protective measures	Integrity and origin verification of transferred data sets (signature or checksum, machine and tool assignment), plausibility check against permissible ranges with rejection and notification, release step by authorised personnel for new recipes, log of transferred data sets. Evidence reference route B: IEC 62443-3-3 SR 3.1, SR 3.4, SR 3.5, SR 1.2.
Step 3 · Information for use	Operating instructions: responsibility of the user for data quality, description of the checks and notifications, instructions in the event of rejected data sets.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 44 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Unauthorised or faulty remote access via the remote maintenance gateway: Via the IPsec VPN connection of the remote maintenance gateway, an unauthorised person with stolen credentials or an authorised technician at the wrong moment intervenes in the cell controller: program or parameter change, acknowledgement of faults or starting of movements while persons are at the loading station or in the maintenance aisle. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 1, 1.1.9 para. 3, 1.2.1 lit. a, 1.2.1 lit. d]

Sub-machine: Remote maintenance gateway / cell controller · also in: Maintenance, Troubleshooting

Step 1 · Inherently safe design measures	Remote access designed so that it cannot trigger hazardous movements or bypass safety functions: the remote maintenance gateway only reaches the standard controller and the HMI panel; the safety PLC has no remote access path. Movement commands and acknowledgement of faults are only possible from control positions with a view of the hazard zone (Annex III, section 1.2.2).
Step 2 · Safeguarding and/or complementary protective measures	Remote maintenance disabled on delivery; a session can only be enabled on site with the key switch at the control desk, ends automatically after four hours and is indicated as "Remote maintenance active" on the HMI panel; IPsec VPN with multi-factor authentication and personal accounts for remote technicians; logging of every session with user, time and actions performed, retention in accordance with Annex III, section 1.2.1, point (f). Evidence reference route B: IEC 62443-3-3 SR 1.1, SR 1.13, SR 2.1, SR 2.8, SR 3.8.
Step 3 · Information for use	Operating instructions (Chapter 13.3): procedure for enabling and ending remote maintenance sessions, obligation for a responsible person to be available on site, action in the event of suspected unauthorised access (end the session with the key switch, inform the manufacturer), contact for the manufacturer's security notifications.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

Maintenance (18 hazards)

No. 6 Mechanical — Risk before: S 5 · O 3 · **RS 15**

Hazard of crushing and impact due to unexpected restart of the turntable or the robot after an emergency stop or after fault clearance: if a coordinated restart prevention system (EN ISO 11161) is absent, individual sub-machines may start up automatically while persons are still present in the hazard zone.

Sub-machine: Overall installation (restart coordination) · also in: Troubleshooting, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: restart after an emergency stop or after fault clearance is a control-system event that cannot be eliminated by design, given the functional principle of the overall installation (coordinated automatic operation of robot and turntable) without cancelling the machine function. No geometric or energetic measure exists that would prevent the restart itself without abolishing the machine function. Protection must therefore be achieved entirely through Step 2 measures (control system and interlocking).
Step 2 · Safeguarding and/or complementary protective measures	1. Coordinated restart prevention in accordance with EN ISO 11161:2007+A1:2010: the overall installation control system shall not release the restart of a sub-machine (turntable, robot) until a deliberate, manual restart command has been issued from a safe position outside all hazard zones. The restart command shall not be triggered automatically following acknowledgement of the emergency stop or following fault clearance. 2. Safety function SF-01 (safe stop, stop category 1 on opening of the maintenance door, PLr d in accordance with EN ISO 13849-1:2023) and SF-03 (emergency stop of the overall installation, stop category 1, PLr d in accordance with EN ISO 13849-1:2023) ensure that all drives are safely brought to a standstill. The restart prevention is implemented as an integral part of safety functions SF-01, SF-03 and SF-04 and is executed at their respective PLr (SF-04: PLr e; SF-01 and SF-03: PLr d in accordance with EN ISO 13849-1:2023). 3. Safety function SF-04 (release of the 180-degree rotary movement of the turntable only when the rotation range is clear, PLr e in accordance with EN ISO 13849-1:2023): the turntable may only execute its rotary movement when the rotation range has been detected as clear by the Type 4 light curtain in accordance with EN IEC 61496-1:2020 (positioned in accordance with EN ISO 13855:2024). This function remains active after restart and prevents start-up in the presence of persons. 4. Safety function SF-05 (safely reduced speed of 250 mm/s with enabling device in set-up mode, PLr d in accordance with EN ISO 13849-1:2023): in set-up mode, restart shall be released exclusively via an enabling device (3-position in accordance with EN ISO 10218-2:2025 section 5.7.7), so that an unexpected restart at full speed is excluded. 5. De-energisation and energy isolation in accordance with EN ISO 14118:2018: before entering the hazard zone for fault-finding or maintenance, the energy supply to all relevant drives (electrical, pneumatic in accordance with EN ISO 4414:2010) shall be disconnected by means of a lockable isolating device and secured against unintentional re-energisation (lockout/tagout). Residual energy (stored pneumatic energy) shall be dissipated before any intervention; the turntable shall be positively locked in its end position. 6. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release: the guard locking keeps the maintenance door closed as long as hazardous movements have not been safely brought to a standstill (stop category 1 completed). Integration is carried out within the scope of SF-01 (PLr d).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the restart sequence after an emergency stop and after fault clearance; explicit statement that restart is permissible only after all hazard zones have been fully vacated and a manual acknowledgement command has been issued from outside. Description of the lockout/tagout procedure in accordance with EN ISO 14118:2018 for all maintenance and fault-finding activities. 2. Warning labelling at the maintenance door and at the acknowledgement units: warning of unexpected restart (warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020), notice of the obligation to acknowledge from outside. 3. Qualification requirement: set-up and maintenance activities may only be carried out by instructed specialist personnel who have been trained in the restart procedure and the lockout/tagout method (EN ISO 10218-2:2025 section 7.5.12). 4. PPE specification: safety footwear (S3 in accordance with EN ISO 20345) shall be worn when entering the hazard zone for fault-finding or maintenance; additional PPE as determined by the user's workplace risk assessment.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to unexpected restart. The restart is a control event of the coordinated automatic operation of robot and turntable; there is no design measure that prevents it without defeating the function of the cell (step 1). After step 2, the overall control system only enables the restart in accordance with EN ISO 11161:2007+A1:2010 upon a deliberate command from the control desk outside the danger zones, the restart interlock is part of SF-01, SF-03 (PL d) and SF-04 (PL e), the rotation enable checks the rotation range also after the restart, and the lockout device for personal padlocks prevents the maintenance door from being closed while a person is inside the cell. For fault-finding and maintenance, the lockable main switch and the lockable compressed air valve with exhaust function in accordance with EN ISO 14118:2018 are provided. The remaining risk is a start-up when a person neither attaches their padlock nor isolates the installation and the restart interlock fails at the same time. A technical measure that replaces isolation by the person is not available according to the state of the art. The restart sequence and the isolation procedure are described in the operating instructions (chapters 9.5 and 10.4).

No. 8 Mechanical

Risk before: S 3 · O 4 · **RS 12**

Cutting and puncture hazard from the welding wire (solid wire 1.0 to 1.2 mm) at the welding torch: The wire protruding from the torch acts like a needle; during set-up, wire threading or torch cleaning, hands and fingers can be punctured or cut.

Sub-machine: Welding torch / wire feed · also in: Setting up, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Automatic wire retraction after the end of welding: The wire feed control automatically retracts the wire by a defined amount (5 to 10 mm) into the torch after each welding cycle, so that the sharp wire tip is recessed within the contact tip and no longer protrudes freely. By design, this minimises the hazard point (free-standing wire tip) for the set-up and cleaning life-cycle phases. In addition: selection of a wire feed system that, in inching mode (set-up), advances the wire only when the button is continuously pressed (dead man's principle), so that the wire is not advanced in an uncontrolled manner.
Step 2 · Safeguarding and/or complementary protective measures	1. Mechanical wire length limitation: An adjustable wire length stop (torch protection cap with a defined opening) is provided at the torch neck, limiting the maximum protruding wire to the minimum dimension necessary for the process. 2. Inhibit of automatic wire feed: Automatic wire feed is inhibited as soon as the maintenance door is opened; with the door open, the wire can be fed only in inching mode at reduced threading speed. 3. Inching mode of the wire feed: inching mode at reduced threading speed is a function of the welding power source, not a safety function; it is designed to prevent unintended rapid wire feed. 4. Marking of the hazard point on the torch and wire feed with warning sign W022 'Warning; Sharp element' in accordance with EN ISO 7010:2020.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Explicit note that the welding wire presents a sharp tip that can pierce the skin even when stationary. Description of the safe procedure for threading wire (feed the wire only in inching mode at reduced threading speed, cut the wire end cleanly with side cutters, never probe with the bare hand). 2. Warning marking on the torch holder and on the wire feed unit: warning sign W022 'Warning; Sharp element' in accordance with EN ISO 7010:2020. 3. Qualification requirement: activities on the torch and wire feed (threading wire, cleaning) may only be carried out by instructed specialist personnel; requirement to be documented in the operating instructions. 4. PPE specification: cut-resistant protective gloves (in accordance with EN 388, puncture resistance of at least performance level 2) must be worn when threading wire and when cleaning the torch; specification to be included in the operating instructions and on the notice posted at the workplace. 5. Note on safe cutting of the wire tip: before any manual activity on the torch, the wire tip must be cut cleanly and burr-free with a suitable pair of side cutters; the tool is to be made available at the workplace.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) from the wire tip. The wire has to protrude from the contact tube for the arc. The automatic retraction after each cycle and the inching mode on the hold-to-run principle (step 1), the length limitation by the torch protection cap, the lock-out of the automatic wire feed when the maintenance door is open and the wire cutter of the torch cleaning station (step 2) limit the exposed wire length to the process dimension. Threading the wire when changing the wire and working on the torch remain manual tasks in which the hand necessarily works at the wire; a protective device between hand and wire cannot be applied for these tasks, so a further step 1 or step 2 measure is not practicable. The remaining puncture or cut injury is reversible. It is countered in step 3 by cut-resistant gloves in accordance with EN 388, cleanly cutting off the wire tip before any manual task, restriction to instructed personnel and sign W022 on the torch holder and the wire feed unit (operating instructions chapters 2.4 and 2.6).

No. 10 Mechanical — Risk before: S 3 · O 3 · **RS 9**

Hazard of tripping, slipping and falling in the area of the loading station and the maintenance aisle due to weld spatter on the floor, cables, hoses (compressed air, shielding gas) and wet areas during cleaning work.

Sub-machine: Loading station / maintenance aisle · also in: Operation, Setting up, Cleaning, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Keep cables and hoses (compressed air, shielding gas) out of the floor area of the loading station and maintenance aisle by design, by routing them in cable ducts, energy chain systems or ceiling-suspended cable management systems, so that no trip hazards arise. Design connections at the loading station as ceiling pendants or wall-mounted socket panels. Reduce weld-spatter exposure on the floor by means of design-integrated shielding plates (spatter-protection shields) at the welding station, so that discharge into the operator area is minimised. The hall floor is not part of the scope of supply; the requirement for the installation site (anti-slip floor covering) is passed on to the user in Step 3.
Step 2 · Safeguarding and/or complementary protective measures	Limit the residual risk from remaining trip and slip hazards by means of the following technical measures: (1) Floor markings (yellow/black in accordance with German ASR A1.3) to identify traffic routes and hazard zones in accordance with (EU) 2023/1230 Annex III, section 1.5.15. (2) Adequate fixed lighting of the loading station and maintenance aisle in accordance with (EU) 2023/1230 Annex III, section 1.1.4, so that obstacles and wet areas can be detected at an early stage; the machine-integrated lighting in accordance with EN 1837 provides 500 lx at the loading station and 200 lx in the maintenance aisle. (3) Spatter-protection mats in the immediate welding area that are easy to remove and clean.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): (1) Reference to the hazard of tripping and slipping due to weld spatter, hoses and wet conditions; prescribe cleaning intervals and cleaning procedures for the floor area. (2) Qualification requirement: all persons entering the loading station and maintenance aisle must have been instructed in the hazards and the traffic-route layout. (3) PPE specification: safety footwear with anti-slip soles (S3 in accordance with EN ISO 20345) shall be worn when entering the loading station and maintenance aisle. (4) Warning labelling at the access to the loading station and maintenance aisle: affix warning sign W011 'Warning; Slippery surface' and mandatory sign M008 'Wear safety footwear' in accordance with EN ISO 7010:2020. (5) Requirement for the installation site: anti-slip floor covering at the loading station and in the maintenance aisle, slip resistance rating of at least R 11 in accordance with German DGUV Rule 108-003.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) due to tripping, slipping and falling. In step 1, cables and hoses have been routed out of the floor area, and spatter guards reduce the spatter carried out of the cell. What remains is welding spatter that reaches the floor through the opening, which is open for loading, and wet areas during cleaning. The opening has to remain open for loading, and the hall floor is not part of the scope of supply; further design measures on the machine do not reach these causes. After step 2, the traffic routes are marked, the loading station is lit with 500 lx and the maintenance aisle with 200 lx, and removable spatter mats are provided in the welding area; the test of trip and slip points has been passed. Any further technical measure would only replace the floor cleaning, which is specified as a daily task. The daily cleaning (operating instructions chapter 10.2), slip-resistant S3 safety footwear, signs W011 and W007 (chapter 2.4) and the requirement for a slip-resistant floor covering at the installation site (overview of residual risks, chapter 2.6) form the information for use.

No. 11 Mechanical — Risk before: S 5 · O 2 · **RS 10**

Hazard arising from simultaneous access by several persons to different zones of the cell (EN ISO 11161): a second person is present inside the cell without the set-up personnel being aware of this; when the robot or the turntable starts up, the second person is struck.

Sub-machine: Overall installation (zone access) · also in: Setting up, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the functional principle of the overall installation requires accessible zones for set-up, maintenance and fault-finding work. The hazard arises from the simultaneous presence of several persons in different zones, which cannot be resolved by geometry, distance or energy limitation alone without defeating the operational purpose. A reduction of the robot or turntable energy to a level that safely excludes injury is not technically realisable with this type of installation.
Step 2 · Safeguarding and/or complementary protective measures	1. Protection of persons when several persons enter the cell, in accordance with EN ISO 11161:2007+A1:2010: the maintenance door has a lockout device for personal padlocks. Each person entering the cell attaches their personal padlock to the lockout device of the opened door. As long as a padlock is attached, the door cannot be closed and automatic mode cannot be started. Movements are then possible only in set-up mode, with the enabling device actuated and at safely reduced speed. Acknowledgement is possible only from outside, at the control desk. 2. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release from the inside in accordance with EN ISO 14119:2025 section 6.9.1, so that persons trapped inside can leave the cell at any time. 3. The enabling of automatic start-up (robot and turntable) is implemented as a safety function: automatic start-up is possible only when the maintenance door is closed and held closed by the guard locking and acknowledgement has been given from outside. The access function is SF-01 (safe stop on opening of the maintenance door) with PLr d in accordance with EN ISO 13849-1:2023. Independently of this, the release of the turntable rotation remains safeguarded by SF-04 (PLr e). 4. In set-up mode, SF-05 applies (safely reduced speed of 250 mm/s with enabling device, PLr d in accordance with EN ISO 13849-1:2023). The enabling device is person-specific. The cell has exactly one enabling device, on the teach pendant; movements in set-up mode are therefore permitted only when nobody other than the person holding the enabling device is inside the cell (for the procedural instruction, see Step 3). 5. The safety distances between the robot working space and areas where persons are present comply with EN ISO 13857:2019 Table 2 and EN ISO 10218-2:2025 sections 5.4.6 and 5.8.9.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the protection of persons at the maintenance door (one personal padlock per person in the lockout device, escape release from the inside), and of the obligation to attach the padlock before entering and to remove it only after leaving the cell. Procedural instruction for multi-person operations (setting up, maintenance, fault-finding) with clear role assignment (responsible person, coordination). 2. Warning signs at the maintenance door: warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020, text sign 'Attach your personal padlock before entering'. 3. Qualification requirement: Set-up and maintenance personnel must be instructed in the multi-person access concept and the use of the lockout device for personal padlocks and of the escape release. The instruction must be documented. 4. PPE specification in the operating instructions: Safety footwear S3 in accordance with EN ISO 20345, close-fitting protective clothing (no entanglement risk from loose clothing) when inside the cell.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) when several persons have access. Set-up, maintenance and fault-finding work require accessible zones; the hazard to a second person cannot be resolved by geometry or energy limitation (step 1). After step 2, every person entering attaches their personal padlock to the lockout device of the maintenance door; as long as a padlock is attached, the door cannot be closed and automatic mode cannot be started, and acknowledgement is only possible from outside (SF-01, PL d). Movements are then only possible in set-up mode with the single, person-bound enabling device and 250 mm/s (SF-05, PL d), and the escape release allows persons to leave from the inside at any time. This protection of persons follows EN ISO 11161:2007+A1:2010. The remaining risk is a person entering the cell without their own padlock while the set-up person initiates movements; even then, the installation only moves at reduced speed under the enabling device of the set-up person. Attaching the padlock remains an action of each individual person; no further step 1 or step 2 measure that prevents this misuse without restricting the set-up work has been identified. Procedure for work involving several persons, text sign at the door and instruction of personnel: operating instructions chapters 2.4, 2.5, 2.6 and 9.3.

No. 12 Electrical — Risk before: S 5 · O 2 · **RS 10**

Hazard from direct or indirect contact with live parts of the welding power source, the robot control cabinet and the cell control system (400 V AC, 32 kVA): Contact with terminals, cables or the interior of the control cabinet when the cabinet is open without isolation can lead to electric shock with ventricular fibrillation or burns.

Sub-machine: Electrical installation (control cabinet / welding power source) · also in: Commissioning, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	All live parts inside the control cabinet (terminals, busbars, power terminals of the welding power source) are designed with touch-proof covers (degree of protection at least IP 2X or IPXXB in accordance with EN 60204-1:2018 section 6.2.2), so that contact with live parts is prevented by the enclosure form itself without the need for a guard. In addition, minimum clearances between live and accessible parts are designed such that the degree of protection IP 2X is maintained even with the cabinet door open (protective caps, insulating covers on terminal strips). This addresses (EU) 2023/1230 Annex III, section 1.5.1 (Electrical energy supply) by analogy, as well as EN 60204-1:2018 section 6.2.
Step 2 · Safeguarding and/or complementary protective measures	1. Isolation and de-energisation (LOTO): Main switch with lockable OFF position in accordance with EN 60204-1:2018 section 5.3 and EN ISO 14118:2018 (prevention of unexpected start-up / energy isolation). The main switch must disconnect the overall installation from the supply on all poles as an isolating device; residual voltage at the capacitors of the welding power source is to be limited to below 60 V DC within 5 s by means of a discharge time or active discharge circuit; where this is not achieved, a warning notice stating the discharge time is affixed to the enclosure (EN 60204-1:2018 section 6.2.4). Cabinet door interlock: The doors of the main control cabinets are fitted with a lock that can only be opened with a key and prevents unauthorised opening (EN 60204-1:2018 section 6.2.2). 2. Protective equipotential bonding and protective conductor: All control cabinet enclosures, the welding power source and the robot control cabinet are connected via a continuous protective conductor (PE) of adequate cross-section (EN 60204-1:2018 section 8.2), so that in the event of an insulation fault the fault current is safely dissipated and the protective device (circuit breaker / RCD) trips. 3. Residual current device (RCD): Use of an RCD (Type B, since DC fault currents from frequency inverters and the welding power source are possible) with a rated residual operating current of 30 mA for circuits on which persons are working; in circuits where an RCD is not compatible with the welding process, insulation monitoring is used instead (EN 60204-1:2018 sections 6.3.3 and 7.7). Not a safety function with a PLr requirement; the measures act passively and by design (warning labelling: see Step 3).
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Document the isolation procedure (LOTO) with a step-by-step instruction, including the discharge time of the capacitors of the welding power source and verification of the absence of voltage using a suitable measuring instrument (voltage tester Category CAT III 600 V). Qualification requirement: Work on the electrical installation may only be carried out by electrically skilled persons (ESP) in accordance with the German accident prevention regulation DGUV Regulation 3, or under the supervision of an ESP by electrically instructed persons. PPE specification: Insulating gloves (in accordance with EN 60903, class 00 for voltages up to 500 V AC), safety goggles (arc flash protection) and electrically insulating footwear are to be worn when working in an open cabinet. Warning labelling: Warning sign W012 'Warning; Electricity' in accordance with EN ISO 7010:2020 to be affixed permanently and clearly visible to all cabinet doors and to the welding power source. Residual risk note in the operating instructions: After operation of the main switch, capacitors in the welding power source and in the frequency inverter of the robot may still carry dangerous voltages (waiting time of at least 1 minute for the welding power source, for the robot drive as specified by the robot manufacturer); absence of voltage must always be verified by measurement.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to electrical voltage of 400 V AC. In step 1, the live parts are covered finger-safe (IP 2X in accordance with EN 60204-1:2018 section 6.2.2), also with the cabinet door open. After step 2, the lockable main switch disconnects all poles, the cabinet doors can only be opened with a key, the DC link of the welding power source discharges to no more than 60 V in a measured 1.9 s, protective conductor (0.08 Ω), fault loop impedance (0.28 Ω) and insulation resistance (> 100 MΩ) have been tested, and fault protection is provided by a type B RCD or insulation monitoring. The remaining risk is the work of the qualified electrician, who has to take measurements on live parts in the open cabinet during commissioning and fault-finding. These measurements cannot be carried out without voltage; for these life cycle phases no further step 1 or step 2 measure is therefore practicable, and the severity remains 5. The isolation procedure including verification of the absence of voltage, the qualification as a qualified electrician, insulating PPE and sign W012 are stated in the operating instructions (chapters 2.4, 2.6, 8.1 and 10).

No. 17 Thermal — Risk before: S 3 · O 3 · **RS 9**

Risk of burns from the hot welding torch and torch neck: The torch neck and the contact tip are strongly heated after the welding process; when changing the torch, during cleaning or during set-up without a cooling period, hands and fingers may be burned.

Sub-machine: Welding torch · also in: Setting up, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Use of active torch cooling (water-cooled torch instead of an air-cooled torch): The continuous water cooling limits the thermal energy in the torch neck and at the contact tip by design to a significantly lower temperature level. Additionally: The torch holder and the change system are designed such that the operator, when changing the torch, touches only thermally decoupled grip areas (plastic or ceramic handle, no direct metal contact with the torch neck). Design in accordance with EN ISO 13732-1:2008 (burn threshold for bare metal around 51 °C for a contact period of 1 min and 48 °C for 10 min).
Step 2 · Safeguarding and/or complementary protective measures	1. Cooling-time monitoring: a temperature sensor on the torch neck reports to the machine control system; the HMI indicates the release for torch changes and cleaning only once the temperature has fallen below the limit value. The function is an operational interlock without a PL requirement under EN ISO 13849-1; no risk reduction is credited to it. 2. Guard: the welding area is enclosed by the safety fence with welding-light-opaque infill panels and welding protection viewing windows (EN ISO 14120:2015); access to the torch for maintenance and cleaning is provided exclusively via the secured maintenance door (SF-01, PLr d). Unintentional access to the hot torch during automatic operation is thereby excluded by design. 3. Provision of a torch rest with a thermally insulated receptacle (ceramic or silicone pad) immediately at the welding station, so that the torch is placed down in a defined manner after the process and is not set down on conductive metal surfaces.
Step 3 · Information for use	1. Operating instructions: state the cooling time after the end of welding explicitly before any torch change, cleaning or set-up work on the torch (reference value as specified by the torch manufacturer); include a procedure for torch changes with the step 'wait for cooling time or check temperature'. 2. Warning labelling: permanently and clearly affix the warning sign 'Warning; Hot surface' (W017 in accordance with EN ISO 7010:2020) to the torch area and to the maintenance door. 3. Qualification: only instructed persons may carry out torch changes and cleaning; instruction covers the risk of burns, cooling times and correct use of PPE. 4. PPE specification: heat-protection gloves (suitable for contact heat, protection class in accordance with EN 407) are mandatory during torch changes, cleaning and set-up work on the torch; this requirement shall be stated in the operating instructions and indicated by the mandatory sign 'Wear protective gloves' (M009 in accordance with EN ISO 7010:2020) at the maintenance door.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 19 Radiation

Risk before: S 4 · O 2 · **RS 8**

Hazard from electromagnetic fields (EMF) generated by the welding power source and the welding cables: High welding currents generate strong magnetic fields; persons with active implants (cardiac pacemakers, insulin pumps) may be endangered by the fields.

Sub-machine: Welding power source / welding cables · also in: Operation, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Route and bundle the welding cables (current conductor and return conductor) so that the forward and return conductors are brought into close spatial proximity (twisted or parallel-routed cable pairs with minimum distance between them): The magnetic fields of both conductors partially cancel each other out, which significantly reduces the resultant field strength in the surrounding area. Keep cables as short as technically possible and avoid unnecessary coiling or routing in loops, as loops increase field strength. Install the welding power source at a distance from the loading station and the control desk.
Step 2 · Safeguarding and/or complementary protective measures	Secure access to the welding area (welding cell) during operation by means of the existing fixed guard (safety fence in accordance with EN ISO 14120:2015), so that persons cannot enter the immediate vicinity of the active welding cables during automatic operation. Design the maintenance door with guard locking in accordance with EN ISO 14119:2025 (SF-01, PLr d), which permits entry only after the welding current has been switched off. During set-up mode and during maintenance work in the vicinity of cables: switch off the welding current before entering the hazard zone and secure it against being switched on again (energy isolation and standstill in accordance with EN ISO 14118:2018). The welding cables run entirely inside the safety fence, so that persons outside the cell keep their distance from the active cables.
Step 3 · Information for use	Operating instructions: Explicit statement that operation of the welding machine generates strong electromagnetic fields. Persons with active or passive metallic implants (cardiac pacemakers, insulin pumps, cochlear implants, metal implants) must not enter the immediate vicinity of the welding cables and the welding power source. Before commencing set-up or maintenance activities in the vicinity of cables, the welding current must be switched off. Qualification requirement: Set-up and maintenance personnel must be instructed regarding the EMF hazard; persons with known implants must be excluded from activities in the immediate vicinity of active welding cables. Warning labelling: Attach the warning sign 'Warning; Magnetic field' (W006 in accordance with EN ISO 7010:2020) at the maintenance door, at the loading station and on the welding power source. Additionally, attach the prohibition sign 'No access for people with active implanted cardiac devices' (P007 in accordance with EN ISO 7010:2020) at the same locations. EMF emissions are to be described qualitatively in the operating instructions; the basis for assessment is the manufacturer's data for the welding power source in accordance with EN IEC 62822-2 (assessment of arc welding equipment with regard to EMF exposure of persons).

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 20 Materials/substances — Risk before: S 4 · O 4 · **RS 16**

Hazard from inhaling welding fumes and vapours (metal oxides, manganese, iron oxides): MAG welding of structural steel generates harmful particles and gases; when extraction is inadequate (saturated filter cartridge, system switched off), concentrations in the operator's breathing zone exceed the workplace exposure limits.

Sub-machine: Overall installation (extraction / welding area) · also in: Operation, Setting up, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Substitution of the welding consumable: Use of solid-wire electrodes with a demonstrably reduced manganese content (low-Mn alloy, e.g. Mn content < 1.0 % in accordance with the safety data sheet) instead of flux-cored wire electrodes or high-manganese wires, to the extent that the welding task (structural steel, weld quality) permits this. In addition: optimisation of welding parameters (arc voltage, wire feed speed, shielding gas composition) to a low-fume setting in accordance with the welding power source manufacturer's recommendation, in order to minimise fume generation at source. Both measures reduce the emitted pollutant mass and thereby the probability of a harmful exposure; the severity of the possible harm remains unchanged.
Step 2 · Safeguarding and/or complementary protective measures	Technical ventilation and extraction in accordance with EN ISO 21904-1:2020 (welding fume extraction): Capture of the welding fume by the capture hood above the welding area with a volumetric flow rate of 1800 m³/h, which ensures the capture velocity at the point of generation. The extraction system must be equipped with filter monitoring (differential-pressure switch) that triggers an alarm when the filter cartridge is saturated or the extraction is faulty; the cell stops in a controlled manner and can be restarted only after the fault has been rectified (operational interlock without a PL requirement under EN ISO 13849-1, no risk reduction is credited to it). Shielding of the welding area by the safety fence with welding-light-opaque infill panels (EN ISO 14120:2015) and the dividing centre wall of the turntable, in order to minimise fume escape into the operator area. Ambient air monitoring for welding fume concentration at the loading station is recommended as an additional measure by the user.
Step 3 · Information for use	Operating instructions (in accordance with (EU) 2023/1230 Annex III, section 1.7.4): Specification of the welding fume types emitted and reference to the workplace exposure limits to be observed in accordance with TRGS 900 and TRGS 528; instruction for regular inspection and replacement of filter cartridges (maintenance interval in accordance with manufacturer's specification EN ISO 21904-1:2020); prohibition of welding operation when the extraction system has failed or is switched off. Warning signs at the welding area: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Harmful welding fume' and mandatory sign 'Wear respiratory protection' (M017) as residual risk marking. PPE requirement: FFP3 particle filtering half mask in accordance with EN 149 or powered air-purifying respirator for set-up, maintenance and cleaning work in the welding area when the extraction system is switched off. Qualification requirement: operators and set-up personnel must be instructed in the hazards of welding fumes and the correct operation of the extraction system (TRGS 528 section 5).

Risk after: S 4 · O 2 · **RS 8 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 8 (S 4, O 2) from welding fumes. The severity results from the properties of the welding fumes (metal oxides, manganese) and remains unchanged; the MAG process is the purpose of the machine and cannot be substituted. In step 1, low-manganese solid wire, as far as the welding task permits, and low-fume parameters are provided. After step 2, the hood above the welding area captures the fumes at 1,800 m³/h, the cell stops in a controlled manner if the extraction is faulty or the filter cartridge is saturated (fault alarm threshold 1,400 m³/h), separation takes place in class W3, and the safety fence and dividing centre wall shield the loading station; capture, effectiveness and separation class have been tested. A complete enclosure is not possible because the loading opening has to remain open for manual loading, and the extraction is switched off during work in the welding area; no further step 1 or step 2 measure for this residual exposure has been identified. The remaining risk consists of residual emissions at the loading station and exposure during set-up, maintenance and cleaning work. FFP3 respiratory protection for this work, the prohibition of welding without effective extraction, filter maintenance and the user's obligations under TRGS 528 are stated in the operating instructions (chapters 1.2, 2.6, 9.1 and 10.2).

No. 21 Materials/substances — Risk before: S 4 · O 2 · **RS 8**

Hazard from shielding gas (argon-CO2 mixture M21) in the event of leakage: Argon and CO2 are heavier than air, so the shielding gas may accumulate near floor level; in the event of larger leakages in poorly ventilated areas, there is a risk of asphyxiation due to oxygen displacement.

Sub-machine: Shielding gas supply / piping system · also in: Operation, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Pressure limitation in the piping system: Limit the operating pressure of the shielding gas supply to the minimum level required for the welding process (pressure regulator at the supply connection of the cell). A lower system pressure reduces the quantity of gas escaping in the event of a fault and thus the potential for accumulation. Additionally: design the pipe routing and connection points so that leakages are minimised by design: use of cutting ring fittings or press fittings instead of hose clamps on fixed pipe sections; reduce hose lengths to the minimum operationally necessary; no routing of pipes near floor level in pits or enclosed chambers (route near the ceiling where possible). These measures address the energy source (stored pressurised gas) and the hazard location (accumulation zone) directly.
Step 2 · Safeguarding and/or complementary protective measures	1. Automatic shut-off of the gas supply: Solenoid valve (de-energised closed) in the shielding gas supply line, which automatically shuts off the gas supply upon machine stop, emergency stop (SF-03) and during operating pauses; additionally, a manual shut-off valve outside the cell. 2. Leak monitoring: Plausibility check of gas consumption via the machine control system (indication when gas flow occurs without an active welding process, as a leakage indicator); daily visual inspection of hose connections as a maintenance requirement. 3. Installation of the shielding gas supply provided on site (cylinder bank or withdrawal station) in a ventilated area of the hall, not in pits, basements or confined recesses. If installed in poorly ventilated areas, the user is required to provide an oxygen warning device (note in the operating instructions). A safety function with a PLr requirement is not necessary for this hazard; the risk is controlled by means of shut-off, installation location and ventilation.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Note on the risk of asphyxiation due to oxygen displacement in the event of larger leaks in poorly ventilated areas; requirement for adequate hall ventilation at the installation site; work on the gas supply only with the line shut off and depressurised (EN ISO 14118:2018). 2. Qualification: Work on compressed gas lines and fittings only by instructed specialist personnel; instruction in accordance with DGUV Rule 100-500 Chapter 2.26 and TRGS 528 (user's obligation). 3. Warning labelling: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Risk of asphyxiation from shielding gas' at the gas supply installation site; supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006) on locked supply areas. 4. When working in confined or poorly ventilated areas (e.g. cylinder changes in recesses): use a portable oxygen warning device; no lone working.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 22 Materials/substances

Risk before: S 3 · O 2 · **RS 6**

Hazard from filter dust when changing the filter cartridge of the welding fume extraction unit: The filter cartridge contains separated welding fumes with metal oxides and fine particles; when changed without appropriate respiratory protective measures, dusts are released and inhaled.

Sub-machine: Welding fume extraction (filter unit) · also in: Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Dust retention by design during filter change: The filter unit is equipped with an integrated bag-in/bag-out system, so that the contaminated filter cartridge can be removed and sealed in a closed plastic bag without direct contact with dust. By design, this minimises dust release at the source (substitution of open removal by a closed change procedure in accordance with EN ISO 12100 section 6.2.4). Additionally: the cleaning pulse (pressure burst) prior to the change is to be permitted ONLY with the housing closed and the extraction system deactivated, in order to compact dust deposits in the cartridge and reduce release when opening.
Step 2 · Safeguarding and/or complementary protective measures	Technical protective measures for the remaining residual risk (residual dust when opening the housing and handling the cartridge): 1. Extraction housing with negative-pressure interlock: The filter housing may by design only be opened when the fan is switched off and the system is depressurised (mechanical interlock, no safety function with PLr requirement, as no motion drive is involved). 2. Local extraction at the change location: A connection stub for a mobile extraction unit (industrial vacuum cleaner dust class H in accordance with EN 60335-2-69, suitability for welding fume dusts) is to be provided on the filter housing; this is activated during the change and captures released residual particles. 3. Labelling of the filter unit: General warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text "Harmful dust" to be permanently affixed to the filter housing.
Step 3 · Information for use	1. Operating instructions (Chapter 10.2): Detailed step-by-step instruction for the filter change with description of the bag-in/bag-out procedure; information on the composition of the separated dusts (metal oxides, fine particles, possibly CMR substances depending on the weld material); disposal note (contaminated filter cartridges to be disposed of as hazardous waste in accordance with applicable waste regulations). 2. Qualification requirement: Filter change to be carried out only by trained specialist personnel who have been informed of the hazard from welding fume dusts. 3. PPE specification: During the filter change, the following must be worn as a minimum: FFP3 particle filtering half mask in accordance with EN 149 for fine particles and metal oxides; protective gloves (chemical-resistant); safety spectacles (particle protection). PPE requirements are to be specified permanently in the operating instructions and by means of a mandatory sign 'Wear respiratory protection' (M017 in accordance with EN ISO 7010:2020) on the filter housing. 4. Reference to occupational health and safety legislation: The user is to be advised of their obligations under TRGS 528 (welding operations) and the German Hazardous Substances Ordinance (GefStoffV), in particular regarding the risk assessment for CMR dusts and the provision of suitable PPE.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 23 Mechanical

Risk before: S 4 · O 3 · **RS 12**

Hazard from residual pneumatic energy during maintenance and fault-clearing work: After the compressed air supply is switched off, residual pressure remains in the lines and cylinders of the clamping device; uncontrolled pressure release can cause clamping elements to move suddenly and injure persons or eject workpieces.

Sub-machine: Pneumatic clamping device / compressed air system · also in: Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Limit residual pneumatic energy by design: in the event of a pressure drop, the pneumatically closing clamps hold the workpiece by means of a pilot-operated non-return valve (pressure-holding valve) in the clamping line; the pressure switch monitors the clamping pressure (SF-04). The volume trapped between the pressure-holding valve and the cylinder is minimised by design (short lines, pressure-holding valves mounted directly on the cylinder), so that only a small amount of energy remains stored. Before any intervention, the trapped clamping pressure is released by opening the clamps; in the event of a fault it is released in a controlled manner using the manual override of the pressure-holding valve. Design in accordance with EN ISO 4414:2010. Note: The severity of a remaining residual energy event is reduced by this measure, as the kinetic energy of the clamping elements is considerably lower with a small residual volume and throttled venting.
Step 2 · Safeguarding and/or complementary protective measures	1. Maintenance shut-off valve with venting function (lockout/tagout-capable) in accordance with EN ISO 4414:2010 and EN ISO 14118:2018: Install a shut-off valve with integrated, controlled venting (soft-exhaust function) at the inlet of the pneumatic clamping device; in the shut-off position, the valve must vent the downstream line section in a controlled and throttled manner before any intervention is possible. The valve shall be secured with a lock (lockout device). 2. Pressure gauge or pressure indicator on the line section between the shut-off valve and the cylinder, so that the operator can visually verify pressure reduction to 0 bar (EN ISO 4414:2010). 3. Residual pressure indicator at the maintenance access: before any intervention, the absence of pressure is checked at the residual pressure indicator; the indicator is an operational device without a PL requirement under EN ISO 13849-1:2023. 4. Guard: the clamping fixtures are located inside the safety fence (EN ISO 14120:2015); access for maintenance and fault clearance is via the maintenance door with guard locking in accordance with EN ISO 14119:2025 (SF-01, PLr d).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Work instruction for maintenance and fault clearing on the pneumatic clamping device with an explicit step-by-step procedure: (a) remove the workpiece and open the clamps, (b) shut off the compressed air supply at the maintenance shut-off valve and wait for venting, (c) in the event of a fault, release any trapped residual pressure using the manual override of the pressure-holding valve, then check that the residual pressure indicator shows 0 bar, (d) attach the lockout padlock, (e) only then intervene in the system. Include a note on the hazard from residual pressure and ejected workpieces. 2. Warning labelling on the clamping device and on the shut-off valve: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Residual pressure in the clamping fixture'; information sign 'Before intervention: vent to 0 bar and lock shut-off valve'. 3. Qualification requirement: maintenance and fault-clearing work on the pneumatics only by instructed specialists with knowledge of pneumatic safety rules (EN ISO 4414:2010). 4. PPE specification: prescribe safety goggles (eye protection against flying parts) and protective gloves when opening pneumatic connections.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 27 Ergonomic — Risk before: S 2 · O 3 · **RS 6**

Insufficient lighting at the loading station and in the maintenance aisle: inadequate illuminance makes it difficult to load and unload workpieces safely and to carry out maintenance work, and increases the risk of errors and accidents.

Sub-machine: Loading station / maintenance aisle · also in: Operation, Setting up, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Machine-integrated workplace lighting at the loading station and in the maintenance aisle to be provided as part of the design: luminaires are permanently integrated into the machine structure (built into the frame of the safety fence) so that the illuminance at the loading station and in the maintenance aisle is permanently ensured independently of the hall lighting. The design is carried out in accordance with EN ISO 12100:2010 section 6.2.8 (ergonomics) in conjunction with EN 1837 (machine-integrated lighting); the lighting as built provides 500 lx at the loading station, 200 lx in the maintenance aisle. The integration into the design eliminates dependence on external lighting sources that may be inadequate.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk from failure or shadowing of the integrated luminaires: monitoring of the operational readiness of the workplace lighting by the machine control system (notification in the event of lamp failure). In addition, maintenance aisle areas to be marked with retroreflective yellow and black floor markings in accordance with the German workplace rule ASR A1.3 (trip hazards, aisle boundaries) and with the warning sign W007 'Warning; Floor-level obstacle' in accordance with EN ISO 7010:2020 at trip hazards. A safety function within the meaning of EN ISO 13849-1 is not required for lighting monitoring; in the event of a lighting failure, work is to be discontinued (Step 3).
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): specification of the illuminance of the workplace lighting: 500 lx at the loading station and 200 lx in the maintenance aisle; notice that work is to be discontinued in the event of failure of the integrated lighting until the lighting has been restored. Text sign on the maintenance door: 'Stop work if the lighting fails'. Qualification requirement: maintenance personnel must be instructed in checking the lighting function before commencing work. Use suitable portable luminaires for brief inspections in the event of a lighting failure; resume regular work only after the lighting has been restored.

Risk after: S 2 · O 1 · **RS 2 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 30 Combination

Risk before: S 5 · O 2 · **RS 10**

Hazard arising from incorrect parameterisation of the robot control system or the safety controller (e.g. incorrect safety distances, incorrect speed limits in set-up mode, incorrect zone releases): Erroneous parameters may result in safety functions not operating as intended, thereby endangering persons through robot movements or turntable movements.

Sub-machine: Overall installation (control / safety control) · also in: Commissioning, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Safety-relevant parameters (speed limits, protection zones, zone releases) are stored exclusively in the safety controller (safety PLC) and are protected against unauthorised or inadvertent modification by a password-protected, role-based access concept. Parameter sets for safety functions SF-01 to SF-05 are stored in the safety controller as immutable, checksum-protected data records (e.g. CRC-32 or equivalent), so that any unintended modification is automatically detected at system start-up and a safe state is enforced. This principle corresponds to the inherently safe control principle in accordance with EN ISO 12100 section 6.2.11 (control principles that limit the occurrence of hazards) and reduces the possibility of erroneous parameters becoming effective at all.
Step 2 · Safeguarding and/or complementary protective measures	1. Validation requirement before release: Every change to safety-relevant parameters requires a documented acceptance test (functional test of all affected safety functions SF-01 to SF-05) carried out by two authorised persons (dual-control principle) before recommissioning. The safety controller may not release automatic operation until a positive acknowledgement has been given. Basis: EN ISO 13849-2:2012 (validation of safety functions) and EN ISO 11161:2007+A1:2010 (verification and validation for integrated manufacturing systems). 2. Parameter verification by the safety controller: The safety controller (PLr e for SF-02 and SF-04, PLr d for SF-01, SF-03 and SF-05 in accordance with EN ISO 13849-1:2023) checks the consistency of the safety-relevant parameters against stored reference values (checksum comparison) at start-up and cyclically. In the event of a discrepancy, stop category 1 in accordance with EN 60204-1:2018 is triggered and a restart is inhibited (no automatic restart in accordance with EN ISO 14118:2018). 3. Set-up mode SF-05: The safely reduced speed of 250 mm/s (SF-05, PLr d) is limited at hardware level in the safety controller and cannot be overridden by parameters of the robot control system. Monitoring is performed by an SRP/CS in accordance with EN ISO 13849-1:2023, category and PL in accordance with SF-05 (PLr d). 4. Zone release turntable SF-04: The release of the 180-degree rotary movement (SF-04, PLr e) is performed exclusively via the safety controller on the basis of verified sensor signals; a release caused by erroneous zone parameters in the robot control system alone is excluded by design. 5. Change management: All parameter changes are stored with a time stamp, user identification and predecessor/successor value in a tamper-proof change log (audit trail) of the safety controller. Basis: EN ISO 11161:2007+A1:2010.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the parameter change procedure with a step-by-step guide, listing of all safety-relevant parameters for each safety function (SF-01 to SF-05), obligation to carry out a validation test after each change, and documentation obligation in the change log. 2. Qualification requirement: Parameter changes to the safety controller may only be carried out by specialist personnel with demonstrated qualification in functional safety (e.g. TÜV certification as Functional Safety Engineer or equivalent) and knowledge of the system. This is to be set out in the operating instructions and in an operating procedure. 3. Warning labelling: The warning sign 'Warning; Electricity' (W012 in accordance with EN ISO 7010:2020) and the supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006) are to be affixed to the safety controller and the control cabinet. Additionally, an information sign stating: 'Parameter changes by authorised specialist personnel only; subsequent validation test required'. 4. Commissioning checklist: Before every initial commissioning and after every parameter change, a system-specific commissioning checklist is to be completed and signed (basis: EN ISO 11161:2007+A1:2010).

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to incorrect parameterisation. In step 1, the safety-relevant parameters are held only in the safety PLC, protected by a role-based access concept and checksum-protected parameter sets. After step 2, the safety PLC checks the parameters against the reference at start-up and cyclically and triggers a stop with restart interlock in the event of a deviation, the speed limit of SF-05 cannot be overwritten via the robot controller, the rotation enable SF-04 comes only from the safety PLC, and every change is logged and validated under the four-eyes principle in accordance with EN ISO 13849-2:2012 before release. The remaining risk is a parameter that is specified incorrectly by authorised personnel and not detected during validation. The parameters have to remain changeable for commissioning, modifications and new clamping fixtures; a measure that detects a technically incorrect but properly entered and validated value is not available according to the state of the art. Change procedure, qualification, commissioning checklist and the text sign on the validation obligation at the control cabinet: operating instructions chapters 2.4 and 2.6.

No. 34 Thermal

Risk before: S 3 · O 3 · **RS 9**

Fire hazard in the welding fume extraction system (filter fire): Sparks and glowing particles drawn in by the process can accumulate in the filter cartridge and ignite a smouldering fire or filter fire, including in a time-delayed manner after the end of a shift. Fire smoke can spread via the pipework system and the air recirculation into the hall.

Sub-machine: Welding fume extraction (filter unit) · also in: Operation

Step 1 · Inherently safe design measures	Spark reduction at the point of origin through the design of the welding parameters and the extraction geometry: Design the capture hood above the welding area and the duct routing so that sparks drawn in have cooled before they reach the filter cartridge. In addition, provide a pre-spark separator (baffle plate/cyclone separator) as an integrated component directly upstream of the filter cartridge, which separates coarse particles and sparks by inertia before they come into contact with the filter medium. This component is an integral part of the extraction system design, not a downstream protective device. Design in accordance with EN ISO 21904-1:2020 (requirements for welding fume extraction systems).
Step 2 · Safeguarding and/or complementary protective measures	The remaining residual risk of a filter fire is limited by the following technical protective measures: 1. Thermal monitoring of the filter cartridge: temperature sensor (thermostat or thermocouple) in the filter housing with a trigger threshold; upon exceedance, automatic shutdown of the extraction fan and closing of a motorised shut-off damper in the pipework system to prevent the supply of oxygen. Integration into the machine control system as an operational interlock without a PL requirement under EN ISO 13849-1, no risk reduction is credited to it; the cell stops in a controlled manner and can be restarted only after the fault has been rectified. 2. Extinguishing device at the filter housing: at least one closable extinguishing agent inlet opening (extinguishing lance) on the housing; an automatic extinguishing device is not part of the scope of supply and, if required, is added by the user in line with the user's fire protection concept. 3. Motorised shut-off damper in the air recirculation duct to the hall: automatic closure upon fire alarm to prevent the spread of smoke into the hall. Integration into the machine control system as an operational interlock without a PL requirement. 4. Smoke and CO detectors in the filter housing and in the exhaust air duct as a redundant detection level, with alarm forwarding to a permanently staffed location or to a fire alarm control panel (user's responsibility, to be agreed with the building fire protection concept). 5. Run-on time of the extraction fan after the end of welding: program a minimum run-on time of 10 minutes at the control system level so that glowing particles still present in the pipework are fully transported into the separator and cooled before the system is shut down. Design of the run-on time based on the pipework length and the volumetric flow rate.
Step 3 · Information for use	Operating instructions (in accordance with (EU) 2023/1230 Annex III, section 1.7.4): - Reference to the fire hazard from sparks and glowing particles in the filter system; description of the damage mechanism including time-delayed ignition. - The prescribed run-on time of the extraction fan after the end of welding (minimum value from the design) as a binding operating instruction. - Maintenance intervals for filter cartridges, pre-spark separators and temperature sensors; specification of the loading level at which the filter cartridge is to be replaced (manufacturer's specification EN ISO 21904-1:2020). - Prohibition on operating the extraction system with a defective temperature sensor or an ineffective shut-off damper. - Procedure in the event of a fire alarm: vacate the installation immediately, alert the fire brigade, do not attempt to deal with the filter housing independently (opening it can fan a smouldering fire). - Note that after the end of a shift, a visual inspection of the filter housing (temperature, odour) is to be carried out before the building is vacated. Warning labelling on the extraction system: - General warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Fire hazard from sparks in the filter' on the filter housing and maintenance opening. - Text sign 'Do not open in the event of a fire alarm' on the maintenance flap of the filter housing. Qualification and instruction: - Operating personnel and maintenance personnel are to be instructed before commencing work and thereafter at least annually on the fire hazard, the function of the protective devices and the correct behaviour in the event of a fire (user's obligation). - Maintenance work on the filter system only by instructed personnel wearing appropriate PPE (protective gloves, and where applicable respiratory protection during filter replacement due to welding fume exposure).

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 40 Corruption/security — Risk before: S 3 · O 3 · **RS 9**

Safety-relevant software not identifiable or labelled: The version status and checksum of the safety software cannot be retrieved at the machine, and safety-relevant software and data are not designated as such. After an intervention, update or device replacement, it cannot be determined whether the machine is still in the inspected state; operation with non-approved software remains undetected. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 3, 1.1.9 para. 4, 1.7.4.2]

Sub-machine: Software / Documentation · also in: Commissioning, Operation

Step 1 · Inherently safe design measures	Design safety-relevant software as a distinct unit with its own version number and checksum (separate from standard and visualisation software) so that unambiguous identification is technically possible.
Step 2 · Safeguarding and/or complementary protective measures	Information page on the HMI showing the version and checksum of all safety-relevant software components (always easily accessible without login, Annex III, section 1.1.9, fourth paragraph), labelling of safety-relevant data in file names, menus and exports, comparison with the acceptance report at start-up. Evidence reference route B: IEC 62443-3-3 SR 3.4.
Step 3 · Information for use	Operating instructions: list of safety-relevant software and data with versions (Annex III, section 1.7.4.2), instructions for retrieving version information, note on the significance for conformity and on the obligation to report deviations.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 41 Corruption/security — Risk before: S 3 · O 3 · **RS 9**

Missing or incomplete records of interventions (logging): Interventions in safety-relevant hardware, software or configuration are not recorded, or are recorded without a timestamp and originator; logs overwrite themselves after a short period or are open to manipulation. Unauthorised interventions remain undetected and the audit trail is not available upon request by the authorities. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 2, 1.1.9 para. 5, 1.2.1 lit. f]

Sub-machine: Control / logging · also in: Operation, Troubleshooting

Step 1 · Inherently safe design measures	Provide event logging as a fixed function of the control system (not deactivatable by the operator), with a non-volatile memory of sufficient capacity.
Step 2 · Safeguarding and/or complementary protective measures	Logging of safety-relevant events with timestamp, user identity and content of the change (log-on, parameter and configuration change, software upload with version and checksum, opening of safety-relevant assemblies, remote-access sessions), protection against deletion and modification, export in readable form, retention of uploads and associated data for up to five years after uploading (Annex III, section 1.2.1, point (f)). Evidence reference route B: IEC 62443-3-3 SR 2.8, SR 2.9, SR 2.11, SR 3.9, SR 6.1.
Step 3 · Information for use	Operating instructions: Access to and export of logs, user's retention obligations when the machine is transferred, procedure in the event of a regulatory request, note on storage capacity and time synchronisation.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 43 Corruption/security — Risk before: S 5 · O 2 · **RS 10**

Unsecured engineering access to the safety controller: The programming access of the safety controller or safety PLC is reachable without a password or with the manufacturer's default credentials; the safety program can be overwritten or placed in a stopped state during operation, and forcing of inputs and outputs is possible. Protective functions are rendered ineffective or actuators are controlled directly. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 2, 1.1.9 para. 3, 1.2.1 lit. a]

Sub-machine: Safety control / engineering · also in: Commissioning, Troubleshooting

Step 1 · Inherently safe design measures	Programming access to the safety controller physically separated from the process network (dedicated port, inside a locked control cabinet), no forcing of safety-relevant signals in the as-delivered state, program changes only in the secured stop state of the machine.
Step 2 · Safeguarding and/or complementary protective measures	Individual password for the safety program access with mandatory password change at commissioning, write protection and access protection levels of the controller activated, logging of all accesses and program changes with version and checksum, display of the program status on the HMI. Evidence reference route B: IEC 62443-3-3 SR 1.1, SR 1.5, SR 2.1, SR 2.8, SR 3.4, SR 7.7.
Step 3 · Information for use	Operating instructions: Access protection and password management as a user obligation, prohibition of program changes without re-verification and documentation, reference to the requirements for substantial modification.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) via the engineering access to the safety controller. The access has to remain available for commissioning, maintenance and fault-finding. In step 1, the programming port is separated from the process network inside the locked control cabinet, forcing of safety-relevant signals is excluded in the as-delivered state, and program changes are only permitted in the secured stop state. After step 2, an individual password, write protection and access protection levels are active, every access and every program change is logged with version and checksum, and the program status can be retrieved on the HMI panel (evidence in accordance with IEC 62443-3-3 SR 1.1, 1.5, 2.1, 2.8, 3.4 and 7.7). The remaining risk is misuse or error by a person with a valid password and cabinet key. A technical measure that distinguishes authorised from improper changes is not available according to the state of the art; deviations become detectable by comparing version and checksum with the acceptance report. Password management as an obligation of the user and the prohibition of program changes without renewed testing and documentation are stated in the operating instructions (chapters 2.6 and 13).

No. 44 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Unauthorised or faulty remote access via the remote maintenance gateway: Via the IPsec VPN connection of the remote maintenance gateway, an unauthorised person with stolen credentials or an authorised technician at the wrong moment intervenes in the cell controller: program or parameter change, acknowledgement of faults or starting of movements while persons are at the loading station or in the maintenance aisle. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 1, 1.1.9 para. 3, 1.2.1 lit. a, 1.2.1 lit. d]

Sub-machine: Remote maintenance gateway / cell controller · also in: Operation, Troubleshooting

Step 1 · Inherently safe design measures	Remote access designed so that it cannot trigger hazardous movements or bypass safety functions: the remote maintenance gateway only reaches the standard controller and the HMI panel; the safety PLC has no remote access path. Movement commands and acknowledgement of faults are only possible from control positions with a view of the hazard zone (Annex III, section 1.2.2).
Step 2 · Safeguarding and/or complementary protective measures	Remote maintenance disabled on delivery; a session can only be enabled on site with the key switch at the control desk, ends automatically after four hours and is indicated as "Remote maintenance active" on the HMI panel; IPsec VPN with multi-factor authentication and personal accounts for remote technicians; logging of every session with user, time and actions performed, retention in accordance with Annex III, section 1.2.1, point (f). Evidence reference route B: IEC 62443-3-3 SR 1.1, SR 1.13, SR 2.1, SR 2.8, SR 3.8.
Step 3 · Information for use	Operating instructions (Chapter 13.3): procedure for enabling and ending remote maintenance sessions, obligation for a responsible person to be available on site, action in the event of suspected unauthorised access (end the session with the key switch, inform the manufacturer), contact for the manufacturer's security notifications.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

Cleaning (6 hazards)

No. 8 Mechanical — Risk before: S 3 · O 4 · **RS 12**

Cutting and puncture hazard from the welding wire (solid wire 1.0 to 1.2 mm) at the welding torch: The wire protruding from the torch acts like a needle; during set-up, wire threading or torch cleaning, hands and fingers can be punctured or cut.

Sub-machine: Welding torch / wire feed · also in: Setting up, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Automatic wire retraction after the end of welding: The wire feed control automatically retracts the wire by a defined amount (5 to 10 mm) into the torch after each welding cycle, so that the sharp wire tip is recessed within the contact tip and no longer protrudes freely. By design, this minimises the hazard point (free-standing wire tip) for the set-up and cleaning life-cycle phases. In addition: selection of a wire feed system that, in inching mode (set-up), advances the wire only when the button is continuously pressed (dead man's principle), so that the wire is not advanced in an uncontrolled manner.
Step 2 · Safeguarding and/or complementary protective measures	1. Mechanical wire length limitation: An adjustable wire length stop (torch protection cap with a defined opening) is provided at the torch neck, limiting the maximum protruding wire to the minimum dimension necessary for the process. 2. Inhibit of automatic wire feed: Automatic wire feed is inhibited as soon as the maintenance door is opened; with the door open, the wire can be fed only in inching mode at reduced threading speed. 3. Inching mode of the wire feed: inching mode at reduced threading speed is a function of the welding power source, not a safety function; it is designed to prevent unintended rapid wire feed. 4. Marking of the hazard point on the torch and wire feed with warning sign W022 'Warning; Sharp element' in accordance with EN ISO 7010:2020.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Explicit note that the welding wire presents a sharp tip that can pierce the skin even when stationary. Description of the safe procedure for threading wire (feed the wire only in inching mode at reduced threading speed, cut the wire end cleanly with side cutters, never probe with the bare hand). 2. Warning marking on the torch holder and on the wire feed unit: warning sign W022 'Warning; Sharp element' in accordance with EN ISO 7010:2020. 3. Qualification requirement: activities on the torch and wire feed (threading wire, cleaning) may only be carried out by instructed specialist personnel; requirement to be documented in the operating instructions. 4. PPE specification: cut-resistant protective gloves (in accordance with EN 388, puncture resistance of at least performance level 2) must be worn when threading wire and when cleaning the torch; specification to be included in the operating instructions and on the notice posted at the workplace. 5. Note on safe cutting of the wire tip: before any manual activity on the torch, the wire tip must be cut cleanly and burr-free with a suitable pair of side cutters; the tool is to be made available at the workplace.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) from the wire tip. The wire has to protrude from the contact tube for the arc. The automatic retraction after each cycle and the inching mode on the hold-to-run principle (step 1), the length limitation by the torch protection cap, the lock-out of the automatic wire feed when the maintenance door is open and the wire cutter of the torch cleaning station (step 2) limit the exposed wire length to the process dimension. Threading the wire when changing the wire and working on the torch remain manual tasks in which the hand necessarily works at the wire; a protective device between hand and wire cannot be applied for these tasks, so a further step 1 or step 2 measure is not practicable. The remaining puncture or cut injury is reversible. It is countered in step 3 by cut-resistant gloves in accordance with EN 388, cleanly cutting off the wire tip before any manual task, restriction to instructed personnel and sign W022 on the torch holder and the wire feed unit (operating instructions chapters 2.4 and 2.6).

No. 10 Mechanical — Risk before: S 3 · O 3 · **RS 9**

Hazard of tripping, slipping and falling in the area of the loading station and the maintenance aisle due to weld spatter on the floor, cables, hoses (compressed air, shielding gas) and wet areas during cleaning work.

Sub-machine: Loading station / maintenance aisle · also in: Operation, Setting up, Maintenance, Troubleshooting · Suggested with AI assistance

Step 1 · Inherently safe design measures	Keep cables and hoses (compressed air, shielding gas) out of the floor area of the loading station and maintenance aisle by design, by routing them in cable ducts, energy chain systems or ceiling-suspended cable management systems, so that no trip hazards arise. Design connections at the loading station as ceiling pendants or wall-mounted socket panels. Reduce weld-spatter exposure on the floor by means of design-integrated shielding plates (spatter-protection shields) at the welding station, so that discharge into the operator area is minimised. The hall floor is not part of the scope of supply; the requirement for the installation site (anti-slip floor covering) is passed on to the user in Step 3.
Step 2 · Safeguarding and/or complementary protective measures	Limit the residual risk from remaining trip and slip hazards by means of the following technical measures: (1) Floor markings (yellow/black in accordance with German ASR A1.3) to identify traffic routes and hazard zones in accordance with (EU) 2023/1230 Annex III, section 1.5.15. (2) Adequate fixed lighting of the loading station and maintenance aisle in accordance with (EU) 2023/1230 Annex III, section 1.1.4, so that obstacles and wet areas can be detected at an early stage; the machine-integrated lighting in accordance with EN 1837 provides 500 lx at the loading station and 200 lx in the maintenance aisle. (3) Spatter-protection mats in the immediate welding area that are easy to remove and clean.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): (1) Reference to the hazard of tripping and slipping due to weld spatter, hoses and wet conditions; prescribe cleaning intervals and cleaning procedures for the floor area. (2) Qualification requirement: all persons entering the loading station and maintenance aisle must have been instructed in the hazards and the traffic-route layout. (3) PPE specification: safety footwear with anti-slip soles (S3 in accordance with EN ISO 20345) shall be worn when entering the loading station and maintenance aisle. (4) Warning labelling at the access to the loading station and maintenance aisle: affix warning sign W011 'Warning; Slippery surface' and mandatory sign M008 'Wear safety footwear' in accordance with EN ISO 7010:2020. (5) Requirement for the installation site: anti-slip floor covering at the loading station and in the maintenance aisle, slip resistance rating of at least R 11 in accordance with German DGUV Rule 108-003.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) due to tripping, slipping and falling. In step 1, cables and hoses have been routed out of the floor area, and spatter guards reduce the spatter carried out of the cell. What remains is welding spatter that reaches the floor through the opening, which is open for loading, and wet areas during cleaning. The opening has to remain open for loading, and the hall floor is not part of the scope of supply; further design measures on the machine do not reach these causes. After step 2, the traffic routes are marked, the loading station is lit with 500 lx and the maintenance aisle with 200 lx, and removable spatter mats are provided in the welding area; the test of trip and slip points has been passed. Any further technical measure would only replace the floor cleaning, which is specified as a daily task. The daily cleaning (operating instructions chapter 10.2), slip-resistant S3 safety footwear, signs W011 and W007 (chapter 2.4) and the requirement for a slip-resistant floor covering at the installation site (overview of residual risks, chapter 2.6) form the information for use.

No. 17 Thermal — Risk before: S 3 · O 3 · **RS 9**

Risk of burns from the hot welding torch and torch neck: The torch neck and the contact tip are strongly heated after the welding process; when changing the torch, during cleaning or during set-up without a cooling period, hands and fingers may be burned.

Sub-machine: Welding torch · also in: Maintenance, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Use of active torch cooling (water-cooled torch instead of an air-cooled torch): The continuous water cooling limits the thermal energy in the torch neck and at the contact tip by design to a significantly lower temperature level. Additionally: The torch holder and the change system are designed such that the operator, when changing the torch, touches only thermally decoupled grip areas (plastic or ceramic handle, no direct metal contact with the torch neck). Design in accordance with EN ISO 13732-1:2008 (burn threshold for bare metal around 51 °C for a contact period of 1 min and 48 °C for 10 min).
Step 2 · Safeguarding and/or complementary protective measures	1. Cooling-time monitoring: a temperature sensor on the torch neck reports to the machine control system; the HMI indicates the release for torch changes and cleaning only once the temperature has fallen below the limit value. The function is an operational interlock without a PL requirement under EN ISO 13849-1; no risk reduction is credited to it. 2. Guard: the welding area is enclosed by the safety fence with welding-light-opaque infill panels and welding protection viewing windows (EN ISO 14120:2015); access to the torch for maintenance and cleaning is provided exclusively via the secured maintenance door (SF-01, PLr d). Unintentional access to the hot torch during automatic operation is thereby excluded by design. 3. Provision of a torch rest with a thermally insulated receptacle (ceramic or silicone pad) immediately at the welding station, so that the torch is placed down in a defined manner after the process and is not set down on conductive metal surfaces.
Step 3 · Information for use	1. Operating instructions: state the cooling time after the end of welding explicitly before any torch change, cleaning or set-up work on the torch (reference value as specified by the torch manufacturer); include a procedure for torch changes with the step 'wait for cooling time or check temperature'. 2. Warning labelling: permanently and clearly affix the warning sign 'Warning; Hot surface' (W017 in accordance with EN ISO 7010:2020) to the torch area and to the maintenance door. 3. Qualification: only instructed persons may carry out torch changes and cleaning; instruction covers the risk of burns, cooling times and correct use of PPE. 4. PPE specification: heat-protection gloves (suitable for contact heat, protection class in accordance with EN 407) are mandatory during torch changes, cleaning and set-up work on the torch; this requirement shall be stated in the operating instructions and indicated by the mandatory sign 'Wear protective gloves' (M009 in accordance with EN ISO 7010:2020) at the maintenance door.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 20 Materials/substances — Risk before: S 4 · O 4 · **RS 16**

Hazard from inhaling welding fumes and vapours (metal oxides, manganese, iron oxides): MAG welding of structural steel generates harmful particles and gases; when extraction is inadequate (saturated filter cartridge, system switched off), concentrations in the operator's breathing zone exceed the workplace exposure limits.

Sub-machine: Overall installation (extraction / welding area) · also in: Operation, Setting up, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Substitution of the welding consumable: Use of solid-wire electrodes with a demonstrably reduced manganese content (low-Mn alloy, e.g. Mn content < 1.0 % in accordance with the safety data sheet) instead of flux-cored wire electrodes or high-manganese wires, to the extent that the welding task (structural steel, weld quality) permits this. In addition: optimisation of welding parameters (arc voltage, wire feed speed, shielding gas composition) to a low-fume setting in accordance with the welding power source manufacturer's recommendation, in order to minimise fume generation at source. Both measures reduce the emitted pollutant mass and thereby the probability of a harmful exposure; the severity of the possible harm remains unchanged.
Step 2 · Safeguarding and/or complementary protective measures	Technical ventilation and extraction in accordance with EN ISO 21904-1:2020 (welding fume extraction): Capture of the welding fume by the capture hood above the welding area with a volumetric flow rate of 1800 m³/h, which ensures the capture velocity at the point of generation. The extraction system must be equipped with filter monitoring (differential-pressure switch) that triggers an alarm when the filter cartridge is saturated or the extraction is faulty; the cell stops in a controlled manner and can be restarted only after the fault has been rectified (operational interlock without a PL requirement under EN ISO 13849-1, no risk reduction is credited to it). Shielding of the welding area by the safety fence with welding-light-opaque infill panels (EN ISO 14120:2015) and the dividing centre wall of the turntable, in order to minimise fume escape into the operator area. Ambient air monitoring for welding fume concentration at the loading station is recommended as an additional measure by the user.
Step 3 · Information for use	Operating instructions (in accordance with (EU) 2023/1230 Annex III, section 1.7.4): Specification of the welding fume types emitted and reference to the workplace exposure limits to be observed in accordance with TRGS 900 and TRGS 528; instruction for regular inspection and replacement of filter cartridges (maintenance interval in accordance with manufacturer's specification EN ISO 21904-1:2020); prohibition of welding operation when the extraction system has failed or is switched off. Warning signs at the welding area: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Harmful welding fume' and mandatory sign 'Wear respiratory protection' (M017) as residual risk marking. PPE requirement: FFP3 particle filtering half mask in accordance with EN 149 or powered air-purifying respirator for set-up, maintenance and cleaning work in the welding area when the extraction system is switched off. Qualification requirement: operators and set-up personnel must be instructed in the hazards of welding fumes and the correct operation of the extraction system (TRGS 528 section 5).

Risk after: S 4 · O 2 · **RS 8 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 8 (S 4, O 2) from welding fumes. The severity results from the properties of the welding fumes (metal oxides, manganese) and remains unchanged; the MAG process is the purpose of the machine and cannot be substituted. In step 1, low-manganese solid wire, as far as the welding task permits, and low-fume parameters are provided. After step 2, the hood above the welding area captures the fumes at 1,800 m³/h, the cell stops in a controlled manner if the extraction is faulty or the filter cartridge is saturated (fault alarm threshold 1,400 m³/h), separation takes place in class W3, and the safety fence and dividing centre wall shield the loading station; capture, effectiveness and separation class have been tested. A complete enclosure is not possible because the loading opening has to remain open for manual loading, and the extraction is switched off during work in the welding area; no further step 1 or step 2 measure for this residual exposure has been identified. The remaining risk consists of residual emissions at the loading station and exposure during set-up, maintenance and cleaning work. FFP3 respiratory protection for this work, the prohibition of welding without effective extraction, filter maintenance and the user's obligations under TRGS 528 are stated in the operating instructions (chapters 1.2, 2.6, 9.1 and 10.2).

No. 22 Materials/substances — Risk before: S 3 · O 2 · **RS 6**

Hazard from filter dust when changing the filter cartridge of the welding fume extraction unit: The filter cartridge contains separated welding fumes with metal oxides and fine particles; when changed without appropriate respiratory protective measures, dusts are released and inhaled.

Sub-machine: Welding fume extraction (filter unit) · also in: Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Dust retention by design during filter change: The filter unit is equipped with an integrated bag-in/bag-out system, so that the contaminated filter cartridge can be removed and sealed in a closed plastic bag without direct contact with dust. By design, this minimises dust release at the source (substitution of open removal by a closed change procedure in accordance with EN ISO 12100 section 6.2.4). Additionally: the cleaning pulse (pressure burst) prior to the change is to be permitted ONLY with the housing closed and the extraction system deactivated, in order to compact dust deposits in the cartridge and reduce release when opening.
Step 2 · Safeguarding and/or complementary protective measures	Technical protective measures for the remaining residual risk (residual dust when opening the housing and handling the cartridge): 1. Extraction housing with negative-pressure interlock: The filter housing may by design only be opened when the fan is switched off and the system is depressurised (mechanical interlock, no safety function with PLr requirement, as no motion drive is involved). 2. Local extraction at the change location: A connection stub for a mobile extraction unit (industrial vacuum cleaner dust class H in accordance with EN 60335-2-69, suitability for welding fume dusts) is to be provided on the filter housing; this is activated during the change and captures released residual particles. 3. Labelling of the filter unit: General warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text "Harmful dust" to be permanently affixed to the filter housing.
Step 3 · Information for use	1. Operating instructions (Chapter 10.2): Detailed step-by-step instruction for the filter change with description of the bag-in/bag-out procedure; information on the composition of the separated dusts (metal oxides, fine particles, possibly CMR substances depending on the weld material); disposal note (contaminated filter cartridges to be disposed of as hazardous waste in accordance with applicable waste regulations). 2. Qualification requirement: Filter change to be carried out only by trained specialist personnel who have been informed of the hazard from welding fume dusts. 3. PPE specification: During the filter change, the following must be worn as a minimum: FFP3 particle filtering half mask in accordance with EN 149 for fine particles and metal oxides; protective gloves (chemical-resistant); safety spectacles (particle protection). PPE requirements are to be specified permanently in the operating instructions and by means of a mandatory sign 'Wear respiratory protection' (M017 in accordance with EN ISO 7010:2020) on the filter housing. 4. Reference to occupational health and safety legislation: The user is to be advised of their obligations under TRGS 528 (welding operations) and the German Hazardous Substances Ordinance (GefStoffV), in particular regarding the risk assessment for CMR dusts and the provision of suitable PPE.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 27 Ergonomic — Risk before: S 2 · O 3 · **RS 6**

Insufficient lighting at the loading station and in the maintenance aisle: inadequate illuminance makes it difficult to load and unload workpieces safely and to carry out maintenance work, and increases the risk of errors and accidents.

Sub-machine: Loading station / maintenance aisle · also in: Operation, Setting up, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Machine-integrated workplace lighting at the loading station and in the maintenance aisle to be provided as part of the design: luminaires are permanently integrated into the machine structure (built into the frame of the safety fence) so that the illuminance at the loading station and in the maintenance aisle is permanently ensured independently of the hall lighting. The design is carried out in accordance with EN ISO 12100:2010 section 6.2.8 (ergonomics) in conjunction with EN 1837 (machine-integrated lighting); the lighting as built provides 500 lx at the loading station, 200 lx in the maintenance aisle. The integration into the design eliminates dependence on external lighting sources that may be inadequate.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk from failure or shadowing of the integrated luminaires: monitoring of the operational readiness of the workplace lighting by the machine control system (notification in the event of lamp failure). In addition, maintenance aisle areas to be marked with retroreflective yellow and black floor markings in accordance with the German workplace rule ASR A1.3 (trip hazards, aisle boundaries) and with the warning sign W007 'Warning; Floor-level obstacle' in accordance with EN ISO 7010:2020 at trip hazards. A safety function within the meaning of EN ISO 13849-1 is not required for lighting monitoring; in the event of a lighting failure, work is to be discontinued (Step 3).
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): specification of the illuminance of the workplace lighting: 500 lx at the loading station and 200 lx in the maintenance aisle; notice that work is to be discontinued in the event of failure of the integrated lighting until the lighting has been restored. Text sign on the maintenance door: 'Stop work if the lighting fails'. Qualification requirement: maintenance personnel must be instructed in checking the lighting function before commencing work. Use suitable portable luminaires for brief inspections in the event of a lighting failure; resume regular work only after the lighting has been restored.

Risk after: S 2 · O 1 · **RS 2 (Low)** Residual risk accepted: Yes, 18/08/2026

Troubleshooting (15 hazards)

No. 1 Mechanical

Risk before: S 5 · O 3 · **RS 15**

Crushing and shearing hazard from the turntable during the automatic rotation: Body parts of the operator (hands, arms) may be drawn in and crushed between the turntable and the fixed dividing centre wall or the safety fence, in particular when reaching into the turntable during rotation to reposition a displaced workpiece (reasonably foreseeable misuse).

Sub-machine: Turntable (rotary unit) · also in: Operation, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Design the gap dimensions between the turntable edge and the fixed dividing centre wall as well as the safety fence such that no crushing points arise: the gaps must not be smaller than the minimum gaps in EN ISO 13854:2019 Table 1 (25 mm for fingers, 100 mm for the hand, 120 mm for the arm, 500 mm for the body). Alternatively, keep the gap so small that no part of the body can enter it (opening sizes in accordance with EN ISO 13857:2019 Table 4). Where neither of the two gap sizes can be achieved, the geometry of the table frame must be configured so that no converging wedge shape is created (parallel or diverging flanks instead of a converging gap). In addition: reduce the mass and rotation speed of the turntable to the functionally necessary minimum (drive design) in order to limit the kinetic energy acting in the crushing gap.
Step 2 · Safeguarding and/or complementary protective measures	Residual risk after Step 1: The rotation range remains a hazard zone that must not be entered while the drive is running. Technical protective measures: 1. Release of the rotary movement only when the rotation range is clear (SF-04, PLr e, EN ISO 13849-1:2023): ESPE (light curtain type 4 in accordance with EN IEC 61496-1:2020) monitors the rotation range completely; arrangement and safety distance in accordance with EN ISO 13855:2024. 2. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release (SF-01, PLr d; stop category 1 in accordance with EN 60204-1:2018). 3. Set-up mode: rotary movement only at safely reduced speed of 250 mm/s and with the enabling device actuated (SF-05, PLr d, stop category 1 in accordance with EN 60204-1:2018). 4. Emergency stop in the operator area in accordance with EN ISO 13850:2015, integrated into SF-03 (PLr d, stop category 1 in accordance with EN 60204-1:2018). 5. Energy isolation prior to interventions: isolating valve with mechanical latching (lockout) in accordance with EN ISO 4414:2010; lock the turntable positively in its end position (EN ISO 14118:2018).
Step 3 · Information for use	1. Operating instructions: entering the rotation range while the turntable is running or unsecured is prohibited. Before any intervention (e.g. repositioning a workpiece), the system must be completely switched off and secured (lockout/tagout). A separate procedure with an enabling device applies to set-up mode and is described in the operating instructions. 2. Warning signs on the machine: the following signs are affixed to the turntable: warning signs W019 'Warning; Crushing' and W024 'Warning; Crushing of hands' and prohibition sign P015 'No reaching in' (in accordance with EN ISO 7010:2020). 3. Who may intervene: set-up and fault rectification may only be carried out by trained personnel. Training must be repeated at least once a year and recorded in writing. 4. Personal protective equipment: protective gloves do not protect against crushing. Reach into the rotation range only when the turntable has been stopped. Safety footwear S3 in accordance with EN ISO 20345 is mandatory throughout the entire area of the installation.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Warning: crushing

Justification of acceptance: Residual risk RS 5 (S 5, O 1). The severity remains 5: the mass and drive of the turntable are required for the 180-degree rotation with a payload of up to 2 x 40 kg plus clamping fixtures in a cycle of around 90 seconds and have already been limited to the functionally necessary level in step 1; the gaps are designed in accordance with EN ISO 13854:2019 and EN ISO 13857:2019, and the table edges have no converging wedge shape. Any further reduction of the energy would prevent the rotation. After step 2, the table only rotates when the rotation range is clear (SF-04, PL e), the maintenance door is guard-locked (SF-01, PL d), set-up mode is limited to 250 mm/s with enabling device (SF-05), and the table is positively locked before any intervention. An accident therefore requires deliberate reaching into the rotating table while bypassing these devices; no additional step 1 or step 2 measure has been identified that would make this misuse more difficult without preventing the rotation. The prohibition and the obligation to isolate before every intervention are stated in the operating instructions (chapters 2.2, 2.6 and 9.1), and signs W019, W024 and P015 are affixed to the turntable.

No. 4 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Crushing hazard at the interface between the turntable and the welding robot (transfer area): During the rotation the loaded fixture moves into the working area of the robot; uncoordinated entry of the robot into the rotation range or missing interlock between the turntable movement and the robot enable can lead to collisions and crushing injuries.

Sub-machine: Interface: turntable / welding robot · also in: Operation, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	The rotation radius of the turntable and the working space boundary of the robot (TCP envelope) are coordinated with each other during the design phase such that the maximum rotation range of the fixture and the minimum robot working space maintain a geometric minimum distance of >= 500 mm (minimum gap to avoid crushing of the body in accordance with EN ISO 13854:2019 Table 1) from each other when both movements would be active simultaneously. This minimises the overlap zone by design; complete elimination of the overlap is not possible with this system topology due to functional constraints, so that the remaining residual overlap is safeguarded by Step 2.
Step 2 · Safeguarding and/or complementary protective measures	SF-04 'Enable of the 180-degree rotary movement of the turntable only when the rotation range is clear' with PLr e in accordance with EN ISO 13849-1:2023 (risk graph: S2/F2/P2). Implementation as an interlocked safety function in the safety PLC: (a) Robot standstill monitoring: the robot must be in a defined rest position outside the rotation range and must confirm this via a safe feedback signal (safe output of the robot controller in accordance with EN ISO 10218-2:2025 sections 5.4.7 and 5.5.8) before the turntable enable is granted. (b) Turntable enable to the robot: as long as the turntable is not in its end position and locked, the robot controller receives no enable signal for the entry area; the turntable is positively locked in its end position. (c) Guard locking of the maintenance door to the rotation range in accordance with EN ISO 14119:2025 with escape release, incorporated in SF-01 (PLr d). (d) Emergency stop of the overall installation in accordance with EN ISO 13850:2015, incorporated in SF-03 (PLr d), stop category 1 in accordance with EN 60204-1:2018. (e) In set-up mode SF-05 applies: safely reduced speed <= 250 mm/s with enabling device (PLr d); the set-up personnel may enter the rotation range only with the enabling device actuated and at reduced speed. The distance of the safety fence from the rotation range complies with EN ISO 13857:2019 Table 2; the safety fence is designed in accordance with EN ISO 14120:2015.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the interlock logic SF-04 and the operating modes Automatic and Set-up; explicit notice that entering the rotation range while the system is running is prohibited. Set-up mode: qualification requirement to be documented (only trained specialist personnel with knowledge of the enabling device). Warning labelling at the rotation range: warning signs W019 'Warning; Crushing' and W024 'Warning; Crushing of hands' in accordance with EN ISO 7010:2020; at the maintenance door additionally the supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006). PPE specification in the operating instructions: safety footwear S3 in accordance with EN ISO 20345; in set-up mode additionally close-fitting protective clothing (no entanglement risk from loose clothing). Note on residual risk in set-up mode and fault-finding: always keep the enabling device actuated, never enter the rotation range without the enabling device.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) at the transfer between turntable and robot. The robot has to reach the station that has just been rotated in; a complete geometric separation of the rotation range and the robot working space is therefore not possible for functional reasons with this installation layout. In step 1, the overlap has been reduced by a minimum distance of 500 mm between the rotation radius and the TCP envelope. The remaining overlap is mutually interlocked: the turntable only rotates when the robot controller confirms the rest position outside the rotation zone via a safe output, and the robot is only released when the table is locked in its end position (SF-04, PL e according to risk graph S2/F2/P2). An accident therefore requires a failure of this interlock or entry while the installation is running by defeating the guard locking (SF-01). The enabling is already implemented at the required performance level; a further step 1 or step 2 measure would not measurably reduce the probability of occurrence. In set-up mode SF-05 applies with 250 mm/s and enabling device. The interlocking logic, the prohibition of entry and the behaviour in set-up mode are described in the operating instructions (chapters 2.5, 2.6 and 9.3).

No. 5 Mechanical

Risk before: S 4 · O 3 · **RS 12**

Falling of workpieces or fixture parts due to failure of the pneumatic clamping device: In the event of compressed air failure or leakage, the clamping elements open in an uncontrolled manner; workpieces of up to 40 kg may fall from the turntable and strike persons at the loading station.

Sub-machine: Pneumatic clamping device (turntable) · also in: Operation, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Use of pneumatically closing clamps with a pilot-operated non-return valve (pressure-holding valve) in the clamping line directly at the clamping cylinder: in the event of compressed air failure or a leak in the supply line, the clamping pressure remains trapped in the cylinder and the workpiece remains clamped; the clamps open only when the valve is actively pilot-opened. The clamping force is designed for the maximum workpiece weight of 40 kg plus a safety factor in accordance with EN ISO 4414:2010. Additionally: limitation of the operating pressure to the level required for the clamping function, in order to minimise the stored pneumatic energy (EN ISO 4414:2010).
Step 2 · Safeguarding and/or complementary protective measures	1. Clamping pressure monitoring with safety function: a pressure switch in the clamping line monitors the clamping pressure; if the pressure falls below the minimum clamping pressure, the enable for the rotary movement of the turntable is inhibited (linked to SF-04, PLr e in accordance with EN ISO 13849-1:2023). As long as the clamping pressure has not been confirmed, the turntable does not rotate. 2. Mechanical interlock of the rotary motion: Positive locking of the turntable in the loading position, so that unintended rotation with a clamped or loose workpiece is prevented; the interlock is released only after the clamping pressure has been confirmed (interlocked with SF-04, PLr e). 3. Enclosure/catch device: Mechanical catch device (deflector plate) below the turntable, designed for the maximum workpiece weight of 40 kg and the maximum drop height, to keep falling parts away from the loading station; design in accordance with EN ISO 14120:2015. 4. Safety distance at the loading station: Arrangement of the loading station such that the hazard zone below the turntable is outside the regular area of presence.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the clamping principle (pneumatically closing clamps with pressure-holding valve) and the clamping pressure monitoring; prohibition of remaining beneath the turntable during operation and during fault-finding without secured standstill; procedure in the event of compressed air failure (shut down the machine, restore the compressed air supply, remove the workpiece only after a pressure check). 2. Energy isolation prior to interventions: Instruction for complete pressure relief of the pneumatic system prior to maintenance and servicing work in accordance with EN ISO 4414:2010 and EN ISO 14118:2018 (prevention of unexpected restart and unexpected energy release); because of the pressure-holding valve, the clamping pressure remains trapped in the clamping cylinders, so the clamps must be opened and depressurised before any work on the clamping device; provide a shut-off and exhaust valve with lockout facility. 3. Warning labelling: Attach warning signs W015 'Warning; Overhead load' and W024 'Warning; Crushing of hands' in accordance with EN ISO 7010:2020 to the turntable and at the loading station. 4. Qualification: Fault-finding and set-up work to be carried out by trained specialist personnel only; requirements to be specified in the operating instructions. 5. PPE: Prescribe the wearing of safety footwear (S3 in accordance with EN ISO 20345) at the loading station as residual risk protection.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 6 Mechanical — Risk before: S 5 · O 3 · **RS 15**

Hazard of crushing and impact due to unexpected restart of the turntable or the robot after an emergency stop or after fault clearance: if a coordinated restart prevention system (EN ISO 11161) is absent, individual sub-machines may start up automatically while persons are still present in the hazard zone.

Sub-machine: Overall installation (restart coordination) · also in: Maintenance, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: restart after an emergency stop or after fault clearance is a control-system event that cannot be eliminated by design, given the functional principle of the overall installation (coordinated automatic operation of robot and turntable) without cancelling the machine function. No geometric or energetic measure exists that would prevent the restart itself without abolishing the machine function. Protection must therefore be achieved entirely through Step 2 measures (control system and interlocking).
Step 2 · Safeguarding and/or complementary protective measures	1. Coordinated restart prevention in accordance with EN ISO 11161:2007+A1:2010: the overall installation control system shall not release the restart of a sub-machine (turntable, robot) until a deliberate, manual restart command has been issued from a safe position outside all hazard zones. The restart command shall not be triggered automatically following acknowledgement of the emergency stop or following fault clearance. 2. Safety function SF-01 (safe stop, stop category 1 on opening of the maintenance door, PLr d in accordance with EN ISO 13849-1:2023) and SF-03 (emergency stop of the overall installation, stop category 1, PLr d in accordance with EN ISO 13849-1:2023) ensure that all drives are safely brought to a standstill. The restart prevention is implemented as an integral part of safety functions SF-01, SF-03 and SF-04 and is executed at their respective PLr (SF-04: PLr e; SF-01 and SF-03: PLr d in accordance with EN ISO 13849-1:2023). 3. Safety function SF-04 (release of the 180-degree rotary movement of the turntable only when the rotation range is clear, PLr e in accordance with EN ISO 13849-1:2023): the turntable may only execute its rotary movement when the rotation range has been detected as clear by the Type 4 light curtain in accordance with EN IEC 61496-1:2020 (positioned in accordance with EN ISO 13855:2024). This function remains active after restart and prevents start-up in the presence of persons. 4. Safety function SF-05 (safely reduced speed of 250 mm/s with enabling device in set-up mode, PLr d in accordance with EN ISO 13849-1:2023): in set-up mode, restart shall be released exclusively via an enabling device (3-position in accordance with EN ISO 10218-2:2025 section 5.7.7), so that an unexpected restart at full speed is excluded. 5. De-energisation and energy isolation in accordance with EN ISO 14118:2018: before entering the hazard zone for fault-finding or maintenance, the energy supply to all relevant drives (electrical, pneumatic in accordance with EN ISO 4414:2010) shall be disconnected by means of a lockable isolating device and secured against unintentional re-energisation (lockout/tagout). Residual energy (stored pneumatic energy) shall be dissipated before any intervention; the turntable shall be positively locked in its end position. 6. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release: the guard locking keeps the maintenance door closed as long as hazardous movements have not been safely brought to a standstill (stop category 1 completed). Integration is carried out within the scope of SF-01 (PLr d).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the restart sequence after an emergency stop and after fault clearance; explicit statement that restart is permissible only after all hazard zones have been fully vacated and a manual acknowledgement command has been issued from outside. Description of the lockout/tagout procedure in accordance with EN ISO 14118:2018 for all maintenance and fault-finding activities. 2. Warning labelling at the maintenance door and at the acknowledgement units: warning of unexpected restart (warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020), notice of the obligation to acknowledge from outside. 3. Qualification requirement: set-up and maintenance activities may only be carried out by instructed specialist personnel who have been trained in the restart procedure and the lockout/tagout method (EN ISO 10218-2:2025 section 7.5.12). 4. PPE specification: safety footwear (S3 in accordance with EN ISO 20345) shall be worn when entering the hazard zone for fault-finding or maintenance; additional PPE as determined by the user's workplace risk assessment.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to unexpected restart. The restart is a control event of the coordinated automatic operation of robot and turntable; there is no design measure that prevents it without defeating the function of the cell (step 1). After step 2, the overall control system only enables the restart in accordance with EN ISO 11161:2007+A1:2010 upon a deliberate command from the control desk outside the danger zones, the restart interlock is part of SF-01, SF-03 (PL d) and SF-04 (PL e), the rotation enable checks the rotation range also after the restart, and the lockout device for personal padlocks prevents the maintenance door from being closed while a person is inside the cell. For fault-finding and maintenance, the lockable main switch and the lockable compressed air valve with exhaust function in accordance with EN ISO 14118:2018 are provided. The remaining risk is a start-up when a person neither attaches their padlock nor isolates the installation and the restart interlock fails at the same time. A technical measure that replaces isolation by the person is not available according to the state of the art. The restart sequence and the isolation procedure are described in the operating instructions (chapters 9.5 and 10.4).

No. 7 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Missing or uncoordinated emergency stop function between sub-machines (robot, turntable, welding power source, extraction system): an emergency stop at one sub-machine does not necessarily stop all other sub-machines; persons may be endangered by components that continue to run.

Sub-machine: Overall installation (emergency stop coordination) · also in: Operation, Setting up · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the coordination of several independent controllers necessarily requires a higher-level control logic. A pure design measure (geometry, energy limitation, substitution) cannot replace the missing interconnection of the emergency stop circuits. The functional principle of the overall installation necessitates active control coordination.
Step 2 · Safeguarding and/or complementary protective measures	Higher-level emergency stop circuit (SF-03) in accordance with EN ISO 13850:2015 and EN ISO 11161:2007+A1:2010: all emergency stop devices of the overall installation are integrated into a common, higher-level safety circuit which, on actuation at any point, brings all hazardous sub-machines (robot, turntable, welding power source, pneumatics) to a coordinated standstill; the extraction system runs on for operational reasons. Stop category 1 in accordance with EN 60204-1:2018 (controlled stopping, followed by energy disconnection): the robot performs a controlled stop along its path, the turntable brakes actively, the welding power source is de-energised, and the clamps remain clamped by the pressure-holding valve. The run-on of the extraction system is not a safety function, but is operationally required. Safety function SF-03 is specified with PLr d in accordance with EN ISO 13849-1:2023 and implemented in Category 3 with PL d. Integration of the robot is carried out via the robot controller in accordance with EN ISO 10218-2:2025 section 5.3.3 (span of control of the emergency stop, safety interface to the higher-level controller). Emergency stop devices are to be designed in accordance with EN ISO 13850:2015 (mushroom-head pushbutton, yellow background, self-latching, release only by deliberate action). Emergency stop devices are to be positioned such that at least one emergency stop device is reachable from every operating station without exposure to a hazard (EN ISO 13850:2015). Restart interlock: after an emergency stop, a manual reset is required before the installation can restart (EN ISO 13850:2015 section 4.1.4), in order to prevent unexpected restart in accordance with EN ISO 14118:2018.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): description of the emergency stop topology of the overall installation with a layout plan of all emergency stop devices and the area of effect of each emergency stop device. Clear instruction that after an emergency stop, the hazard zone of all sub-machines must be inspected before the reset is carried out. Set-up mode and fault-finding: instruction that intervention in the hazard zone is only permissible after all sub-machines have come to a complete standstill and the maintenance door has been secured against closing (personal padlock in the lockout device). Qualification requirement: set-up and fault-finding only by instructed specialist personnel who are familiar with the emergency stop topology. Marking at the control desk: text sign stating the area of effect of the emergency stop devices (the emergency stop acts on all sub-machines of the cell), supplemented by warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) in the coordination of the emergency stop. Linking the emergency stop circuits of several sub-machines is only possible by means of the control system; there is no step 1 measure for this. A higher-level emergency stop circuit SF-03 in category 3 with PL d is implemented, which stops robot, turntable, welding power source and pneumatics together from every emergency stop device (control desk, maintenance door, teach pendant), with manual reset in accordance with EN ISO 13850:2015 and scope of effect in accordance with EN ISO 11161:2007+A1:2010; the required performance level is achieved and the emergency stop test items have been passed. The remaining risk is the overrun during the controlled stop in stop category 1. This category has been chosen because the robot brakes under control along its path and the clamps hold the workpiece via the pressure-holding valve; a stop in category 0 would give up this control without eliminating the overrun. The emergency stop is a complementary protective measure and does not replace any safeguard. The arrangement and scope of effect of the emergency stop devices are stated in the operating instructions (chapters 2.5 and 9.5) and on the text sign at the control desk.

No. 10 Mechanical — Risk before: S 3 · O 3 · **RS 9**

Hazard of tripping, slipping and falling in the area of the loading station and the maintenance aisle due to weld spatter on the floor, cables, hoses (compressed air, shielding gas) and wet areas during cleaning work.

Sub-machine: Loading station / maintenance aisle · also in: Operation, Setting up, Maintenance, Cleaning · Suggested with AI assistance

Step 1 · Inherently safe design measures	Keep cables and hoses (compressed air, shielding gas) out of the floor area of the loading station and maintenance aisle by design, by routing them in cable ducts, energy chain systems or ceiling-suspended cable management systems, so that no trip hazards arise. Design connections at the loading station as ceiling pendants or wall-mounted socket panels. Reduce weld-spatter exposure on the floor by means of design-integrated shielding plates (spatter-protection shields) at the welding station, so that discharge into the operator area is minimised. The hall floor is not part of the scope of supply; the requirement for the installation site (anti-slip floor covering) is passed on to the user in Step 3.
Step 2 · Safeguarding and/or complementary protective measures	Limit the residual risk from remaining trip and slip hazards by means of the following technical measures: (1) Floor markings (yellow/black in accordance with German ASR A1.3) to identify traffic routes and hazard zones in accordance with (EU) 2023/1230 Annex III, section 1.5.15. (2) Adequate fixed lighting of the loading station and maintenance aisle in accordance with (EU) 2023/1230 Annex III, section 1.1.4, so that obstacles and wet areas can be detected at an early stage; the machine-integrated lighting in accordance with EN 1837 provides 500 lx at the loading station and 200 lx in the maintenance aisle. (3) Spatter-protection mats in the immediate welding area that are easy to remove and clean.
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): (1) Reference to the hazard of tripping and slipping due to weld spatter, hoses and wet conditions; prescribe cleaning intervals and cleaning procedures for the floor area. (2) Qualification requirement: all persons entering the loading station and maintenance aisle must have been instructed in the hazards and the traffic-route layout. (3) PPE specification: safety footwear with anti-slip soles (S3 in accordance with EN ISO 20345) shall be worn when entering the loading station and maintenance aisle. (4) Warning labelling at the access to the loading station and maintenance aisle: affix warning sign W011 'Warning; Slippery surface' and mandatory sign M008 'Wear safety footwear' in accordance with EN ISO 7010:2020. (5) Requirement for the installation site: anti-slip floor covering at the loading station and in the maintenance aisle, slip resistance rating of at least R 11 in accordance with German DGUV Rule 108-003.

Risk after: S 3 · O 2 · **RS 6 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 6 (S 3, O 2) due to tripping, slipping and falling. In step 1, cables and hoses have been routed out of the floor area, and spatter guards reduce the spatter carried out of the cell. What remains is welding spatter that reaches the floor through the opening, which is open for loading, and wet areas during cleaning. The opening has to remain open for loading, and the hall floor is not part of the scope of supply; further design measures on the machine do not reach these causes. After step 2, the traffic routes are marked, the loading station is lit with 500 lx and the maintenance aisle with 200 lx, and removable spatter mats are provided in the welding area; the test of trip and slip points has been passed. Any further technical measure would only replace the floor cleaning, which is specified as a daily task. The daily cleaning (operating instructions chapter 10.2), slip-resistant S3 safety footwear, signs W011 and W007 (chapter 2.4) and the requirement for a slip-resistant floor covering at the installation site (overview of residual risks, chapter 2.6) form the information for use.

No. 11 Mechanical

Risk before: S 5 · O 2 · **RS 10**

Hazard arising from simultaneous access by several persons to different zones of the cell (EN ISO 11161): a second person is present inside the cell without the set-up personnel being aware of this; when the robot or the turntable starts up, the second person is struck.

Sub-machine: Overall installation (zone access) · also in: Setting up, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Inherently safe design measures exhausted: the functional principle of the overall installation requires accessible zones for set-up, maintenance and fault-finding work. The hazard arises from the simultaneous presence of several persons in different zones, which cannot be resolved by geometry, distance or energy limitation alone without defeating the operational purpose. A reduction of the robot or turntable energy to a level that safely excludes injury is not technically realisable with this type of installation.
Step 2 · Safeguarding and/or complementary protective measures	1. Protection of persons when several persons enter the cell, in accordance with EN ISO 11161:2007+A1:2010: the maintenance door has a lockout device for personal padlocks. Each person entering the cell attaches their personal padlock to the lockout device of the opened door. As long as a padlock is attached, the door cannot be closed and automatic mode cannot be started. Movements are then possible only in set-up mode, with the enabling device actuated and at safely reduced speed. Acknowledgement is possible only from outside, at the control desk. 2. Guard locking of the maintenance door in accordance with EN ISO 14119:2025 with escape release from the inside in accordance with EN ISO 14119:2025 section 6.9.1, so that persons trapped inside can leave the cell at any time. 3. The enabling of automatic start-up (robot and turntable) is implemented as a safety function: automatic start-up is possible only when the maintenance door is closed and held closed by the guard locking and acknowledgement has been given from outside. The access function is SF-01 (safe stop on opening of the maintenance door) with PLr d in accordance with EN ISO 13849-1:2023. Independently of this, the release of the turntable rotation remains safeguarded by SF-04 (PLr e). 4. In set-up mode, SF-05 applies (safely reduced speed of 250 mm/s with enabling device, PLr d in accordance with EN ISO 13849-1:2023). The enabling device is person-specific. The cell has exactly one enabling device, on the teach pendant; movements in set-up mode are therefore permitted only when nobody other than the person holding the enabling device is inside the cell (for the procedural instruction, see Step 3). 5. The safety distances between the robot working space and areas where persons are present comply with EN ISO 13857:2019 Table 2 and EN ISO 10218-2:2025 sections 5.4.6 and 5.8.9.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the protection of persons at the maintenance door (one personal padlock per person in the lockout device, escape release from the inside), and of the obligation to attach the padlock before entering and to remove it only after leaving the cell. Procedural instruction for multi-person operations (setting up, maintenance, fault-finding) with clear role assignment (responsible person, coordination). 2. Warning signs at the maintenance door: warning sign W018 'Warning; Automatic start-up' in accordance with EN ISO 7010:2020, text sign 'Attach your personal padlock before entering'. 3. Qualification requirement: Set-up and maintenance personnel must be instructed in the multi-person access concept and the use of the lockout device for personal padlocks and of the escape release. The instruction must be documented. 4. PPE specification in the operating instructions: Safety footwear S3 in accordance with EN ISO 20345, close-fitting protective clothing (no entanglement risk from loose clothing) when inside the cell.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) when several persons have access. Set-up, maintenance and fault-finding work require accessible zones; the hazard to a second person cannot be resolved by geometry or energy limitation (step 1). After step 2, every person entering attaches their personal padlock to the lockout device of the maintenance door; as long as a padlock is attached, the door cannot be closed and automatic mode cannot be started, and acknowledgement is only possible from outside (SF-01, PL d). Movements are then only possible in set-up mode with the single, person-bound enabling device and 250 mm/s (SF-05, PL d), and the escape release allows persons to leave from the inside at any time. This protection of persons follows EN ISO 11161:2007+A1:2010. The remaining risk is a person entering the cell without their own padlock while the set-up person initiates movements; even then, the installation only moves at reduced speed under the enabling device of the set-up person. Attaching the padlock remains an action of each individual person; no further step 1 or step 2 measure that prevents this misuse without restricting the set-up work has been identified. Procedure for work involving several persons, text sign at the door and instruction of personnel: operating instructions chapters 2.4, 2.5, 2.6 and 9.3.

No. 12 Electrical — Risk before: S 5 · O 2 · **RS 10**

Hazard from direct or indirect contact with live parts of the welding power source, the robot control cabinet and the cell control system (400 V AC, 32 kVA): Contact with terminals, cables or the interior of the control cabinet when the cabinet is open without isolation can lead to electric shock with ventricular fibrillation or burns.

Sub-machine: Electrical installation (control cabinet / welding power source) · also in: Maintenance, Commissioning · Suggested with AI assistance

Step 1 · Inherently safe design measures	All live parts inside the control cabinet (terminals, busbars, power terminals of the welding power source) are designed with touch-proof covers (degree of protection at least IP 2X or IPXXB in accordance with EN 60204-1:2018 section 6.2.2), so that contact with live parts is prevented by the enclosure form itself without the need for a guard. In addition, minimum clearances between live and accessible parts are designed such that the degree of protection IP 2X is maintained even with the cabinet door open (protective caps, insulating covers on terminal strips). This addresses (EU) 2023/1230 Annex III, section 1.5.1 (Electrical energy supply) by analogy, as well as EN 60204-1:2018 section 6.2.
Step 2 · Safeguarding and/or complementary protective measures	1. Isolation and de-energisation (LOTO): Main switch with lockable OFF position in accordance with EN 60204-1:2018 section 5.3 and EN ISO 14118:2018 (prevention of unexpected start-up / energy isolation). The main switch must disconnect the overall installation from the supply on all poles as an isolating device; residual voltage at the capacitors of the welding power source is to be limited to below 60 V DC within 5 s by means of a discharge time or active discharge circuit; where this is not achieved, a warning notice stating the discharge time is affixed to the enclosure (EN 60204-1:2018 section 6.2.4). Cabinet door interlock: The doors of the main control cabinets are fitted with a lock that can only be opened with a key and prevents unauthorised opening (EN 60204-1:2018 section 6.2.2). 2. Protective equipotential bonding and protective conductor: All control cabinet enclosures, the welding power source and the robot control cabinet are connected via a continuous protective conductor (PE) of adequate cross-section (EN 60204-1:2018 section 8.2), so that in the event of an insulation fault the fault current is safely dissipated and the protective device (circuit breaker / RCD) trips. 3. Residual current device (RCD): Use of an RCD (Type B, since DC fault currents from frequency inverters and the welding power source are possible) with a rated residual operating current of 30 mA for circuits on which persons are working; in circuits where an RCD is not compatible with the welding process, insulation monitoring is used instead (EN 60204-1:2018 sections 6.3.3 and 7.7). Not a safety function with a PLr requirement; the measures act passively and by design (warning labelling: see Step 3).
Step 3 · Information for use	Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Document the isolation procedure (LOTO) with a step-by-step instruction, including the discharge time of the capacitors of the welding power source and verification of the absence of voltage using a suitable measuring instrument (voltage tester Category CAT III 600 V). Qualification requirement: Work on the electrical installation may only be carried out by electrically skilled persons (ESP) in accordance with the German accident prevention regulation DGUV Regulation 3, or under the supervision of an ESP by electrically instructed persons. PPE specification: Insulating gloves (in accordance with EN 60903, class 00 for voltages up to 500 V AC), safety goggles (arc flash protection) and electrically insulating footwear are to be worn when working in an open cabinet. Warning labelling: Warning sign W012 'Warning; Electricity' in accordance with EN ISO 7010:2020 to be affixed permanently and clearly visible to all cabinet doors and to the welding power source. Residual risk note in the operating instructions: After operation of the main switch, capacitors in the welding power source and in the frequency inverter of the robot may still carry dangerous voltages (waiting time of at least 1 minute for the welding power source, for the robot drive as specified by the robot manufacturer); absence of voltage must always be verified by measurement.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) due to electrical voltage of 400 V AC. In step 1, the live parts are covered finger-safe (IP 2X in accordance with EN 60204-1:2018 section 6.2.2), also with the cabinet door open. After step 2, the lockable main switch disconnects all poles, the cabinet doors can only be opened with a key, the DC link of the welding power source discharges to no more than 60 V in a measured 1.9 s, protective conductor (0.08 Ω), fault loop impedance (0.28 Ω) and insulation resistance (> 100 MΩ) have been tested, and fault protection is provided by a type B RCD or insulation monitoring. The remaining risk is the work of the qualified electrician, who has to take measurements on live parts in the open cabinet during commissioning and fault-finding. These measurements cannot be carried out without voltage; for these life cycle phases no further step 1 or step 2 measure is therefore practicable, and the severity remains 5. The isolation procedure including verification of the absence of voltage, the qualification as a qualified electrician, insulating PPE and sign W012 are stated in the operating instructions (chapters 2.4, 2.6, 8.1 and 10).

No. 13 Electrical — Risk before: S 4 · O 2 · **RS 8**

Hazard from welding current at the workpiece and at the fixture: the welding circuit carries high currents (typically 100 to 350 A); in the event of a faulty earth connection or damaged insulation, persons who touch the workpiece or the fixture may receive an electric shock.

Sub-machine: Welding power source / fixture · also in: Setting up, Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	Design the fixture frame and workpiece holders such that touchable conductive surfaces that lie within the welding current circuit are galvanically isolated from the machine frame by design, using insulation (insulating plates made of glass-fibre epoxy between the fixture base plate and the machine table, as well as insulating clamping jaw inserts). By design, this interrupts the unintentional current path via the frame and touchable external surfaces. In addition: define the earth cable connection point directly on the workpiece or at a designated location on the fixture that is not touchable by the operator, and integrate it by means of shaping (recess, cable routing channel) in such a way that incorrect positioning of the earth clamp is impeded by design.
Step 2 · Safeguarding and/or complementary protective measures	1. Welding power source: The welding power source has protection class I and degree of protection IP23S in accordance with EN IEC 60974-1; integration into the protective conductor chain of the overall installation shall be carried out in accordance with EN 60204-1:2018 section 8 (protective conductor cross-sections, connection points). 2. Monitoring of the earth connection: The earth current monitoring of the welding power source is activated; in the event of interruption or an impermissibly high contact resistance, the welding process is inhibited. The function is an operational interlock without a PL requirement (not a safety function within the meaning of EN ISO 13849-1:2023); no risk reduction is credited for it. 3. Equipotential bonding: All conductive parts of the fixture that are not deliberately insulated are included in the protective equipotential bonding of the installation (EN 60204-1:2018 section 8.2). 4. Access restriction during the welding process: The loading station is safeguarded by the light curtain (SF-02, PLr e in accordance with EN ISO 13849-1:2023); during active welding, access to the welding area is prevented by the interlocked maintenance door (SF-01, PLr d) and the enable logic of the turntable (SF-04, PLr e), so that contact with live parts in automatic mode is prevented by both design and control-engineering means. 5. Cable management: Welding cables and earth cables are routed in enclosed cable ducts or protective conduits (protection against mechanical damage); minimum bending radii as specified by the manufacturer shall be observed; cables shall be secured with strain relief.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Description of the correct connection of the earth clamp (position, cleaning of the contact surface, permissible clamping areas); notice that touching the workpiece and the fixture during the welding process is prohibited; inspection intervals for insulation and cable condition (visual inspection every working day, six-monthly insulation measurement by an electrically skilled person, see Chapter 10.2). 2. Qualification requirement: Setting up, fault-finding and maintenance on the welding power source and its connections may only be carried out by an electrically skilled person or an electrically instructed person under the supervision of an electrically skilled person (terms as defined in EN 60204-1:2018 section 3.1). 3. Warning labelling on the fixture and in the welding area: Attach warning sign W012 'Warning; Electricity' in accordance with EN ISO 7010:2020 at a clearly visible location; attach a text sign 'Check earth clamp before commencing welding'. 4. PPE specification in the operating instructions: When setting up and fault-finding in the welding area, insulating gloves (protection class suitable for low voltage) and welding protective clothing shall be worn.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 21 Materials/substances — Risk before: S 4 · O 2 · **RS 8**

Hazard from shielding gas (argon-CO2 mixture M21) in the event of leakage: Argon and CO2 are heavier than air, so the shielding gas may accumulate near floor level; in the event of larger leakages in poorly ventilated areas, there is a risk of asphyxiation due to oxygen displacement.

Sub-machine: Shielding gas supply / piping system · also in: Operation, Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Pressure limitation in the piping system: Limit the operating pressure of the shielding gas supply to the minimum level required for the welding process (pressure regulator at the supply connection of the cell). A lower system pressure reduces the quantity of gas escaping in the event of a fault and thus the potential for accumulation. Additionally: design the pipe routing and connection points so that leakages are minimised by design: use of cutting ring fittings or press fittings instead of hose clamps on fixed pipe sections; reduce hose lengths to the minimum operationally necessary; no routing of pipes near floor level in pits or enclosed chambers (route near the ceiling where possible). These measures address the energy source (stored pressurised gas) and the hazard location (accumulation zone) directly.
Step 2 · Safeguarding and/or complementary protective measures	1. Automatic shut-off of the gas supply: Solenoid valve (de-energised closed) in the shielding gas supply line, which automatically shuts off the gas supply upon machine stop, emergency stop (SF-03) and during operating pauses; additionally, a manual shut-off valve outside the cell. 2. Leak monitoring: Plausibility check of gas consumption via the machine control system (indication when gas flow occurs without an active welding process, as a leakage indicator); daily visual inspection of hose connections as a maintenance requirement. 3. Installation of the shielding gas supply provided on site (cylinder bank or withdrawal station) in a ventilated area of the hall, not in pits, basements or confined recesses. If installed in poorly ventilated areas, the user is required to provide an oxygen warning device (note in the operating instructions). A safety function with a PLr requirement is not necessary for this hazard; the risk is controlled by means of shut-off, installation location and ventilation.
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Note on the risk of asphyxiation due to oxygen displacement in the event of larger leaks in poorly ventilated areas; requirement for adequate hall ventilation at the installation site; work on the gas supply only with the line shut off and depressurised (EN ISO 14118:2018). 2. Qualification: Work on compressed gas lines and fittings only by instructed specialist personnel; instruction in accordance with DGUV Rule 100-500 Chapter 2.26 and TRGS 528 (user's obligation). 3. Warning labelling: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Risk of asphyxiation from shielding gas' at the gas supply installation site; supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006) on locked supply areas. 4. When working in confined or poorly ventilated areas (e.g. cylinder changes in recesses): use a portable oxygen warning device; no lone working.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 23 Mechanical

Risk before: S 4 · O 3 · **RS 12**

Hazard from residual pneumatic energy during maintenance and fault-clearing work: After the compressed air supply is switched off, residual pressure remains in the lines and cylinders of the clamping device; uncontrolled pressure release can cause clamping elements to move suddenly and injure persons or eject workpieces.

Sub-machine: Pneumatic clamping device / compressed air system · also in: Maintenance · Suggested with AI assistance

Step 1 · Inherently safe design measures	Limit residual pneumatic energy by design: in the event of a pressure drop, the pneumatically closing clamps hold the workpiece by means of a pilot-operated non-return valve (pressure-holding valve) in the clamping line; the pressure switch monitors the clamping pressure (SF-04). The volume trapped between the pressure-holding valve and the cylinder is minimised by design (short lines, pressure-holding valves mounted directly on the cylinder), so that only a small amount of energy remains stored. Before any intervention, the trapped clamping pressure is released by opening the clamps; in the event of a fault it is released in a controlled manner using the manual override of the pressure-holding valve. Design in accordance with EN ISO 4414:2010. Note: The severity of a remaining residual energy event is reduced by this measure, as the kinetic energy of the clamping elements is considerably lower with a small residual volume and throttled venting.
Step 2 · Safeguarding and/or complementary protective measures	1. Maintenance shut-off valve with venting function (lockout/tagout-capable) in accordance with EN ISO 4414:2010 and EN ISO 14118:2018: Install a shut-off valve with integrated, controlled venting (soft-exhaust function) at the inlet of the pneumatic clamping device; in the shut-off position, the valve must vent the downstream line section in a controlled and throttled manner before any intervention is possible. The valve shall be secured with a lock (lockout device). 2. Pressure gauge or pressure indicator on the line section between the shut-off valve and the cylinder, so that the operator can visually verify pressure reduction to 0 bar (EN ISO 4414:2010). 3. Residual pressure indicator at the maintenance access: before any intervention, the absence of pressure is checked at the residual pressure indicator; the indicator is an operational device without a PL requirement under EN ISO 13849-1:2023. 4. Guard: the clamping fixtures are located inside the safety fence (EN ISO 14120:2015); access for maintenance and fault clearance is via the maintenance door with guard locking in accordance with EN ISO 14119:2025 (SF-01, PLr d).
Step 3 · Information for use	1. Operating instructions ((EU) 2023/1230 Annex III, section 1.7.4): Work instruction for maintenance and fault clearing on the pneumatic clamping device with an explicit step-by-step procedure: (a) remove the workpiece and open the clamps, (b) shut off the compressed air supply at the maintenance shut-off valve and wait for venting, (c) in the event of a fault, release any trapped residual pressure using the manual override of the pressure-holding valve, then check that the residual pressure indicator shows 0 bar, (d) attach the lockout padlock, (e) only then intervene in the system. Include a note on the hazard from residual pressure and ejected workpieces. 2. Warning labelling on the clamping device and on the shut-off valve: general warning sign W001 in accordance with EN ISO 7010:2020 with the supplementary text 'Residual pressure in the clamping fixture'; information sign 'Before intervention: vent to 0 bar and lock shut-off valve'. 3. Qualification requirement: maintenance and fault-clearing work on the pneumatics only by instructed specialists with knowledge of pneumatic safety rules (EN ISO 4414:2010). 4. PPE specification: prescribe safety goggles (eye protection against flying parts) and protective gloves when opening pneumatic connections.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 31 Combination — Risk before: S 5 · O 2 · **RS 10**

Hazard from differing safety levels of the sub-machines from different manufacturers (robot, welding power source, turntable, extraction system): missing or incomplete interface interlocking between the sub-machines may result in one sub-machine starting up even though another is in an unsafe condition (EN ISO 11161).

Sub-machine: Overall installation (system integration) · also in: Commissioning, Operation · Suggested with AI assistance

Step 1 · Inherently safe design measures	System architecture with a single, higher-level safety controller (Safety Master) as an inherently safe control principle in accordance with EN ISO 12100 section 6.2.11: All safety-relevant status signals of the sub-machines (robot operating mode, turntable end position, extraction system operation, welding power source ready) are routed exclusively via the safety controller. No sub-machine drive receives an enable signal unless the safety controller has assessed the overall state as safe. Through this centralisation, the possibility of an incomplete interface interlock is reduced to a minimum by design: there are no parallel, mutually independent enable paths between the sub-machines. The interface definition is carried out in accordance with EN ISO 11161:2007+A1:2010 (system integration, responsibilities, interface description) and is documented in the safety concept of the overall installation.
Step 2 · Safeguarding and/or complementary protective measures	1. Interlock matrix in accordance with EN ISO 11161:2007+A1:2010: For each sub-machine combination, a complete state matrix (operating mode x state of the other sub-machines) is created and implemented in the safety controller. Each enable signal is implemented as an AND-combination of all relevant safety states. 2. Safety function SF-04 (enable of the 180-degree rotary movement of the turntable only when the rotation range is clear, PLr e) ensures that the turntable only rotates when the protective field of the light curtain is clear, the clamps are closed and the robot is demonstrably outside the rotation range. The safety function is designed to PLr e in accordance with EN ISO 13849-1:2023 and validated in accordance with EN ISO 13849-2:2012. 3. Safety function SF-01 (safe stopping upon opening of the maintenance door, stop category 1, PLr d) and SF-02 (safe stopping upon interruption of the light curtain, PLr e) are coordinated across the overall installation: a stop signal from one sub-machine triggers the coordinated stop of all sub-machines via the safety controller. Stop category 1 in accordance with EN 60204-1:2018 section 9.2.2 applies to the robot and the turntable. 4. Emergency stop of the overall installation (SF-03, stop category 1, PLr d) in accordance with EN ISO 13850:2015 acts on all sub-machines simultaneously via the safety controller. Emergency stop devices are arranged at the control desk, at the maintenance door and on the teach pendant. 5. Prevention of unexpected start-up in accordance with EN ISO 14118:2018: After every stop (emergency stop, activation of a protective device, interruption of energy supply), a deliberate restart command is required; automatic restart is excluded. 6. Set-up mode with safely reduced speed (SF-05, 250 mm/s, PLr d) and enabling device in accordance with EN ISO 10218-2:2025 section 5.7.7; in this mode, the robot and the turntable move only with the enabling device actuated and at safely reduced speed, and the welding power source is safely switched off via SF-01 while the maintenance door is open.
Step 3 · Information for use	Operating instructions for the overall installation in accordance with (EU) 2023/1230 Annex III, section 1.7.4: The interface interlock logic (state matrix, enable conditions per sub-machine) is to be documented in full. For each sub-machine, the handover point of safety responsibility (sub-machine manufacturer up to the interface, integrator from the interface onwards) is defined in writing in the safety concept of the overall installation in accordance with EN ISO 11161:2007+A1:2010 and is to be stated in the operating instructions. Qualification requirement: commissioning, parameterisation and modifications to the safety controller may only be carried out by qualified specialist personnel with knowledge of EN ISO 13849-1:2023 and EN ISO 11161. Warning labelling at the control desk: warning sign 'Warning; Automatic start-up' (W018 in accordance with EN ISO 7010:2020). The operating instructions must describe procedures for fault-finding and commissioning, including the sequence in which sub-machines may be commissioned and the verification steps for checking the interface interlock prior to the first automatic operation.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) at the interfaces of sub-machines from different manufacturers. The robot (partly completed machinery with declaration of incorporation), welding power source and extraction unit have their own control systems, and their integration requires a higher-level logic. In step 1, all safety-relevant states are routed through a single safety PLC without parallel enabling paths. After step 2, an interlocking matrix of all operating modes and states is implemented as an AND logic, SF-01 to SF-05 act across the entire installation, every stop leads to a coordinated stop of all sub-machines, and validation is carried out in accordance with EN ISO 13849-2:2012 and EN ISO 11161:2007+A1:2010. The remaining risk is a systematic error in the specification of the matrix that remains undetected during validation. The internal safety of the purchased sub-machines is the responsibility of their respective manufacturers; at the interfaces for which the manufacturer of the assembly is responsible, no further step 1 or step 2 measure beyond the central interlocking and its validation has been identified. Transfer points of responsibility, commissioning sequence and test steps of the interface interlocking: operating instructions chapters 1.1, 2.6 and 8.3.

No. 41 Corruption/security — Risk before: S 3 · O 3 · **RS 9**

Missing or incomplete records of interventions (logging): Interventions in safety-relevant hardware, software or configuration are not recorded, or are recorded without a timestamp and originator; logs overwrite themselves after a short period or are open to manipulation. Unauthorised interventions remain undetected and the audit trail is not available upon request by the authorities. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 2, 1.1.9 para. 5, 1.2.1 lit. f]

Sub-machine: Control / logging · also in: Operation, Maintenance

Step 1 · Inherently safe design measures	Provide event logging as a fixed function of the control system (not deactivatable by the operator), with a non-volatile memory of sufficient capacity.
Step 2 · Safeguarding and/or complementary protective measures	Logging of safety-relevant events with timestamp, user identity and content of the change (log-on, parameter and configuration change, software upload with version and checksum, opening of safety-relevant assemblies, remote-access sessions), protection against deletion and modification, export in readable form, retention of uploads and associated data for up to five years after uploading (Annex III, section 1.2.1, point (f)). Evidence reference route B: IEC 62443-3-3 SR 2.8, SR 2.9, SR 2.11, SR 3.9, SR 6.1.
Step 3 · Information for use	Operating instructions: Access to and export of logs, user's retention obligations when the machine is transferred, procedure in the event of a regulatory request, note on storage capacity and time synchronisation.

Risk after: S 3 · O 1 · **RS 3 (Low)** Residual risk accepted: Yes, 18/08/2026

No. 43 Corruption/security — Risk before: S 5 · O 2 · **RS 10**

Unsecured engineering access to the safety controller: The programming access of the safety controller or safety PLC is reachable without a password or with the manufacturer's default credentials; the safety program can be overwritten or placed in a stopped state during operation, and forcing of inputs and outputs is possible. Protective functions are rendered ineffective or actuators are controlled directly. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 2, 1.1.9 para. 3, 1.2.1 lit. a]

Sub-machine: Safety control / engineering · also in: Commissioning, Maintenance

Step 1 · Inherently safe design measures	Programming access to the safety controller physically separated from the process network (dedicated port, inside a locked control cabinet), no forcing of safety-relevant signals in the as-delivered state, program changes only in the secured stop state of the machine.
Step 2 · Safeguarding and/or complementary protective measures	Individual password for the safety program access with mandatory password change at commissioning, write protection and access protection levels of the controller activated, logging of all accesses and program changes with version and checksum, display of the program status on the HMI. Evidence reference route B: IEC 62443-3-3 SR 1.1, SR 1.5, SR 2.1, SR 2.8, SR 3.4, SR 7.7.
Step 3 · Information for use	Operating instructions: Access protection and password management as a user obligation, prohibition of program changes without re-verification and documentation, reference to the requirements for substantial modification.

Risk after: S 5 · O 1 · **RS 5 (Medium)** Residual risk accepted: Yes, 18/08/2026

Justification of acceptance: Residual risk RS 5 (S 5, O 1) via the engineering access to the safety controller. The access has to remain available for commissioning, maintenance and fault-finding. In step 1, the programming port is separated from the process network inside the locked control cabinet, forcing of safety-relevant signals is excluded in the as-delivered state, and program changes are only permitted in the secured stop state. After step 2, an individual password, write protection and access protection levels are active, every access and every program change is logged with version and checksum, and the program status can be retrieved on the HMI panel (evidence in accordance with IEC 62443-3-3 SR 1.1, 1.5, 2.1, 2.8, 3.4 and 7.7). The remaining risk is misuse or error by a person with a valid password and cabinet key. A technical measure that distinguishes authorised from improper changes is not available according to the state of the art; deviations become detectable by comparing version and checksum with the acceptance report. Password management as an obligation of the user and the prohibition of program changes without renewed testing and documentation are stated in the operating instructions (chapters 2.6 and 13).

No. 44 Corruption/security — Risk before: S 4 · O 3 · **RS 12**

Unauthorised or faulty remote access via the remote maintenance gateway: Via the IPsec VPN connection of the remote maintenance gateway, an unauthorised person with stolen credentials or an authorised technician at the wrong moment intervenes in the cell controller: program or parameter change, acknowledgement of faults or starting of movements while persons are at the loading station or in the maintenance aisle. [MR (EU) 2023/1230 Annex III No. 1.1.9 para. 1, 1.1.9 para. 3, 1.2.1 lit. a, 1.2.1 lit. d]

Sub-machine: Remote maintenance gateway / cell controller · also in: Operation, Maintenance

Step 1 · Inherently safe design measures	Remote access designed so that it cannot trigger hazardous movements or bypass safety functions: the remote maintenance gateway only reaches the standard controller and the HMI panel; the safety PLC has no remote access path. Movement commands and acknowledgement of faults are only possible from control positions with a view of the hazard zone (Annex III, section 1.2.2).
Step 2 · Safeguarding and/or complementary protective measures	Remote maintenance disabled on delivery; a session can only be enabled on site with the key switch at the control desk, ends automatically after four hours and is indicated as "Remote maintenance active" on the HMI panel; IPsec VPN with multi-factor authentication and personal accounts for remote technicians; logging of every session with user, time and actions performed, retention in accordance with Annex III, section 1.2.1, point (f). Evidence reference route B: IEC 62443-3-3 SR 1.1, SR 1.13, SR 2.1, SR 2.8, SR 3.8.
Step 3 · Information for use	Operating instructions (Chapter 13.3): procedure for enabling and ending remote maintenance sessions, obligation for a responsible person to be available on site, action in the event of suspected unauthorised access (end the session with the key switch, inform the manufacturer), contact for the manufacturer's security notifications.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

Decommissioning (1 hazard)

No. 33 Mechanical — Risk before: S 4 · O 2 · **RS 8**

Hazard during dismantling of the cell at the end of its service life: When dismantling safety fence segments, the robot base frame and the control cabinet, hazards arise from heavy components (crushing, falling), residual energy in lines (compressed air, electrical) and sharp edges on sheet-metal parts.

Sub-machine: Overall installation (dismantling / disposal) · Suggested with AI assistance

Step 1 · Inherently safe design measures	Design safety fence segments, the robot base frame and the control cabinet with standardised lifting points (e.g. eyebolt threaded bores in accordance with DIN 580 or integrated crane eyes), so that each component can be rigged individually and in a positionally secured manner without persons having to stand beneath the suspended load. Deburr sheet-metal edges on enclosure parts and safety fence profiles already at the design stage and break them with a radius >= 0.5 mm (manufacturing drawing) in order to inherently reduce the risk of cuts. Design pneumatic lines with a de-energised default state upon energy isolation: select valves such that, when the compressed-air supply is switched off, the lines are automatically vented (spring return to venting position in accordance with EN ISO 4414:2010); the pressure trapped in the clamping cylinders by the pressure-holding valve is released before dismantling by opening the clamps.
Step 2 · Safeguarding and/or complementary protective measures	1. Energy isolation and de-energisation prior to commencing dismantling: Identify the isolating device for electrical energy (main switch with locking facility in accordance with EN 60204-1:2018 section 5.3) and the shut-off valve with venting function for compressed air (EN ISO 4414:2010), and lock them in a secured, de-energised state before commencing dismantling (lockout/tagout procedure in accordance with EN ISO 14118:2018). Verify absence of voltage by measurement before opening the control cabinet and line connections. 2. Load handling: For components with an individual weight of more than 25 kg (reference mass in accordance with EN 1005-2:2003+A1:2008), suitable lifting equipment (crane, pallet truck, vacuum lifter) with adequate load capacity and CE marking must be used (lifting points and weights: see operating instructions, Chapters 5.2 and 5.3). 3. Safe distance during lifting: Prohibition on remaining beneath suspended loads in accordance with the operating procedure; barrier around the dismantling area.
Step 3 · Information for use	Operating instructions (Chapter 11, (EU) 2023/1230 Annex III, section 1.7.4): Step-by-step dismantling instructions with a defined sequence (energy isolation and venting first, then mechanical dismantling); weight data and centre-of-gravity position for each component; specification of lifting points with a diagram; reference to the lockout/tagout procedure in accordance with EN ISO 14118:2018. Warning labelling on the control cabinet and pneumatic distributor: warning sign 'Warning; Electricity' (W012 in accordance with EN ISO 7010:2020) and an information sign indicating possible residual pressure in the pneumatic lines. Qualification requirement: Dismantling to be carried out only by skilled personnel with training in electrical engineering (for work on electrical equipment) and instruction in the handling of lifting equipment. PPE specification: protective gloves against mechanical risks (EN 388), safety footwear S3 (EN ISO 20345), safety helmet when using lifting equipment.

Risk after: S 4 · O 1 · **RS 4 (Low)** Residual risk accepted: Yes, 18/08/2026

Assessments under further legal acts (own methodology, not part of the risk assessment according to EN ISO 12100)

Each assessment follows the methodology of the legal act concerned. Hazards to persons arising from it are listed with their risk estimation in the hazard list.

Electromagnetic compatibility (EMC 2014/30/EU)

Apparatus (finished appliance, or a combination made available as a single functional unit), Industrial environment: evidence via Measurement on the complete system (laboratory test report) is on file; still outstanding: increased immunity of the safety functions. Immunity to EN IEC 61000-6-2, emission to EN IEC 61000-6-4. 1 point outstanding.

MR (EU) 2023/1230 Annex III No. 1.2.1 (safety and reliability of control systems), No. 1.5.10 and No. 1.5.11 (radiation from the machine and external radiation): the control system has to remain safe even under electromagnetic disturbance. In addition, the EMC Directive 2014/30/EU applies with the essential requirements of Annex I: the emission must not make the intended operation of other equipment impossible, and the machine must be sufficiently immune to the disturbances to be expected. Procedure under Art. 14 (Annex II internal production control or Annex III EU type-examination). For fixed installations, Annex I No. 2 applies instead of conformity assessment, with the good engineering practices and the documentation obligation of Art. 19(1).

Classification	Apparatus (finished appliance, or a combination made available as a single functional unit)
Electromagnetic environment	Industrial environment
Immunity	EN IEC 61000-6-2
Emission	EN IEC 61000-6-4
Route of evidence	Measurement on the complete system (laboratory test report)
Test evidence	RSZ-2600-EMV-001
Safety functions depending on electronic systems	yes, evidence of increased immunity outstanding
Warning in the operating instructions (restriction of use Art. 18(2), drives C2 to C4)	present
Conformity assessment procedure (Article 14)	Internal production control (Annex II, Module A)
Result	Evidence outstanding

Cybersecurity (CRA, Regulation (EU) 2024/2847)

Covered under Article 2(1) CRA, classification: Default product (not listed in Annex III or IV). The reporting obligations under Article 14 CRA apply to this product; the remaining obligations apply where it is placed on the market on or after 11 December 2027 or substantially modified on or after that date (Article 71(2), Article 69(2) CRA).

The Machinery Regulation (EU) 2023/1230 requires protection against corruption in Annex III No. 1.1.9 and safe control systems in No. 1.2.1. Alongside it stands the Cyber Resilience Act (Regulation (EU) 2024/2847) with obligations of its own: it applies to products with digital elements whose use includes a direct or indirect data connection to a device or network (Article 2(1) CRA). The reporting obligations under Article 14 CRA have applied since 11 September 2026, including to products already placed on the market (Article 69(3) CRA); the remaining obligations apply to products placed on the market on or after 11 December 2027 or substantially modified on or after that date (Article 71(2), Article 69(2) CRA). Both legal

acts apply side by side. CRA compliance may facilitate the demonstration of compliance with Annex III No. 1.1.9 and 1.2.1 (recital 53 CRA), but it creates no presumption of conformity (Article 20(9) of the Machinery Regulation, a contrario).

Scope (Article 2(1) CRA)	Covered: the product falls under the Cyber Resilience Act (Article 2(1) CRA). Which obligations apply today depends on the date of placing on the market.
Core functionality (Article 7(1) CRA)	Robot-assisted MAG welding of steel assemblies in series production. The software controls the robot, turntable, welding process and fume extraction. Networking, VPN and access functions come from purchased components and are not the core functionality of the cell; they are recorded as components with their own classification.
Classification (Annexes III and IV CRA)	Default product (not listed in Annex III or IV)
Classification confirmed	Yes
Obligations in force	The product is placed on the market before 11 December 2027. Of the Cyber Resilience Act, only the reporting obligations under Article 14 then apply (Article 69(3) CRA); the essential cybersecurity requirements, the CRA conformity assessment and the CRA CE marking only apply once the product is substantially modified on or after 11 December 2027 (Article 69(2) CRA). Cybersecurity requirements under other legal acts are unaffected, such as those of the Radio Equipment Directive via Delegated Regulation (EU) 2022/30 until 10 December 2027 and Annex III No. 1.1.9 of the Machinery Regulation from 20 January 2027.
Reporting obligations (Article 14 CRA)	The reporting obligations under Article 14 CRA have applied since 11 September 2026, including for products placed on the market earlier (Article 69(3) CRA).
EU declaration of conformity (Article 28 CRA)	No declaration under the Regulation: for placing on the market before 11 December 2027 only the reporting obligations under Article 14 apply (Article 69(3) CRA), as long as the product is not substantially modified afterwards (Article 69(2) CRA).
Cybersecurity risk assessment and evidence	The cybersecurity risk assessment under Article 13(2) and (3) CRA, the requirements of Annex I, the third-party components, the support period and the reporting process are kept separately and documented in the CRA report. They are not a risk assessment to EN ISO 12100.

List of the applicable essential health and safety requirements

Annex IV Part A point (b)(i) of Regulation (EU) 2023/1230; requirements under Annex III

56 applicable, 73 not applicable, 0 open (of 129)

All 129 requirements have been assessed.

No.	Requirement	Status	Justification / evidence	Hazards
1.1.2	Principles of safety integration	**applicable**	Risk assessment in accordance with EN ISO 12100:2010 with 42 hazards across all life cycle phases, protective measures for each hazard in the order of steps 1 to 3. Limits of the machine, intended use and reasonably foreseeable misuse: operating instructions chapters 1.1, 2.1 and 2.2; residual risks and PPE: chapter 2.6.	

No.	Requirement	Status	Justification / evidence	Hazards
1.1.3	Materials and products	**applicable**	Welding fumes and filter dust generated during operation are assessed as hazardous substances (test protocol: released hazardous substances identified, passed). The fence infill panels and the centre wall are non-combustible and resistant to welding spatter. Operating and auxiliary substances (coolant, anti-spatter agent, lubricants) are handled and disposed of in accordance with the safety data sheet: operating instructions chapters 10.3 and 11.	No. 16, No. 20, No. 22
1.1.4	Lighting	**applicable**	Machine-integrated workplace lighting with 500 lx at the loading station and 200 lx in the maintenance aisle, failure message on the HMI panel: operating instructions chapters 3 and 4.1; functional check at initial commissioning (chapter 8.3) and daily (chapter 10.2).	No. 27
1.1.5	Design of machinery or a related product to facilitate its handling	**applicable**	Marked lifting points, centre-of-gravity positions and masses for each transport unit, transport securing devices and permissible means of transport: operating instructions chapter 5; instructions for dismantling and onward transport: chapter 11.	No. 28, No. 33
1.1.6	Ergonomics	**applicable**	Manual handling up to 15 kg in accordance with EN 1005-2:2003+A1:2008, above that the lifting aid provided by the user; height-adjustable standing platform, gripping points at elbow height, no forced cycle (cycle start by the operator): operating instructions chapters 4.2, 4.3 and 9.1.	No. 9, No. 35
1.1.7	Operating positions	**applicable**	The operator position is outside the welding area behind the dividing centre wall. Welding fumes are captured at the point of origin (test protocol: capture at the point of origin and effectiveness 1,800 m³/h, passed); a normally closed solenoid valve shuts off the shielding gas supply at stop and during breaks: operating instructions chapters 4.1 and 4.2.	No. 20, No. 21
1.1.8	Seating	not applicable	The cell has no workstation at which a seat can be provided: at the loading station, the operator loads and unloads workpieces in a cycle of around 90 seconds, up to 15 kg by hand and heavier ones with the lifting aid (operating instructions chapters 2.1 and 4.2). This task requires freedom of movement while standing; the working conditions do not permit a seat. The working height is adapted by means of the height-adjustable standing platform (hazard no. 35).	
1.1.9	Protection against corruption	**applicable**	Test protocol protection against corruption: items A1 to A6 and A12 passed. Cell network connected only via the supplied gateway with firewall, remote maintenance only after enabling at the key switch, version and checksum of the safety-relevant software retrievable on the HMI panel without login, protected event log: operating instructions chapter 13.	No. 36, No. 37, No. 39, No. 40, No. 41, No. 42, No. 43, No. 44
1.2.1	Safety and reliability of control systems	**applicable**	Safety functions in accordance with EN ISO 13849-1:2023: SF-01 (PL d, category 3), SF-02 (PL e, category 4), SF-03 (PL d, category 3), SF-04 (PL e, category 4), SF-05 (PL d, category 3), required PL achieved in each case; validation in accordance with EN ISO 13849-2:2012 (operating instructions chapters 2.5 and 8.3). Immunity in accordance with EN IEC 61000-6-2:2019, test report RSZ-2600-EMV-001. Test protocol protection against corruption: A8 (tracing log) passed, A10 not applicable (no wireless control).	No. 14, No. 30, No. 31, No. 36, No. 37, No. 38, No. 39, No. 41, No. 42, No. 43, No. 44

No.	Requirement	Status	Justification / evidence	Hazards
1.2.2	Control devices	**applicable**	Control devices on the control desk next to the loading opening, outside the danger zone and with a view of the opening: cycle start, acknowledgement, emergency stop, lockable mode selector switch, remote maintenance key switch; teach pendant with three-position enabling device; audible start-up warning before every automatic start: operating instructions chapters 2.5, 4.2 and 9.2.	No. 6
1.2.3	Starting	**applicable**	Starting only by deliberate actuation of cycle start with the protective field clear and the safety functions acknowledged; restart interlock after a protective device has tripped, after emergency stop and after power recovery in accordance with EN ISO 14118:2018 (test protocol: restart interlock after power failure, passed): operating instructions chapters 2.5, 4.3 and 9.5.	No. 6, No. 38
1.2.4	Stopping	**applicable**	The requirements for stopping are demonstrated under sub-items 1.2.4.1 to 1.2.4.4.	
1.2.4.1	Normal stop	**applicable**	Stopping in normal operation at the end of the shift via the HMI panel into the home position and at the main switch, which disconnects all poles; electrical equipment in accordance with EN 60204-1:2018: operating instructions chapters 9.2 and 9.5.	
1.2.4.2	Operational stop	**applicable**	During the operational stop while loading, the standstill remains monitored: the turntable only rotates after cycle start with the protective field clear and the rest position of the robot confirmed by a safe signal (SF-04, PL e), and it is positively locked in its end position; an intrusion into the protective field triggers the safe stop (SF-02, PL e): operating instructions chapters 2.5 and 4.3.	No. 4
1.2.4.3	Emergency stop	**applicable**	Emergency stop SF-03 (PL d, category 3) in accordance with EN ISO 13850:2015 with emergency stop devices on the control desk, at the maintenance door and on the teach pendant, stop category 1 in accordance with EN 60204-1:2018, restart only after unlatching and acknowledgement (test protocol: emergency stop at all stations and in all operating modes as well as tested electrically, passed): operating instructions chapters 2.5 and 9.5.	No. 7
1.2.4.4	Assembly of machinery or related products	**applicable**	Assembly of machinery in accordance with EN ISO 11161:2007+A1:2010: one common safety PLC for all sub-machines; emergency stop and the tripping of protective devices act on robot, turntable, welding power source and wire feed unit; text sign stating the scope of effect of the emergency stop devices on the control desk: operating instructions chapters 2.4 and 2.5.	No. 7, No. 31, No. 39
1.2.5	Selection of control or operating modes	**applicable**	Lockable mode selector switch with the operating modes automatic and set-up; in set-up mode, movements only at safely reduced speed of 250 mm/s and with the three-position enabling device (SF-05, PL d) in accordance with EN ISO 10218-2:2025 (test protocol: mode selector switch passed, two-hand control not applicable): operating instructions chapters 2.5 and 9.3.	No. 2, No. 11

No.	Requirement	Status	Justification / evidence	Hazards
1.2.6	Failure of the power supply or communication network connection	**applicable**	After power recovery, the installation remains stopped by the restart interlock; in the event of a compressed air failure, the pressure-holding valve keeps the workpieces clamped and the pressure switch locks the rotary movement (operating instructions chapter 9.5). Behaviour in the event of failure, restoration or change of the communication network connection tested (test protocol protection against corruption: A9 passed).	No. 5, No. 38
1.3.1	Risk of loss of stability	**applicable**	Anchoring of the robot base and turntable with M16 heavy-duty anchors for a tilting moment of up to approximately 8 kNm and requirements for the hall floor (operating instructions chapters 7.2 and 8.2), marking "Risk of tipping before anchoring" on the base frame (chapter 2.4); test protocol: stability and anchoring passed.	No. 29
1.3.2	Risk of break-up during operation	**applicable**	Pressurised parts of the pneumatic system in accordance with EN ISO 4414:2010 (test protocol: pressure test at 6.0 bar with verified response pressure of the pressure relief valve of 7.5 bar and hose/line condition, passed); collision protection clutch on the welding torch with safety stop; semi-annual check of the tightening torques of the anchoring: operating instructions chapters 2.5 and 10.2.	
1.3.3	Risks due to falling or ejected objects	**applicable**	Pressure-holding valve in the clamping line and clamping pressure monitoring in SF-04, deflector plate under the turntable as a catching device and impact protection, enclosure of the welding area against spatter, lifting points for transport: operating instructions chapters 2.5, 4.1 and 5.	No. 5, No. 9, No. 16, No. 23, No. 28
1.3.4	Risks due to surfaces, edges or angles	**applicable**	The risk assessment evaluates sharp edges on sheet metal parts for dismantling at the end of the service life; procedure and protective equipment: operating instructions chapter 11.	No. 33
1.3.5	Risks due to multiple machinery or related products	not applicable	The RSZ-2600 is not combined machinery within the meaning of this requirement: it performs a single operation (MAG welding) and has no elements for different operations between which the workpiece is transferred by hand (operating instructions chapters 2.1 and 4.3). The interaction of the sub-machines of the assembly is demonstrated under 1.2.4.4.	
1.3.6	Risks related to variations in operating conditions	**applicable**	Only released welding programs, program selection on the HMI panel; set-up and change of clamping fixtures only by the set-up person with the installation stopped and the clamping circuit depressurised, new clamping fixtures only after release by the manufacturer, first-part inspection after every set-up, new programs first in set-up mode: operating instructions chapters 2.1, 3 and 9.4.	No. 30, No. 42
1.3.7	Risks related to moving parts	**applicable**	Gaps at the turntable in accordance with EN ISO 13854:2019, safety distances in accordance with EN ISO 13857:2019, robot and robot cell in accordance with EN ISO 10218-1:2025 and EN ISO 10218-2:2025; protective measures against moving parts via SF-01 to SF-05 (test protocol: safety fence distances, interlocking guards and light curtain passed): operating instructions chapter 2.5.	No. 1, No. 2, No. 3, No. 4, No. 6, No. 8, No. 11, No. 32

No.	Requirement	Status	Justification / evidence	Hazards
1.3.8	Choice of protection against risks arising from moving parts	**applicable**	Choice of protective devices: fixed safety fence in accordance with EN ISO 14120:2015 around the robot working space, interlocking maintenance door with guard locking in accordance with EN ISO 14119:2025 for occasional access, type 4 light curtain at the loading opening for access in every cycle with safety distance in accordance with EN ISO 13855:2024: operating instructions chapter 2.5.	No. 1, No. 3, No. 32
1.3.8.1	Moving transmission parts	**applicable**	The turntable drive is clad, and the cladding is designed as a guard in accordance with EN ISO 14120:2015; cladding and base panels must be fully fitted during assembly (operating instructions chapter 8.2). The robot drives operate inside the safety fence. Test protocol: fastening of the guards passed.	
1.3.8.2	Moving parts involved in the process	**applicable**	Moving parts involved in the process (robot with torch, turntable, wire feed) are made inaccessible by the safety fence and the guard-locked maintenance door; only the loading opening remains accessible, safeguarded by the light curtain (SF-02) and the rotation enable (SF-04); in set-up mode SF-05 applies: operating instructions chapters 2.5 and 9.3.	No. 1, No. 2, No. 3, No. 4, No. 8, No. 32
1.3.9	Risks of uncontrolled movements	**applicable**	Against movement from standstill: pressure-holding valve in the clamping line with manual override, positive locking of the turntable, shut-off valve with exhaust function and residual pressure indicator (test protocol: residual pressure release documented, passed); supporting a robot axis before releasing the brake: operating instructions chapters 2.5, 2.6 and 10.4.	No. 5, No. 6, No. 23
1.4.1	General requirements	**applicable**	Guards and protective devices permanently mounted, removable only with a tool and protected against defeat (coded actuator in accordance with EN ISO 14119:2025), distances in accordance with EN ISO 13857:2019 (test protocol: visual inspection of all guards, fastening and safety fence distances passed); daily and periodic checks: operating instructions chapters 9.4 and 10.2.	No. 3, No. 32
1.4.2	Special requirements for guards	**applicable**	The special requirements for guards are demonstrated under 1.4.2.1 and 1.4.2.2; design in accordance with EN ISO 14120:2015.	
1.4.2.1	Fixed guards	**applicable**	Safety fence 2200 mm with welding-light-opaque infill panels and base panel in accordance with EN ISO 14120:2015, panels removable only with a tool, flank plates and covers beside and below the light curtain in accordance with EN ISO 13857:2019 Table 4 (test protocol: safety fence distances in accordance with EN ISO 13857 passed): operating instructions chapter 2.5.	No. 3, No. 32
1.4.2.2	Interlocking movable guards	**applicable**	Maintenance door with interlocking and guard locking in accordance with EN ISO 14119:2025 (SF-01, PL d), release only after the arc has been extinguished and standstill is monitored, escape release from the inside, lockout device for personal padlocks (test protocol: interlocking guards passed): operating instructions chapter 2.5.	No. 3, No. 6, No. 11

No.	Requirement	Status	Justification / evidence	Hazards
1.4.2.3	Adjustable guards restricting access	not applicable	The cell has no adjustable guards: the robot working space is enclosed by fixed guards (1.4.2.1) and the interlocking maintenance door (1.4.2.2), and the loading opening is safeguarded by a light curtain (1.4.3). Adjustable access to moving parts is not required for the work process (operating instructions chapters 2.5 and 4.3).	
1.4.3	Special requirements for protective devices	**applicable**	Type 4 light curtain with 30 mm resolution at the loading opening (SF-02, PL e, category 4) without muting, safety distance in accordance with EN ISO 13855:2024, measured overrun distance of the turntable 45 mm with 60 mm permissible; three-position enabling device on the teach pendant (SF-05). Test protocol: light curtain and overrun distance measurement passed. Operating instructions chapter 2.5.	No. 2, No. 32
1.5.1	Electricity supply	**applicable**	Electrical equipment in accordance with EN 60204-1:2018, safety objectives of the Low Voltage Directive in accordance with Annex III No. 1.5.1 (operating instructions chapter 1.4). Electrical test protocol: protective conductor 0.08 Ω, fault loop impedance 0.28 Ω with disconnection condition met, insulation resistance > 100 MΩ at 500 V DC, residual voltage 1.9 s to ≤ 60 V and circuit diagram conformity passed. Isolation and discharge time: chapters 8.1 and 10.	No. 12, No. 13
1.5.2	Static electricity	not applicable	The risk assessment identifies no hazard from electrostatic charging: the cell processes steel assemblies only and no insulating webs, plastics or flammable liquids, and the installation site is not a potentially explosive area (operating instructions chapters 1.1 and 7.3). All conductive assemblies including the safety fence are connected to the protective conductor (test protocol: protective conductor 0.08 Ω up to the earthing point of the safety fence).	
1.5.3	Energy supply other than electricity	**applicable**	Pneumatic system in accordance with EN ISO 4414:2010 at 6 bar with lockable shut-off valve with exhaust function and residual pressure indicator; shielding gas M21 with normally closed solenoid valve. Test protocol: pressure test, leakage test, hose/line condition, residual pressure release and tightness of substance-carrying parts passed. Operating instructions chapters 4.1, 7.4 and 10.	No. 5, No. 21, No. 23
1.5.4	Errors of fitting	**applicable**	Assembly in a defined sequence with tightening torques in accordance with installation plan RSZ-2600-LAY-001 (operating instructions chapter 8.2); cable routing, shield connections and equipotential bonding only in accordance with electrical circuit diagram RSZ-2600-EPL-001, with a text sign on the control cabinet (chapters 2.4 and 7.3); workpiece-specific clamping fixtures only after release by the manufacturer (chapter 3); after replacing the welding power source, robot controller or safety components, repeated functional test of SF-01 to SF-05 (chapter 7.3).	No. 14, No. 29
1.5.5	Extreme temperatures	**applicable**	Cooling lockout period for each welding program with red signal light at the removal station, temperature monitoring at the torch neck with release indication, contact temperatures in accordance with EN ISO 13732-1:2008 as design reference; warning sign W017 and hand protection: operating instructions chapters 2.4, 2.5 and 9.1.	No. 15, No. 17

No.	Requirement	Status	Justification / evidence	Hazards
1.5.6	Fire	**applicable**	Enclosure with non-combustible infill panels, spark pre-separator, temperature monitoring of the filter cartridge, motorised shut-off dampers, smoke and CO detectors, extraction run-on of at least 10 minutes; behaviour in the event of a fire in the extraction unit and forwarding of the fire alarm by the user: operating instructions chapters 1.2, 2.5 and 9.5.	No. 16, No. 34
1.5.7	Explosion	not applicable	The risk assessment identifies no explosion hazard, and the machine profile of the project indicates no explosive atmosphere: the shielding gas M21 (82 percent argon, 18 percent CO2) is non-flammable, no other gases are used, and operation in potentially explosive areas is excluded (operating instructions chapters 1.1, 1.3 and 2.1). The fire hazard from sparks in the filter cartridge is dealt with under 1.5.6.	
1.5.8	Noise	**applicable**	Emission sound pressure level at the loading station LpA = 84 dB(A), K = 2.5 dB in accordance with EN ISO 11202:2010, sound power level LWA = 96 dB(A) in accordance with EN ISO 3746:2010, declaration in accordance with EN ISO 4871:2009 with measurement conditions and C-weighted peak value (test protocol: emission sound pressure level, sound power level and noise statement in the operating instructions passed): operating instructions chapter 3; noise reduction during assembly: chapter 8.2.	No. 24
1.5.9	Vibrations	not applicable	The risk assessment identifies no hazard from vibration: the cell is a stationary machine anchored in the floor without hand-held or hand-guided tools and without a seat or driving position, and the operator stands on the standing platform in front of the cell (operating instructions chapters 4.2 and 7.2). The turntable drive is mounted on elastic supports (hazard no. 24, step 1).	
1.5.10	Radiation	**applicable**	Optical radiation of the arc: enclosure with welding-light-opaque infill panels, viewing windows and welding curtain, guard locking of the maintenance door until the arc is extinguished, warning sign W027. Electromagnetic fields: access to the vicinity of the welding cables only with the welding current switched off, warning sign W006 and prohibition sign P007. Operating instructions chapters 2.4 and 2.5.	No. 18, No. 19
1.5.11	External radiation	**applicable**	Immunity for the industrial environment in accordance with EN IEC 61000-6-2:2019, measurement on the overall installation in test report RSZ-2600-EMV-001 (EMC test protocol passed); shielded safety cables and separate cable ducts for welding current cables and control cables: operating instructions chapter 7.3.	No. 14
1.5.12	Laser radiation	not applicable	The cell contains no laser equipment: the welding process is MAG welding (process 135), the scope of supply in accordance with operating instructions chapter 1.1 contains no laser source, and the risk assessment identifies no hazard from laser radiation.	

No.	Requirement	Status	Justification / evidence	Hazards
1.5.13	Emissions of hazardous materials and substances	**applicable**	Welding fume extraction in accordance with EN ISO 21904-1:2020 with capture hood, 1,800 m³/h, fault alarm below 1,400 m³/h, separation class W3; shielding gas with normally closed solenoid valve; low-dust filter change via bag-in/bag-out system. Test protocol: released hazardous substances identified, capture at the point of origin, effectiveness, filter class and monitoring, tightness and statements in the operating instructions passed. Operating instructions chapters 3, 9.1 and 10.2.	No. 20, No. 21, No. 22
1.5.14	Risk of being trapped in a machine	**applicable**	Escape release of the maintenance door from the inside without tools, lockout device for personal padlocks against being locked in, release of trapped persons via the brake release device of the robot and the motor brake of the turntable: operating instructions chapters 2.5 and 2.6.	No. 11
1.5.15	Risk of slipping, tripping or falling	**applicable**	Cables and hoses routed out of the floor area, cable bridges with drive-over protection, yellow and black floor markings, lighting, warning signs W011 and W007 (test protocol: trip/slip hazards passed); cleaning of the floor: operating instructions chapters 2.4, 2.5 and 10.2.	No. 10, No. 27
1.5.16	Lightning	not applicable	The cell is intended exclusively for installation in dry indoor areas of a production hall, and outdoor use is excluded (operating instructions chapters 1.1, 2.1 and 7.3). During use it is not exposed to lightning effects that would require a discharge system on the machine.	
1.6.1	Machinery or related product maintenance	**applicable**	Inspection and maintenance schedule with daily to annual tasks, maintenance with the machine stopped and isolated, functional checks of the protective devices from outside the cell, diagnostics on the HMI panel from outside, maintenance record form RSZ-2600-WNW-001: operating instructions chapter 10.	
1.6.2	Access to operating positions and servicing points	**applicable**	Clearance of at least 1.0 m all round and at least 1.2 m in front of the maintenance door, operating and staging area of 2.0 m in front of the loading opening, clear hall height of at least 3.2 m for work on the cell roof, access to the inside of the cell via the maintenance door: operating instructions chapters 4.2 and 7.1.	No. 10
1.6.3	Isolation of energy sources	**applicable**	Main switch with lockable off position, disconnecting all poles in accordance with EN 60204-1:2018; lockable compressed air shut-off valve with exhaust function and residual pressure indicator in accordance with EN ISO 4414:2010; isolation and securing in accordance with EN ISO 14118:2018 (test protocol: residual voltage and residual pressure release passed): operating instructions chapters 2.5, 8.1 and 10.	No. 6, No. 12, No. 23, No. 33
1.6.4	Operator intervention	**applicable**	Interventions are limited: program-controlled torch cleaning with wire cutter, diagnostics on the HMI panel from outside the cell, functional checks from outside. Unavoidable interventions (wire change, torch change, moving the robot clear) only in set-up mode with SF-05 or with the installation isolated, torch change only after release by the temperature monitoring: operating instructions chapters 4.3, 9.3 and 10.4.	No. 8, No. 17

No.	Requirement	Status	Justification / evidence	Hazards
1.6.5	Cleaning of internal parts	**applicable**	The filter housing of the extraction unit is cleaned without entering it: cartridge change via the bag-in/bag-out system, cleaning with an industrial vacuum cleaner of dust class H, no blowing out: operating instructions chapter 10.2.	No. 22
1.7.1	Information and warnings on the machinery or related product	**applicable**	Information on the HMI panel in plain text, signal tower and indicators: operating instructions chapter 9.2; safety signs in accordance with EN ISO 7010:2020: chapter 2.4.	
1.7.1.1	Information and information devices	**applicable**	HMI panel with program selection, operating status, fault messages in plain text and maintenance intervals; version and checksum of the safety-relevant software under "Info" without login: operating instructions chapters 9.2 and 13.	
1.7.1.2	Warning devices	**applicable**	Audible start-up warning before every automatic start, signal tower green, yellow and red, red signal light during the cooling lockout period, messages on failure of the workplace lighting and on fire alarm of the extraction unit, indication "Remote maintenance active": operating instructions chapters 9.2 and 13.	
1.7.2	Warning of residual risks	**applicable**	Warning, prohibition and mandatory signs in accordance with EN ISO 7010:2020 and text signs at the danger points: operating instructions chapter 2.4; residual risks by life cycle phase with the protective measures from the risk assessment: chapter 2.6.	
1.7.3	Marking of machinery or related products	**applicable**	Rating plate on the right-hand side wall of the control cabinet with manufacturer, type, serial number, year of construction, electrical connection data, weight and CE marking (operating instructions chapter 3). Test protocol: particulars checked on the finished plate; it is affixed after the declaration of conformity has been signed.	
1.7.4	Instructions	**applicable**	Operating instructions edition 09/2026, version 1.1, 13 chapters, prepared in accordance with Annex III No. 1.7.4 to 1.7.4.2 (chapters 1.4 and 1.5). Test protocol: statements in the operating instructions on hazardous substances, noise statement in the operating instructions and item A11 on protection against corruption passed.	
1.7.4.1	General principles for the drafting of instructions	**applicable**	Structure following the life cycle from delivery to disposal, safety information grouped in chapter 2 and at the beginning of the task chapters, graded warnings and list of abbreviations (chapter 1.5), reasonably foreseeable misuse (chapter 2.2), rule for translations (chapter 1.4).	
1.7.4.2	Contents of the instructions	**applicable**	Contents in accordance with Annex III No. 1.7.4.2: limits and use (chapters 1 and 2), technical data and noise emission values (chapter 3), transport (chapter 5), storage (chapter 6), installation (chapter 7), assembly and initial commissioning (chapter 8), operation (chapter 9), maintenance (chapter 10), dismantling and disposal (chapter 11), documents (chapter 12) and cybersecurity with software version and updates (chapter 13).	No. 24, No. 28, No. 40

No.	Requirement	Status	Justification / evidence	Hazards
1.7.5	Sales literature	not applicable	The RSZ-2600 is a special machine built as a one-off for one user (operating instructions chapter 4); sales literature on this machine is not part of the project documents. If such literature is prepared, its safety and emission information must correspond to the operating instructions.	
2.1	Machinery and related products for foodstuffs and machinery and related products for cosmetics or pharmaceutical products	not applicable	Part 2 applies to machinery for foodstuffs, cosmetic or pharmaceutical products, to portable hand-held or hand-guided machinery, to machinery for working wood and materials with similar physical characteristics and to machinery for pesticide application. The RSZ-2600 is a stationary welding cell for steel assemblies (operating instructions chapter 2.1) and belongs to none of these categories.	
2.2	Portable hand-held or hand-guided machinery or related products	not applicable	Part 2 applies to machinery for foodstuffs, cosmetic or pharmaceutical products, to portable hand-held or hand-guided machinery, to machinery for working wood and materials with similar physical characteristics and to machinery for pesticide application. The RSZ-2600 is a stationary welding cell for steel assemblies (operating instructions chapter 2.1) and belongs to none of these categories.	
2.3	Machinery or related products for working wood and material with similar physical characteristics	not applicable	Part 2 applies to machinery for foodstuffs, cosmetic or pharmaceutical products, to portable hand-held or hand-guided machinery, to machinery for working wood and materials with similar physical characteristics and to machinery for pesticide application. The RSZ-2600 is a stationary welding cell for steel assemblies (operating instructions chapter 2.1) and belongs to none of these categories.	
2.4	Machinery or related products for plant protection products application	not applicable	Part 2 applies to machinery for foodstuffs, cosmetic or pharmaceutical products, to portable hand-held or hand-guided machinery, to machinery for working wood and materials with similar physical characteristics and to machinery for pesticide application. The RSZ-2600 is a stationary welding cell for steel assemblies (operating instructions chapter 2.1) and belongs to none of these categories.	
3.2.1	Driving position	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.2.2	Seating	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	

No.	Requirement	Status	Justification / evidence	Hazards
3.2.3	Positions for other persons	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.2.4	Monitoring function	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.3.1	Control devices	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.3.2	Starting/moving	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.3.3	Travelling function	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.3.4	Movement of pedestrian-controlled machinery	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	

No.	Requirement	Status	Justification / evidence	Hazards
3.3.5	Control circuit failure	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.4.1	Uncontrolled movements	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.4.2	Moving transmission parts	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.4.3	Roll-over and tip-over	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.4.4	Falling objects	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.4.5	Means of access	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	

No.	Requirement	Status	Justification / evidence	Hazards
3.4.6	Towing devices	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.4.7	Transmission of power between self-propelled machinery (or tractor) and recipient machinery	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.5.1	Batteries	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.5.2	Fire	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.5.3	Emissions of hazardous substances	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.5.4	Risk of contact with live overhead lines	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	

No.	Requirement	Status	Justification / evidence	Hazards
3.6.1	Signs, signals and warnings	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.6.2	Marking	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.6.3	Instructions (mobility)	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.6.3.1	Vibrations	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.6.3.2	Multiple uses	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	
3.6.3.3	Autonomous mobile machinery or related products	not applicable	Part 3 applies to hazards due to the mobility of machinery. The RSZ-2600 is a stationary assembly of machinery: the robot base and the turntable are anchored in the hall floor with heavy-duty anchors (operating instructions chapters 7.2 and 8.2); the cell does not travel, is not pedestrian-controlled and has no driving or riding position. Transport and relocation take place only in transport units, with the installation shut down, using industrial trucks or a crane (chapter 5).	

No.	Requirement	Status	Justification / evidence	Hazards
4.1.2	Protection against mechanical hazards	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.1	Risks due to lack of stability	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.2	Machinery or related products running on guide rails and rail tracks	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.3	Mechanical strength	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.4	Pulleys, drums, wheels, ropes and chains	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.5	Lifting accessories and their components	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	

No.	Requirement	Status	Justification / evidence	Hazards
4.1.2.6	Control of movements	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.7	Movements of loads during handling	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.8	Machinery serving fixed landings	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.8.1	Movements of the carrier	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.8.2	Access to the carrier	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.8.3	Risks due to contact with the moving carrier	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	

No.	Requirement	Status	Justification / evidence	Hazards
4.1.2.8.4	Risk due to the load falling off the carrier	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.2.8.5	Landings	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.1.3	Fitness for purpose	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.2.1	Control of movements	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.2.2	Loading control	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.2.3	Installations guided by ropes	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	

No.	Requirement	Status	Justification / evidence	Hazards
4.3.1	Chains, ropes and webbing	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.3.2	Lifting accessories	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.3.3	Lifting machinery or related products	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.4.1	Lifting accessories	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
4.4.2	Lifting machinery or related products	not applicable	Part 4 applies to hazards due to lifting operations. The RSZ-2600 does not lift loads: the turntable rotates the workpieces about a vertical axis without any change in height, the robot guides the welding torch, and loading and unloading are carried out by the operator (operating instructions chapters 4.1 and 4.3). The lifting aid for workpieces over 15 kg is provided on site by the user; it is not part of the scope of supply and not part of this assembly of machinery (chapter 1.1).	
5.1	Risks due to lack of stability	not applicable	Part 5 applies to machinery intended for underground work. The RSZ-2600 is intended exclusively for installation in a dry production hall (operating instructions chapters 2.1 and 7.3).	
5.2	Movement	not applicable	Part 5 applies to machinery intended for underground work. The RSZ-2600 is intended exclusively for installation in a dry production hall (operating instructions chapters 2.1 and 7.3).	
5.3	Control devices	not applicable	Part 5 applies to machinery intended for underground work. The RSZ-2600 is intended exclusively for installation in a dry production hall (operating instructions chapters 2.1 and 7.3).	
5.4	Stopping	not applicable	Part 5 applies to machinery intended for underground work. The RSZ-2600 is intended exclusively for installation in a dry production hall (operating instructions chapters 2.1 and 7.3).	

No.	Requirement	Status	Justification / evidence	Hazards
5.5	Fire	not applicable	Part 5 applies to machinery intended for underground work. The RSZ-2600 is intended exclusively for installation in a dry production hall (operating instructions chapters 2.1 and 7.3).	
5.6	Exhaust emissions	not applicable	Part 5 applies to machinery intended for underground work. The RSZ-2600 is intended exclusively for installation in a dry production hall (operating instructions chapters 2.1 and 7.3).	
6.1	General (lifting of persons)	not applicable	Part 6 applies to machinery presenting hazards due to the lifting of persons. The RSZ-2600 does not lift or carry persons. The height-adjustable standing platform at the loading station is adjusted to the operator's body height before work starts and serves as a standing surface during work (operating instructions chapters 4.2 and 9.4).	
6.2	Control devices	not applicable	Part 6 applies to machinery presenting hazards due to the lifting of persons. The RSZ-2600 does not lift or carry persons. The height-adjustable standing platform at the loading station is adjusted to the operator's body height before work starts and serves as a standing surface during work (operating instructions chapters 4.2 and 9.4).	
6.3	Risks to persons in or on the carrier	not applicable	Part 6 applies to machinery presenting hazards due to the lifting of persons. The RSZ-2600 does not lift or carry persons. The height-adjustable standing platform at the loading station is adjusted to the operator's body height before work starts and serves as a standing surface during work (operating instructions chapters 4.2 and 9.4).	
6.4	Machinery or related products serving fixed landings	not applicable	Part 6 applies to machinery presenting hazards due to the lifting of persons. The RSZ-2600 does not lift or carry persons. The height-adjustable standing platform at the loading station is adjusted to the operator's body height before work starts and serves as a standing surface during work (operating instructions chapters 4.2 and 9.4).	
6.5	Markings (lifting of persons)	not applicable	Part 6 applies to machinery presenting hazards due to the lifting of persons. The RSZ-2600 does not lift or carry persons. The height-adjustable standing platform at the loading station is adjusted to the operator's body height before work starts and serves as a standing surface during work (operating instructions chapters 4.2 and 9.4).	

For the protective measures per hazard, see the risk assessment.

2. Standards applied

standards applied, from the checklist

Notes according to the Official Journal: EN ISO 11202:2010: The Official Journal cites this standard together with EN ISO 11202:2010/A1:2021. The presumption of conformity relates to the cited version. The version without the amendment lost its presumption of conformity on 11/10/2023.
EN ISO 14119:2025: The Official Journal cites this standard together with EN ISO 14119:2025/A11:2026. The presumption of conformity relates to the cited version.

Type-A standards (basic safety standards) (1)

Standard	Title	Listed under
EN ISO 12100:2010	Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010)	2006/42/EC

Type-B standards (generic safety standards) (20)

Standard	Title	Listed under
EN 1005-2:2003+A1:2008	Safety of machinery - Human physical performance - Part 2: Manual handling of machinery and component parts of machinery	2006/42/EC
EN 60204-1:2018	Safety of machinery - Electrical equipment of machines - Part 1: General requirements	2006/42/EC, 2014/35/EU
EN IEC 61000-6-2:2019	Electromagnetic compatibility (EMC). Part 6-2: Generic standards. Immunity for industrial environments	2014/30/EU
EN IEC 61000-6-4:2019	Electromagnetic compatibility (EMC). Part 6-4: Generic standards. Emission standard for industrial environments	2014/30/EU
EN ISO 11161:2007+A1:2010	Safety of machinery. Integrated manufacturing systems. Basic requirements	2006/42/EC
EN ISO 11202:2010	Acoustics - Noise emitted by machinery and equipment - Determination of emission sound pressure levels at a work station and at other specified positions applying approximate environmental corrections (ISO 11202:2010)	2006/42/EC
EN ISO 13732-1:2008	Ergonomics of the thermal environment - Methods for the assessment of human responses to contact with surfaces - Part 1: Hot surfaces (ISO 13732-1:2006)	2006/42/EC
EN ISO 13849-1:2023	Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2023)	2006/42/EC

Standard	Title	Listed under
EN ISO 13849-2:2012	Safety of machinery - Safety-related parts of control systems - Part 2: Validation (ISO 13849-2:2012)	2006/42/EC
EN ISO 13850:2015	Safety of machinery - Emergency stop function - Principles for design (ISO 13850:2015)	2006/42/EC
EN ISO 13854:2019	Safety of machinery - Minimum gaps to avoid crushing of parts of the human body (ISO 13854:2017)	2006/42/EC
EN ISO 13855:2024	Safety of machinery - Positioning of safeguards with respect to the approach of the human body (ISO 13855:2024)	2006/42/EC
EN ISO 13857:2019	Safety of machinery - Safety distances to prevent hazard zones being reached by upper and lower limbs (ISO 13857:2019)	2006/42/EC
EN ISO 14118:2018	Safety of machinery - Prevention of unexpected start-up (ISO 14118:2017)	2006/42/EC
EN ISO 14119:2025	Safety of machinery - Interlocking devices associated with guards - Principles for design and selection (ISO 14119:2024)	2006/42/EC
EN ISO 14120:2015	Safety of machinery - Guards - General requirements for the design and construction of fixed and movable guards (ISO 14120:2015)	2006/42/EC
EN ISO 3746:2010	Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Survey method using an enveloping measurement surface over a reflecting plane (ISO 3746:2010)	2000/14/EC, 2006/42/EC
EN ISO 4414:2010	Pneumatic fluid power - General rules and safety requirements for systems and their components (ISO 4414:2010)	2006/42/EC
EN ISO 4871:2009	Acoustics - Declaration and verification of noise emission values of machinery and equipment (ISO 4871:1996)	2000/14/EC, 2006/42/EC
EN ISO 7010:2020	Graphical symbols. Safety colours and safety signs. Registered safety signs	

Type-C standards (product standards) (3)

Standard	Title	Listed under
EN ISO 10218-1:2025	Robotics - Safety requirements - Part 1: Industrial robots (ISO 10218-1:2025)	2006/42/EC
EN ISO 10218-2:2025	Robotics - Safety requirements - Part 2: Industrial robot applications and robot cells (ISO 10218-	2006/42/EC

Standard	Title	Listed under
	2:2025)	
EN ISO 21904-1:2020	Health and safety in welding and allied processes - Equipment for capture and separation of welding fume - Part 1: General requirements (ISO 21904-1:2020)	2006/42/EC

3. Declaration of Conformity

Annex V MR

EU DECLARATION OF CONFORMITY

in accordance with Annex V Part A of the Machinery Regulation (EU) 2023/1230

1. Product Identification

Description: Robotic welding cell RSZ-2600 (assembly of machinery)

Type / Model: RSZ-2600

Serial Number / Range: RSZ2600-2026-0001

Year of Manufacture: 2026

2. Manufacturer

Muster Maschinenbau GmbH

Beispielstraße 1

12345 Musterstadt, Germany

4. This declaration of conformity is issued under the sole responsibility of the manufacturer.

5. Object of the declaration

Robotic welding cell RSZ-2600 (assembly of machinery), RSZ-2600

6. Applicable Union harmonisation legislation

The object of the declaration described above is in conformity with the following Union harmonisation legislation:

Machinery Regulation (EU) 2023/1230 (OJ L 165, 29.6.2023, p. 1)

Further applicable Union harmonisation legislation

Conformity with the following Union legislation is also declared:

- EMC Directive 2014/30/EU (OJ L 96, 29.3.2014, p. 79)

7. Applied Harmonised Standards

- —

No references of harmonised standards under Article 20(1) of Regulation (EU) 2023/1230 have yet been published in the Official Journal of the European Union. The standards applied are therefore listed as other technical specifications, including their edition (Annex V, Part A, point 7).

Other Applied Technical Standards and Specifications

- EN ISO 12100:2010
- EN ISO 13849-1:2023
- EN 60204-1:2018
- EN ISO 13857:2019

- EN ISO 13855:2024
- EN ISO 14120:2015
- EN ISO 11161:2007+A1:2010 (parts applied: zone concept, operating modes and interfaces between the part-machines)
- EN ISO 10218-2:2025
- EN ISO 4414:2010
- EN ISO 13850:2015
- EN ISO 13854:2019
- EN ISO 11202:2010+A1:2021
- EN ISO 4871:2009
- EN IEC 61000-6-2:2019
- EN IEC 61000-6-4:2019
- EN ISO 14119:2025+A11:2026
- EN ISO 14118:2018
- EN ISO 13849-2:2012
- EN ISO 10218-1:2025
- EN ISO 13732-1:2008
- EN ISO 21904-1:2020
- EN ISO 3746:2010
- EN 1005-2:2003+A1:2008
- EN ISO 7010:2020

9. Conformity assessment procedure (Machinery Regulation (EU) 2023/1230)

The machinery or related product is subject to the conformity assessment procedure based on internal production control (Module A).

Internal production control (Module A, Annex VI)

We hereby declare under our sole responsibility that the machinery described above is in conformity with all relevant provisions of the Machinery Regulation (EU) 2023/1230. The machinery fulfils the essential health and safety requirements of Annex III of the Machinery Regulation (EU) 2023/1230. Conformity with the following Union legislation is also declared: EMC Directive 2014/30/EU (OJ L 96, 29.3.2014, p. 79).

10. Additional information

Signed for and on behalf of: Muster Maschinenbau GmbH

Musterstadt, 15 March 2027

M. Beispiel
CE coordinator

4. Technical documentation

Annex IV MR (machinery legislation)

Technical file according to Annex IV Part A of MR (EU) 2023/1230

66 of 68 items completed (97%) · Mandatory items open: 0 of 41

1. General information (5/5)

Basic information on the product and manufacturer · Annex IV Part A MR, marking according to Annex III No. 1.7.3 MR

Name and address of the manufacturer MANDATORY Done

Full company name and postal address

Note: Taken from project data: manufacturer data from the settings. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, master sheet Technical Documentation.

Name and address of the authorised representative (if any) Not applicable

Only if an authorised representative has been appointed in the EU

Note: Not applicable: the manufacturer is established in the European Union; an authorised representative in accordance with Article 3(19) MR (appointment in accordance with Article 12 MR) has therefore not been appointed.

Justification (n/a): The manufacturer Muster Maschinenbau GmbH is established in the EU (Germany) and fulfils all manufacturer obligations under MR (EU) 2023/1230 itself. An authorised representative within the meaning of Article 3(19) MR (appointment in accordance with Article 12 MR) has therefore not been appointed.

Designation of the machinery / product designation MANDATORY Done

Unique designation including type, series, model

Note: Taken from project data: machine designation from the project. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, master sheet Technical Documentation.

Serial number / model range MANDATORY Done

Unique identification of each individual machine

Note: Serial number RSZ2600-2026-0001. Single unit manufactured as special-purpose machinery, not a series. Stated on the rating plate and in the declaration of conformity.

Year of construction MANDATORY Done

Year in which the manufacturing process was completed

Note: 2026. Stated on the rating plate in accordance with Annex III, section 1.7.3 MR and in the declaration of conformity.

2. General description of the machinery (4/4)

Technical description and intended use · Annex IV Part A (a) MR

General description of the machinery MANDATORY Done

Operating principle, design, main components

Note: Document RSZ-2600-TD-001 System description, Rev. A. Robotic welding cell comprising an articulated-arm robot (partly completed machinery with EU declaration of incorporation), two-station turntable, MAG welding power source, welding fume extraction unit, safety fence with interlocked maintenance door and light curtain at the loading station. Placed on the market as an assembly of machinery in accordance with Article 3(1)(d) MR (EU) 2023/1230.

Intended use MANDATORY Done

What the machine is intended for, including reasonably foreseeable misuse

Note: Taken from project data: intended use from the risk assessment (step 1). Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, risk assessment, section Intended Use.

Limits of the machine MANDATORY Done

Limits of use, space limits, time limits (service life, maintenance intervals)

Note: Taken from project data: limits of the machine from the risk assessment (step 1). Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, risk assessment, section Limits of the Machine.

Drawings, photos and diagrams MANDATORY Done

Overall view, detailed views of safety-relevant areas

Note: Drawing set RSZ-2600-ZG-001 to -042, Rev. B, with overall view, sections through the turntable, detail of the safety fence and light curtain mounting. Filing in PDM under project MUSTER-2026-001.

3. Risk assessment (5/5)

Documentation of the risk assessment according to EN ISO 12100 · Annex IV Part A (b) MR

Description of the procedure applied MANDATORY Done

Methodology according to EN ISO 12100 (risk estimation, evaluation, reduction)

Note: Taken from project data: risk assessment in the project (methodology in accordance with EN ISO 12100, documented in the RA export). Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, risk assessment, methodology section.

List of all identified hazards MANDATORY Done

Systematic hazard identification for all life-cycle phases

Note: Taken from project data: 42 hazards in the risk assessment. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, risk assessment (Module 1 of the dossier).

Protection objectives / requirements applied MANDATORY Done

Which essential health and safety requirements (Annex III MR) are applicable

Requirements list: 56 applicable, 73 not applicable, 0 open (of 129)

Note: Comparison of the essential health and safety requirements of Annex III MR (EU) 2023/1230: checklist RSZ-2600-TD-003, Rev. A. Key items: 1.1.9, 1.2.1, 1.2.4.3, 1.2.4.4, 1.2.5, 1.2.6, 1.3.7, 1.4.1, 1.4.2.2, 1.5.1, 1.5.8, 1.5.10, 1.5.13, 1.6.3, 1.7.1, 1.7.3, 1.7.4.

Description of the protective measures MANDATORY Done

Three-step method: inherently safe design measures → safeguarding and/or complementary protective measures → information for use

Note: Taken from project data: measures per hazard in the risk assessment. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, risk assessment (Module 1 of the dossier).

Residual risks and their evaluation MANDATORY Done

Documentation of accepted residual risks with justification

Note: Taken from project data: residual risk acceptance documented in the risk assessment. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, risk assessment, residual risk documentation.

4. Standards and directives (3/3)

Applied standards and complied directives · Annex IV Part A (e) and (f) MR

List of all Union harmonisation legislation applied MANDATORY Done

MD 2006/42/EC, MR 2023/1230, EMC Directive, LVD, etc.

Note: Taken from project data: directives from the standards analysis and declaration of conformity. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, standards analysis and declaration of conformity.

References to the harmonised standards or common specifications applied MANDATORY

Not applicable

References of the harmonised standards under Art. 20(1) or of the common specifications under Art. 20(3) MR, with the parts applied where applied partially (Annex IV Part A (e) MR); as long as no standards under the MR are cited in the Official Journal, justified “not applicable”

Note: Taken from project data: 24 standards in the standards checklist. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001, standards checklist (Module 2 of the dossier).

Justification (n/a): No harmonised standards under Article 20(1) and no common specifications under Article 20(3) of the Machinery Regulation (EU) 2023/1230 have yet been published in the Official Journal. The 24 standards of the standards checklist are therefore documented as other technical specifications (item "Other technical specifications", declaration of conformity no. 7).

Other technical specifications MANDATORY Done

Descriptions of the other technical specifications used to meet the essential requirements where harmonised standards or common specifications were not applied or only applied in part (Annex IV Part A (f) MR)

Note: The 24 standards of the standards checklist (Module 2 of the dossier) are applied with their edition; as long as no references under the Machinery Regulation have been published, they count as other technical specifications and are listed as such in the declaration of conformity. Component-related product standards: Proof for the component concerned rests with the supplier. Where the integrator additionally applies one of these standards for the integration, this is noted below; the declaration of conformity lists these standards as well. EN IEC 61496-1:2020 and EN IEC 61496-2:2020 (Type 4 light curtain, proof provided by the ESPE manufacturer), EN IEC 60974-1:2022 (welding power source, supplier conformity via the Low Voltage and EMC Directives), EN ISO 21904-1:2020 (welding fume extraction: proof for the component provided by the equipment manufacturer; the integrator applies the standard for integrating the extraction into the cell), EN ISO 10218-1:2025 (robot: proof for the component via the EU declaration of incorporation in accordance with Annex V Part B together with the assembly instructions; the integrator applies the standard for the integration, for example for operating mode selection, the enabling device and safely reduced speed). Used by the integrator as a basis for selection and design, without presumption of conformity: EN ISO 25980:2023 (welding curtains and screens).

5. Drawings and calculations (11/11)

Technical documents and evidence · Annex IV Part A (c), (d), (g), (m) and (n) MR

General arrangement / overview drawing MANDATORY Done

Scale overall drawing with main dimensions

Note: Layout drawing RSZ-2600-LAY-001, Rev. C: installation plan with safety fence, maintenance door, light curtain, loading station, escape route and minimum distances to adjacent installations.

Detailed, design and manufacturing drawings MANDATORY Done

Design and manufacturing drawings and schemes of the machinery, its components, sub-assemblies and circuits (Annex IV Part A (c) MR)

Note: Released drawing set RSZ-2600-ZG-001 to -042, Rev. B: assembly and part drawings of the turntable, robot base, safety fence with maintenance door and control desk; circuits in electrical diagram RSZ-2600-EPL-001, pneumatic diagram RSZ-2600-PPL-001 and safety circuit diagram RSZ-2600-SPL-001; calculations in strength verification RSZ-2600-BER-001. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001.

Descriptions and explanations of the drawings and operation MANDATORY Done

Descriptions and explanations necessary for the understanding of the drawings and schemes and the operation of the machinery (Annex IV Part A (d) MR)

Note: System description RSZ-2600-TD-001, Rev. A: design, mode of operation, operating modes and sequence of a welding cycle with references to the installation plan, circuit and pneumatic diagrams; the function of the safety devices is described in the specifications of safety functions SF-01 to SF-05. Verified on 18 August 2026; filing location: PDM system Muster Maschinenbau, project MUSTER-2026-001.

Circuit diagrams (electrical, pneumatic, hydraulic) MANDATORY Done

Complete circuit diagrams of all control circuits (electrical according to EN 60204-1); without such equipment, “not applicable” with a reason

Note: Electrical circuit diagram RSZ-2600-EPL-001 in accordance with EN 60204-1 section 17, with terminal plan and equipment list. Pneumatic diagram RSZ-2600-PPL-001 in accordance with EN ISO 4414, with service unit, safety exhaust valve and workpiece clamps. Hydraulics not present on this machine.

Safety circuit diagrams / safety functions MANDATORY Done

Representation of all safety-related parts of the control system (SRP/CS); without a safety-related control system, “not applicable” with a reason

Note: Safety circuit diagram RSZ-2600-SPL-001 with safety functions SF-01 to SF-05, assignment of sensors, safety PLC and shutdown paths, feedback circuits of the positively guided contactors.

Strength calculations / structural analysis MANDATORY Done

Calculation evidence for load-bearing parts, welds, etc.

Note: Strength verification RSZ-2600-BER-001: turntable base frame, robot pedestal, anchoring with 2 × 4 heavy-duty anchors M16 and safety fence.

Performance level evidence for each safety function MANDATORY Done

Achieved PL (a to e) according to EN ISO 13849-1 or SIL according to EN IEC 62061, with validation according to EN ISO 13849-2; without safety functions of the control system, “not applicable” with a reason

Note: SISTEMA projects RSZ-2600-SF01 to -SF05 with reports as PDF. Verification PL greater than or equal to PLr fulfilled for all five safety functions (SF-01 PL d, SF-02 PL e, SF-03 PL d, SF-04 PL e, SF-05 PL d). Validation in accordance with EN ISO 13849-2 documented in RSZ-2600-VAL-001.

EMC test report Done

Evidence of electromagnetic compatibility according to the EMC Directive

Note: EMC test report RSZ-2600-EMV-001: immunity in accordance with EN IEC 61000-6-2:2019 and emission in accordance with EN IEC 61000-6-4:2019 for industrial environments verified, including consideration of the effects of the welding power source on the safety PLC. Verification of the increased immunity of the safety functions is still open (see the EMC test record).

Noise measurement report Done

Measured values with their uncertainty, the measurement standard applied and the operating conditions (noise measurement standard of the type-C standard, otherwise EN ISO 11201/11204 or EN ISO 3744/3746); these must be stated in the instructions

Note: Noise measurement report RSZ-2600-LRM-001: determination in accordance with EN ISO 11202:2010, declaration and verification in accordance with EN ISO 4871:2009. Emission sound pressure level at the loading station LpA 84 dB(A), uncertainty K = 2.5 dB, A-weighted sound power level LWA 96 dB(A), uncertainty KWA = 3 dB (EN ISO 3746, accuracy grade 3). Operating condition and measurement method described in the report.

Source code or programmed logic of the safety-related software Done

To be provided upon a reasoned request by a competent national authority, where that authority needs it to verify compliance with the essential health and safety requirements of Annex III MR (Annex IV Part A (m) MR)

Note: Held by the manufacturer and submitted on a reasoned request from a competent national authority (Annex IV Part A point (m) MR): program of the safety PLC as a project of the engineering software, safety configuration of the robot controller and parameterisation of the light curtain, each with version and checksum as recorded in the acceptance report and in the software bill of materials RSZ-2600-SBOM-001. Filed in the PDM system Muster Maschinenbau, project MUSTER-2026-001. Firmware and operating software of the purchased controllers remain with the respective supplier.

Characteristics, capabilities and limitations of sensor-based, remotely controlled or autonomous functions

Not applicable

For sensor-based, remotely controlled or autonomous machinery whose safety-related operation is driven by sensor data: a description of the general characteristics, capabilities and limitations of the system, the data and the development, testing and validation procedures (Annex IV Part A (n) MR)

Justification (n/a): The cell is not sensor-based, remotely driven or autonomous machinery within the meaning of Annex IV Part A point (n) MR: the robot executes approved, fixed welding programs. The sensors of the cell (light curtain, guard locking, pressure switch, workpiece presence sensors) act as protective devices or as enabling conditions in a fixed sequence; the safety-relevant operation is not derived from sensor data. Remote maintenance only reaches the standard controller and the HMI panel, and motion commands are only possible from operating positions with a view of the hazard zone (hazard 44).

6. Tests and checks (5/5)

Test reports and acceptance documentation · Annex IV Part A (g) and (o) MR

Test reports / test results MANDATORY Done

Results of all tests and measurements carried out

Note: Test records RSZ-2600-PRP-001, factory tests at the reference cell (see chapter Test records).

Functional test of safety devices MANDATORY Done

Evidence of the function of all protective devices (emergency stop, interlocking guards, light curtains)

Note: Functional test of safety functions SF-01 to SF-05 in accordance with validation plan RSZ-2600-VAL-001 at the reference cell.

Protective conductor test / insulation measurement MANDATORY Done

Electrical safety test according to EN 60204-1; without electrical equipment, “not applicable” with a reason

Note: Electrical test in accordance with EN 60204-1 section 18, test report RSZ-2600-ELP-001: continuity of the protective conductor system, fault loop impedance, insulation resistance, protection against residual voltages and functional test. The optional voltage test in accordance with section 18.4 is not performed (see test report).

Tests on components and fittings for safe assembly MANDATORY Done

Reports and results of the tests and trials the manufacturer carried out on the components, fittings or the complete machinery to establish whether, by its design or construction, the machinery can be safely assembled and put into service

Note: Tests for safe assembly and putting into service during the erection of the reference cell in the manufacturer's works: alignment and anchoring of the turntable and the robot base with four heavy-duty anchors M16 each (strength calculation RSZ-2600-BER-001, tightening torque in accordance with the anchor approval), installation of the robot in accordance with the robot manufacturer's assembly instructions and the installation conditions of its EU declaration of incorporation, assembly of the safety fence, maintenance door and light curtain in accordance with installation plan RSZ-2600-LAY-001, leak test of the pneumatics, electrical test in accordance with EN 60204-1 (RSZ-2600-ELP-001), functional test and validation of the safety functions (RSZ-2600-VAL-001) and factory acceptance test (RSZ-2600-FAT-001). The assembly sequence and the checks after assembly are set out in Chapter 8 of the operating instructions; at the user's premises they are repeated during re-assembly and documented in RSZ-2600-SAT-001 (planned after delivery in 03/2027).

Acceptance report Done

Documentation of the final acceptance with signature

Note: Factory acceptance test (FAT) at the reference cell in the manufacturer's works, report RSZ-2600-FAT-001 with defect list and release note. The site acceptance test at the user's premises (SAT, RSZ-2600-SAT-001) is planned after delivery in 03/2027 and will then be countersigned by the manufacturer and the user.

7. Operating instructions (12/12)

Complete operating instructions with all mandatory information · Annex IV Part A (i) MR, content according to Annex III No. 1.7.4 MR

Language versions for each target market MANDATORY Done

Instructions, safety information and the information under Annex III Section 1.7 in the language determined by the destination Member State and easily understood by users (Art. 10(7), final subparagraph, MR); for Germany in German (Section 2(1) MaschinenDG). The MR does not know a marking “original instructions”

Note: Operating instructions in German, drawn up in accordance with Annex III, sections 1.7.4 to 1.7.4.2 MR. The English version is identified as a translation; in case of doubt the German version prevails. Delivery in the language of the country of use.

Declaration of conformity in the instructions or access address stated MANDATORY Done

The instructions contain the EU declaration of conformity, or the internet address or machine-readable code where it can be accessed (Annex III No. 1.7.4.2(1)(c) MR); digital declarations stay online for the lifetime, at least ten years (Art. 10(8) MR)

Note: The EU declaration of conformity is enclosed with the operating instructions (Annex III, section 1.7.4.2, point (c) MR): Chapter 1.4 of the operating instructions states this expressly, Chapters 1.1 and 12 list it among the accompanying documents. The version of RSZ-2600-KE-001 signed for the placing on the market on 15 March 2027 is enclosed; an internet address is therefore not required.

For digital instructions: access, format, availability and paper version Not applicable

Only where the instructions are provided digitally: (1) state on the machinery, its packaging or in an accompanying document how the digital instructions can be accessed; (2) a format that can be printed, downloaded and stored; (3) available online for at least ten years after the placing on the market; (4) on request by the user at the time of purchase, free of charge in paper form within one month (Art. 10(7) MR)

Justification (n/a): The operating instructions are supplied in paper form with the machine (scope of delivery in accordance with Chapter 1.1, documentation in the marked accessory box in accordance with Chapter 5). Digital provision in accordance with Article 10(7) MR is not intended; the information on access, format, availability and paper version therefore does not apply.

Safety information in paper form for non-professional users Not applicable

Where the machinery may be used by non-professional users under reasonably foreseeable circumstances, the safety information essential for safe putting into service and use must be supplied in paper form (Art. 10(7), fifth subparagraph, MR)

Justification (n/a): The cell is intended for industrial use in a production hall. Loading and unloading are carried out by trained specialist personnel, set-up and maintenance by setters and maintenance personnel (operating instructions Chapters 2.1 and 9). Use by non-professional users is not to be expected under reasonably foreseeable conditions (Article 10(7), fifth subparagraph, MR).

Safety notices and warnings MANDATORY Done

Residual risks, intended use, prohibited use

Note: Operating instructions Chapter 2. Warnings and safety notices corresponding to the safety signs from the risk assessment (W001 with supplementary text, W006, W007, W011, W012, W015, W017, W018, W019, W022, W024, W027, P007, P015, M003, M004, M008, M009, M010, M017 and D-P006 in accordance with the German workplace rule ASR A1.3), coordinated with the labelling on the machine in accordance with Annex III, sections 1.7.1 and 1.7.3 MR.

Assembly and commissioning instructions MANDATORY Done

Transport, installation, connection, initial commissioning

Note: Operating instructions Chapter 8 (Assembly/Installation/Commissioning), including the incorporated assembly instructions of the robot manufacturer in accordance with Annex XI MR and the installation conditions from its EU declaration of incorporation.

Instructions for use MANDATORY Done

Description of all operating modes, controls, displays

Note: Operating instructions Chapter 9: Operation in automatic and set-up modes, loading procedure with the lifting aid rule (up to 15 kg by hand, above 15 kg with the lifting aid provided by the user on site), response to activation of the light curtain, acknowledgement after emergency stop.

Maintenance and servicing instructions MANDATORY Done

Maintenance intervals, lubrication schedules, wear parts, spare parts list

Note: Operating instructions Chapter 10 with maintenance schedule, semi-annual testing of safety functions SF-01 to SF-05, testing of the guard locking in accordance with EN ISO 14119, replacement of the filter cartridge using the bag-in/bag-out system, maintenance of the spark pre-separator, temperature sensor and shut-off dampers of the welding fume extraction system, the paragraph on cleaning and isolation requirements (LOTO) before mechanical, electrical and pneumatic work.

Fault clearance MANDATORY Done

Typical faults, fault diagnosis, remedial measures

Note: Operating instructions Chapter 10, section on fault clearance with fault table (Annex III, section 1.7.4.2 MR). Diagnosis from outside with the cell switched on, interventions inside the cell in set-up mode with the enabling device, mechanical, electrical and pneumatic work only after isolation and securing against re-energisation (discharge time at least 1 minute); access exclusively via the interlocked maintenance door.

Decommissioning and disposal MANDATORY Done

Instructions for safe dismantling and disposal notices

Note: Operating instructions Chapter 11: venting the pneumatics via the safety exhaust valve, waiting for the discharge time of the DC-link capacitors (measured 1.9 s to ≤ 60 V; waiting time at least 1 minute), disposal of the filter cartridges of the welding fume extraction system as hazardous waste, dismantling in reverse order of assembly.

Noise emission values MANDATORY Done

Workstation emission sound pressure level LpA, peak sound pressure level LpC,peak from 130 dB(C) upwards and sound power level LWA, each with its measurement uncertainty, plus the measurement method and the operating conditions

Note: Operating instructions Chapter 3 in accordance with Annex III, section 1.7.4.2, point (u) MR: emission sound pressure level LpA 84 dB(A) at the loading station, uncertainty K = 2.5 dB, A-weighted sound power level LWA 96 dB(A) with uncertainty KWA = 3 dB, as LpA exceeds 80 dB(A). LpA determined in accordance with EN ISO 11202, LWA in accordance with EN ISO 3746, declared in accordance with EN ISO 4871.

Vibration data (if applicable) Not applicable

Always state hand-arm vibration (vibration total value and, for repeated impacts, also the mean peak amplitude, each with its measurement uncertainty; there is no longer a declaration threshold) under MR Annex III 2.2.1.1; for mobile machinery also state whole-body vibration (> 0.5 m/s²) or that it does not exceed this value under 3.6.3.1

Note: Not applicable: the machine is stationary, has no hand-held or hand-guided operating element and no seated workstation. The hand-arm vibration measurable at the control desk is below the action value; evidence in RSZ-2600-VIB-001.

8. Conformity assessment, manufacture and retention (10/10)

Completion of the conformity assessment procedure, the declarations of incorporated products and the means by which conformity is maintained in manufacture · Annex IV Part A (h), (j), (k) and (l) MR, Annex V Part A MR (declaration of conformity), Art. 23 and 24 MR (CE marking), Art. 10(3) MR (retention)

EU declaration of conformity issued MANDATORY Done

According to Annex V Part A MR, with all mandatory particulars

Note: Prepared, not yet signed (signature planned for the first placing on the market on 15 March 2027): EU declaration of conformity (internal document no. RSZ-2600-KE-001, filed in PDM) in accordance with Annex V Part A MR (EU) 2023/1230. Conformity assessment procedure: internal production control (Module A) in accordance with Article 25(4) in conjunction with Annex VI MR; the machine does not fall under any category of Annex I MR, neither Part A nor Part B. MR transition: the first placing on the market is planned for March 2027 and therefore falls after the date of application of the Machinery Regulation (EU) 2023/1230 on 20 January 2027; the machine is to be assessed throughout in accordance with the MR. Only bringing forward the placing on the market to before 20 January 2027 would make the Machinery Directive 2006/42/EC applicable.

Declarations of conformity of incorporated machinery and products Done

Where applicable, copies of the EU declarations of conformity for incorporated machinery, related products and products covered by other Union harmonisation legislation (Annex IV Part A (k) MR)

Note: Copies of the declarations of conformity of the incorporated CE-marked products are available: MAG welding power source with wire feeder (Low Voltage and EMC Directives), welding fume extraction unit, the safety components Type 4 light curtain, safety PLC and interlocking device with guard locking, and the interference-relevant components of the EMC component list (test records EMC). Filed in the PDM system Muster Maschinenbau, project MUSTER-2026-001, supplier documentation. The robot is covered under the declarations of incorporation.

Declarations of incorporation and assembly instructions of incorporated partly completed machinery

Done

Where applicable, the EU declaration of incorporation under Annex V Part B MR and the assembly instructions under Annex XI MR for each incorporated partly completed machinery (Annex IV Part A (j) MR)

Note: EU declaration of incorporation in accordance with Annex V Part B MR and assembly instructions in accordance with Annex XI MR from the robot manufacturer for the articulated-arm industrial robot with robot controller and teach pendant. The installation conditions are assessed in the risk assessment of the assembly and incorporated in Chapter 8 of the operating instructions. No other partly completed machinery is incorporated. Filed in the PDM system Muster Maschinenbau, project MUSTER-2026-001, supplier documentation.

Notified body certificate or evidence of full application of the standards Not applicable

Only for machinery listed in Annex I MR: the notified body certificate under Art. 25(2) and (3) MR or, where permitted, evidence of full application of the harmonised standards (Module A, Annex VI MR)

Justification (n/a): The robotic welding cell does not fall under any category of Annex I MR, neither Part A nor Part B. The conformity assessment procedure is internal production control (Module A) in accordance with Article 25(4) in conjunction with Annex VI MR; a certificate from a notified body is not required. The documentation for Module A is this technical documentation.

Means of ensuring conformity during production MANDATORY Done

A description of the means by which the manufacturer ensures, during manufacture, that the machinery conforms to the design specifications (Annex IV Part A (h) MR)

Note: Single unit: conformity with the design specifications is ensured during manufacture by the following means: manufacture and assembly in accordance with the released drawing set RSZ-2600-ZG-001 to -042 (Rev. B) and the circuit and pneumatic diagrams, changes only via the change procedure in the PDM system Muster Maschinenbau; incoming inspection of the safety-related purchased parts against the order specification and the supplier's declaration of conformity; tests in accordance with test records RSZ-2600-PRP-001 and RSZ-2600-ELP-001, validation of the safety functions in accordance with RSZ-2600-VAL-001 and factory acceptance test RSZ-2600-FAT-001 with release note; comparison of the installed safety-related software version with version and checksum in the acceptance report. Still open is adding software release and vulnerability check under the Cyber Resilience Act to the production inspection (section Cybersecurity, item manufacturing and monitoring processes).

For series production: list of the internal measures taken Not applicable

For machinery manufactured in series, a list of the internal measures that ensure all manufactured units remain in conformity with the Regulation (Annex IV Part A (l) MR)

Justification (n/a): No series production: the RSZ-2600 is special-purpose machinery manufactured as a single unit with serial number RSZ2600-2026-0001, not a series. The means of ensuring conformity during manufacture are described under the previous item. The term series production in the intended use refers to the user's workpieces, not to the cell.

Sample testing, complaints, non-conformities and recalls Done

Take changes in production, design or the standards applied into account in series production; where appropriate in view of the risks, carry out sample testing of machinery made available and investigate the results; where necessary, keep a register of complaints, non-conforming machinery and recalls and keep distributors informed (Art. 10(4) MR)

Note: Single unit: sample testing from ongoing series production does not apply. Complaints, non-conformities and any recalls are recorded by the manufacturer in the complaints register of its quality management system; changes to the design or to the standards applied are handled through the change procedure in the PDM system and assigned to the technical documentation. The cell is delivered directly to the user; no distributors are involved.

CE marking MANDATORY Done

Clearly visible, legible and indelible on the machinery, form and minimum height as in Annex II to Regulation (EC) No 765/2008 (Article 30); where a notified body is involved, its identification number follows (Article 24(3) MR); affixed before placing on the market (Article 24(2)); if not yet affixed, record the status in the note

Note: Prepared, not yet affixed: CE marking in accordance with Articles 23 and 24 MR on the rating plate, character height 10 mm, permanent, visible and legible. The plate bearing the CE marking will be affixed to the right-hand side wall of the control cabinet after the declaration of conformity has been signed.

Rating plate MANDATORY Done

Minimum information under Art. 10(5) and (6) MR: designation, year of construction, model, series or type, batch or serial number, the manufacturer's name, registered trade name or registered trade mark, postal address and website or e-mail address, CE marking; if it has not yet been affixed, record its status in the note

Note: Rating plate in accordance with Annex III, section 1.7.3 MR produced and checked for completeness (Muster Maschinenbau GmbH with full address, website www.muster-maschinenbau.example and e-mail service@muster-maschinenbau.example as the digital contact in accordance with Article 10(6) MR, designation Robotic Welding Cell RSZ-2600, series or type designation, serial number, year of construction 2026, CE marking). The plate bearing the CE marking will be affixed to the right-hand side wall of the control cabinet after the declaration of conformity has been signed.

Technical file retained for ten years MANDATORY Done

At least ten years after the machinery has been placed on the market or put into service (Article 10(3) MR), retention obligation of the manufacturer

Note: Retention in accordance with Article 10(3) MR for at least ten years after placing the machine on the market. Filing in the PDM system of the manufacturer (Muster Maschinenbau GmbH); responsibility lies with the manufacturer (Article 10(3) MR).

9. Cybersecurity (CRA) (11/13)

Technical documentation under Annex VII of the Cyber Resilience Act, insofar as the points are relevant to the product. For a unit placed on the market before 11 December 2027 it is voluntary preparation and only becomes mandatory after a substantial modification on or after that date (Article 69(2) CRA); for units placed on the market on or after 11 December 2027 it is mandatory (Article 71(2) CRA). Without a confirmed date the classification remains open. · Annex VII of Regulation (EU) 2024/2847 (CRA), Article 13(12) and Article 31 CRA

Intended purpose Done

Annex VII No. 1(a) CRA

Note: Intended purpose in the CRA report (scope of the assessment) and in the operating instructions, Safety chapter.

Software versions affecting compliance Done

Annex VII No. 1(b) CRA

Note: Released software versions with checksums in the software bill of materials RSZ-2600-SBOM-001 and in the acceptance report.

Photographs or illustrations (hardware) Done

Annex VII No. 1(c) CRA

Note: Overall view and layout drawing of the cell in the technical documentation under Annex IV of the Machinery Regulation.

User information per Annex II Done

Annex VII No. 1(d) CRA

Note: Operating instructions, chapter 13 Cybersecurity.

Design information, system architecture Done

Annex VII No. 2(a) CRA

Note: Network plan with cell network, gateway and MES segment (NET-01), data flow diagram DFP-01, interfaces and assets in the CRA report.

Vulnerability handling processes, SBOM, CVD, contact, update distribution — Done

Annex VII No. 2(b) CRA

Note: Procedure VA-SEC-04, software bill of materials RSZ-2600-SBOM-001, coordinated vulnerability disclosure policy, contact address, update concept UPD-01.

Production and monitoring processes — Open

Annex VII No. 2(c) CRA

Note: Software release and vulnerability check will be added to the production test by the end of 2026.

Cybersecurity risk assessment — Done

Annex VII No. 3 CRA

Note: CRA report: scope of the assessment, interfaces and assets, risk assessment, requirements matrix.

Support period rationale — Done

Annex VII No. 4 CRA

Note: CRA report, support period section (12 years, until 03/2039, with justification).

Standards, specifications, schemes applied — Done

Annex VII No. 5 CRA

Note: No harmonised standard for the Cyber Resilience Act has been published in the Official Journal (status 17 September 2026); IEC 62443-4-1 and IEC 62443-4-2 used as guidance, without presumption of conformity.

Test reports — Open

Annex VII No. 6 CRA

Note: Reports NET-T-02 and RST-01 are available; the penetration test on the reference cell follows before placing on the market.

Copy of EU declaration of conformity — Not applicable

Annex VII No. 7 CRA

Justification (n/a): Placing on the market on 15 March 2027, i.e. before 11 December 2027: the main obligations of the Cyber Resilience Act do not apply to this unit (Article 69(2) and Article 71(2) CRA), so there is no EU declaration of conformity under this Regulation.

SBOM on reasoned request — Done

Annex VII No. 8 CRA

Note: The software bill of materials RSZ-2600-SBOM-001 exists for every software version and is provided to the market surveillance authority upon a reasoned request.

5. Test reports

Safety and functional tests

1. Electrical test to EN 60204-1

Electrical safety test of the machine control system · EN 60204-1:2018

Protective conductor test (continuity measurement) MANDATORY Passed

Test 1 under EN 60204-1 clause 18.2: continuity of the protective bonding circuit, resistance between the PE terminal and every touchable conductive part, measured with a test current of 0.2 A to 10 A from a PELV source

Measured value (Ω): 0.08 Ω (PE to most remote accessible point, safety fence earthing point)

Test date: 18/08/2026

Tested by: Jonas Weber

Fault loop impedance and disconnection conditions MANDATORY Passed

Test 2 under EN 60204-1 clause 18.2: measure the fault loop impedance and verify that the associated overcurrent protective device is suitable for automatic disconnection in the TN system

Measured value Zs (Ω): Zs = 0.28 Ω, disconnection condition met with 63 A gG

Test date: 17/08/2026

Tested by: Jonas Weber

Insulation resistance measurement Passed

Test under EN 60204-1 clause 18.3: measurement between live conductors and the protective bonding circuit at 500 V DC; insulation resistance at least 1 MΩ (on individual sections with slip rings or similar, at least 50 kΩ). Under clause 18.1 it is not part of the minimum scope where there is no product standard (which always comprises tests a, b, c and h); where the type C standard requires it, it must be carried out.

Measured value (MΩ): > 100 MΩ at 500 V DC (all main circuits against PE)

Test date: 18/08/2026

Tested by: Jonas Weber

Voltage test / dielectric strength test Not applicable

Voltage test under EN 60204-1 clause 18.4: test voltage = 2 × rated supply voltage or 1000 V, whichever is GREATER, for approximately 1 second. FIRST disconnect equipment not rated for this test voltage (frequency inverters, power supplies, electronics). Under clause 18.1 it is not part of the minimum scope where there is no product standard (which always comprises tests a, b, c and h); where the type C standard requires it, it must be carried out.

Test date: 18/08/2026

Tested by: Jonas Weber

Justification: Voltage test in accordance with 18.4 not performed (optional test; frequency converters and electronics would have to be disconnected). Proof provided via 18.2 (protective conductor, loop impedance), 18.3 (insulation resistance) and 18.5 (residual voltage).

Residual voltage test Passed

Test under EN 60204-1 clause 18.5: after disconnecting the supply, the residual voltage at accessible live parts must drop to 60 V or less within 5 s (at plugs and sockets without touch protection: within 1 s). Under clause 18.1 it is not part of the minimum scope where there is no product standard (which always comprises tests a, b, c and h); where the type C standard requires it, it must be carried out.

Discharge time to ≤ 60 V (s): 1.9 s to ≤ 60 V (DC link of welding power source)

Test date: 17/08/2026

Tested by: Jonas Weber

Emergency stop function tested (electrical) MANDATORY Passed

All emergency stop devices tested for function and type of release

Test date: 08/08/2026

Tested by: Jonas Weber

Circuit diagram conformity MANDATORY Passed

Wiring matches the circuit diagram, ferrules fitted, labelling present

Test date: 08/08/2026

Tested by: Jonas Weber

EMC measures documented Passed

Shielded cables, filter circuitry, earthing concept

Test date: 08/08/2026

Tested by: Jonas Weber

2. Functional test of safety devices

Testing and validation of all safety-related functions · EN ISO 13849-1 / EN ISO 13849-2 / EN IEC 62061 / EN 60204-1:2018 clause 18.6 / EN ISO 14119 / EN ISO 14120

Functional safety: 5 of 5 safety functions with documented validation.

Emergency stop: all stations and operating modes MANDATORY Passed

Emergency stop halts all hazardous movements in every operating mode

Test date: 08/08/2026

Tested by: Jonas Weber

Interlocking guards (doors and gates) MANDATORY Passed

Opening stops the machine; closing alone does not restart it (restart interlock)

Test date: 08/08/2026

Tested by: Jonas Weber

Guard locking required? Stopping time versus access time MANDATORY Passed

Stopping time of the hazardous movement compared with the time a person needs to reach the hazard zone after opening (approach according to EN ISO 13855); if the hazard zone can be reached before the hazard has ceased, guard locking is fitted and effective (EN ISO 14119)

Test date: 18/08/2026

Tested by: Jonas Weber

Justification: Guard locking required and fitted: the working space of the robot and turntable lies directly behind the maintenance door, so a person reaches it without any appreciable distance after opening. The overall stopping time of the robot and turntable is 250 ms (measured for SF-02), after which the arc must also have been extinguished; the hazard therefore ends later than the hazard zone can be reached. Design in accordance with EN ISO 14119:2025 on the de-energised principle; the door is only released after standstill monitoring of the robot and turntable and once the arc is extinguished (SF-01, PL d), tested in accordance with validation plan RSZ-2600-VAL-001.

Protection against defeating the interlock MANDATORY Passed

Motivation to defeat assessed (e.g. impeded setting or fault clearance) and measures against simple defeat implemented, such as coded actuators, concealed or protected mounting, plausibility monitoring (EN ISO 14119)

Test date: 18/08/2026

Tested by: Jonas Weber

Justification: Motivation to defeat assessed: teaching, program testing and fault-finding are possible in set-up mode with safely reduced speed and enabling device (SF-05) without bridging the maintenance door; there is no operational incentive to defeat the interlock. Measures in accordance with EN ISO 14119:2025 clause 8: actuators with a high coding level, switches and actuators mounted with non-detachable fasteners, safety fence panels removable only with a tool (hazard no. 3). Visual inspection of coding and fastening without findings.

Light barrier / AOPD / light curtain (ESPE) MANDATORY Passed

Interruption stops the hazardous movement; if muting is fitted: muting is correctly configured and monitored

Test date: 08/08/2026

Tested by: Jonas Weber

Justification: Type 4 light curtain at the loading station verified (SF-02); muting is not provided on this system (this verification point is therefore not applicable).

Restart interlock after power failure MANDATORY Passed

No unexpected restart after power is restored

Test date: 08/08/2026

Tested by: Jonas Weber

Mode selector switch MANDATORY Passed

Switching between operating modes correct, reduced speed in set-up mode

Test date: 08/08/2026

Tested by: Jonas Weber

Validation against the safety requirement specification MANDATORY Passed

Checked for each safety function: triggering event, reaction of the machine, safe state, operating modes, behaviour on loss of energy and restart conditions match the specification (EN ISO 13849-1 clause 5, validation under EN ISO 13849-2)

Test date: 18/08/2026

Tested by: Jonas Weber

Justification: Validation in accordance with validation plan RSZ-2600-VAL-001 at the reference cell for SF-01 to SF-05: for each safety function, triggering event, machine response, safe state, effectiveness in the operating modes Automatic and Set-up, behaviour on loss of power and restart conditions checked against the specification in the Functional Safety module, without deviation.

Fault simulation carried out per channel MANDATORY Passed

Analysis and testing under EN ISO 13849-2 clause 5 and its annexes: single faults simulated per channel, the safety function is maintained or the machine goes to the safe state

Test date: 18/08/2026

Tested by: Jonas Weber

Justification: Fault simulation in accordance with EN ISO 13849-2 for SF-01 to SF-05 (RSZ-2600-VAL-001): interruption and cross-circuit per input channel, welding of each contactor in the feedback circuit and failure of each shut-down path simulated. In every case the safety function was maintained or the safety PLC detected the fault, stopped the machine and blocked the restart.

Response time of the safety function measured Passed

Measured time from actuation to the safe state; input for the minimum distance under EN ISO 13855 and evidence of the specified response time

Response time (ms): 250 ms (SF-02, from interruption of the light curtain to standstill of robot and turntable; input value T in accordance with EN ISO 13855)

Test date: 18/08/2026

Tested by: Jonas Weber

3. Mechanical tests

Mechanical safety and strength · EN ISO 12100 / machine-specific C standards

Safety fence: safety distances in accordance with EN ISO 13857 MANDATORY Passed

Safety distances preventing hazard zones being reached by the upper limbs: height of the hazard zone, height of the protective structure and distance or opening size evidenced against the tables of EN ISO 13857

Test date: 08/08/2026

Tested by: Jonas Weber

Fastening of the guards MANDATORY Passed

Removable only with a tool, no loose connections

Test date: 08/08/2026

Tested by: Jonas Weber

Overall stopping performance time T measured MANDATORY Passed

Time from actuation of the protective device until the hazardous movement stops, including the response time of the protective device and of the control system (EN ISO 13855)

Stopping time T (ms): 250 ms (overall stopping time T for SF-02 including the response time of light curtain and safety PLC, measured on robot and turntable)

Test date: 18/08/2026

Tested by: Jonas Weber

Approach speed K established MANDATORY Passed

K under EN ISO 13855 for the type of approach (perpendicular approach to a light curtain usually 2000 mm/s, 1600 mm/s at greater distances)

K (mm/s): 1600 mm/s (EN ISO 13855:2024, approach perpendicular to the protective field of the light curtain at the loading station; with K = 2000 mm/s, S exceeds 500 mm, therefore K = 1600 mm/s)

Test date: 18/08/2026

Tested by: Jonas Weber

Intrusion distance C established MANDATORY Passed

Additional distance for intrusion into the hazard zone before actuation, depending on the resolution and arrangement of the protective device (EN ISO 13855)

C (mm): 128 mm (additional distance for reaching through, 8 × (d – 14) at detection capability d = 30 mm, EN ISO 13855:2024)

Test date: 18/08/2026

Tested by: Jonas Weber

Minimum distance S calculated MANDATORY Passed

S = K × T + C under EN ISO 13855, calculated with the measured overall stopping performance time

Minimum distance S (mm): 528 mm (S = K × T + C = 1600 mm/s × 0.25 s + 128 mm; the reserve of 72 mm to the implemented distance is available for the supplemental distance Z in accordance with EN ISO 13855:2024)

Test date: 18/08/2026

Tested by: Jonas Weber

Actual distance measured MANDATORY Passed

Actual distance between the protective device and the hazard zone on the machine as built; it must be at least the calculated minimum distance S

Actual distance (mm): 600 mm (between the protective field of the light curtain and the nearest danger point at the front station, at least S = 528 mm)

Test date: 18/08/2026

Tested by: Jonas Weber

Overrun distance measurement Passed

Distance the hazardous movement still travels after actuation; together with the stopping time T it is the input for the minimum distance under EN ISO 13855

Overrun distance (mm): 45 mm (turntable after interruption of the light curtain, SF-02; permissible ≤ 60 mm)

Test date: 18/08/2026

Tested by: Jonas Weber

Stability / anchoring MANDATORY Passed

Machine installed and anchored so it cannot tip over

Test date: 08/08/2026

Tested by: Jonas Weber

Trip/slip hazards eliminated Passed

Cables and hoses routed away, oil spills removed

Test date: 08/08/2026

Tested by: Jonas Weber

4. Hydraulics / pneumatics

Test of the fluid power systems · EN ISO 4413 / EN ISO 4414

Pressure test MANDATORY Passed

System pressure within specification, pressure relief valve functional

System pressure (bar): 6.0 bar (system pressure; pressure relief valve response pressure 7.5 bar verified)

Test date: 18/08/2026

Tested by: Jonas Weber

Leakage test MANDATORY Passed

No visible leaks at fittings, hoses or cylinders

Test date: 08/08/2026

Tested by: Jonas Weber

Hose/line condition MANDATORY Passed

No kinks, chafing points or ageing; burst protection fitted

Test date: 08/08/2026

Tested by: Jonas Weber

Residual pressure release documented MANDATORY Passed

Procedure for depressurising for maintenance is in place

Test date: 08/08/2026

Tested by: Jonas Weber

5. Noise emission

Determination of the noise emission values to be stated in the instructions · EN ISO 11201 / EN ISO 11202 / EN ISO 11204 / EN ISO 3744 / EN ISO 3746 / EN ISO 4871 (observe the noise measurement standard of the type-C standard)

Noise exposure at the workplace (in Germany the LärmVibrationsArbSchV implementing Directive 2003/10/EC) is assessed by the employer. It is not a basis of testing for the manufacturer and does not replace the emission measurement.

Emission sound pressure level determined MANDATORY Passed

Sound pressure level at the operator's position and other relevant positions; the fact that LpA does not exceed 70 dB(A) also requires this evidence

LpA (dB(A)): LpA = 84 dB(A), K = 2.5 dB (EN ISO 11202, loading station)

Test date: 18/08/2026

Tested by: Jonas Weber

Sound power level determined MANDATORY Passed

LWA under EN ISO 3744 or EN ISO 3746 (to be stated if LpA exceeds 80 dB(A))

LWA (dB(A)): LWA = 96 dB(A) (EN ISO 3746)

Test date: 18/08/2026

Tested by: Jonas Weber

Peak C-weighted instantaneous sound pressure level determined MANDATORY Passed

Determine LpC,peak at the workstations; it must be stated as soon as it exceeds 63 Pa (130 dB with reference to 20 µPa)

LpC,peak (dB(C)): 122 dB(C) (LpC,peak at the loading station in accordance with EN ISO 11202; below 130 dB(C), therefore no statement required in the operating instructions)

Test date: 18/08/2026

Tested by: Jonas Weber

Measurement uncertainty determined for every noise value MANDATORY Passed

Every stated noise emission value comes with its uncertainty K (EN ISO 4871); without it the statement in the instructions is incomplete

Uncertainty K (dB): KpA = 2.5 dB for LpA = 84 dB(A), KWA = 3 dB for LWA = 96 dB(A) (EN ISO 4871)

Test date: 18/08/2026

Tested by: Jonas Weber

Measurement method applied is documented MANDATORY Passed

Name the measurement standard, the accuracy grade and the measuring points: the noise measurement standard of the relevant type-C standard, otherwise EN ISO 11201/11202/11204 for emission sound pressure and EN ISO 3744/3746 for sound power

Measurement standard / accuracy grade: EN ISO 11202:2010 for LpA and LpC,peak at the loading station (accuracy grade 2), EN ISO 3746:2010 for LWA (accuracy grade 3), declaration and verification in accordance with EN ISO 4871:2009; measurement report RSZ-2600-LRM-001

Test date: 18/08/2026

Tested by: Jonas Weber

Operating conditions during the measurement are described MANDATORY Passed

The operating state, load, processed material and installation during the measurement are recorded and reproduced in the instructions

Test date: 18/08/2026

Tested by: Jonas Weber

Justification: Automatic mode with an approved welding program at a cycle time of approximately 90 seconds, MAG welding active, turntable in operation, welding fume extraction in operation, maintenance door closed; measuring position at the loading station in front of the loading opening (standing person). Reproduced in Chapter 3 of the operating instructions and in measurement report RSZ-2600-LRM-001.

Noise statement entered in the operating instructions MANDATORY Passed

Noise emission values stated under Annex III 1.7.4.2 point (u) MR, each value with its uncertainty, plus the measurement method and the operating conditions; where LpA ≤ 70 dB(A), state that explicitly

Test date: 08/08/2026

Tested by: Jonas Weber

6. Hazardous substances

Capture and control of released hazardous substances · EN ISO 12100 / EN ISO 14123-1:2015

The risk assessment for work with hazardous substances, protective measures at the workplace and instructing employees are the responsibility of the employer (in Germany the GefStoffV and TRGS). The manufacturer provides the information for this in the instructions.

Released hazardous substances identified MANDATORY Passed

The type and quantity of substances released during intended use (e.g. welding fume, ozone, dust, coolant mist, solvents) are recorded

Test date: 08/08/2026

Tested by: Jonas Weber

Capture at the point of origin MANDATORY Passed

Extraction captures the substances at the source (takes priority over general ventilation measures, EN ISO 12100 clause 6.3.4.4)

Test date: 08/08/2026

Tested by: Jonas Weber

Effectiveness test of the extraction MANDATORY Passed

Capture efficiency or air volume flow and capture velocity measured and documented

Volume flow (m³/h): 1,800 m³/h (extraction capacity at the capture hood, fault alarm threshold 1,400 m³/h)

Test date: 18/08/2026

Tested by: Jonas Weber

Filter/separation class and monitoring MANDATORY Passed

Filter class matched to the substance (e.g. welding fume class W3), filter monitoring and maintenance interval defined

Filter/welding fume class: Welding fume separator class W3

Test date: 18/08/2026

Tested by: Jonas Weber

Tightness of substance-carrying parts MANDATORY Passed

Lines, housings and connections of the substance-carrying components are tight; no uncontrolled release

Test date: 08/08/2026

Tested by: Jonas Weber

Statements in the operating instructions MANDATORY Passed

The type of hazardous substances, required extraction rate, filter changes and personal protective equipment are described in the operating instructions

Test date: 08/08/2026

Tested by: Jonas Weber

7. Acceptance / release

Final acceptance and documentation · EN ISO 12100 / Annex I No. 1.7.4 MD or Annex III No. 1.7.4 MR

Testing before first use, recurring inspections and instructing employees are the duty of the employer (in Germany the BetrSichV and ArbSchG). The manufacturer hands over the documents for this.

Visual inspection of all guards MANDATORY Passed

Completeness, damage, signs of tampering

Test date: 08/08/2026

Tested by: Jonas Weber

Rating plate complete and correct MANDATORY Passed

Model, series or type, year of construction, batch or serial number (Article 10(5) of the Machinery Regulation); name, registered trade name or registered trade mark, postal address and website, email address or other digital contact of the manufacturer (Article 10(6)), for imported machinery the same information of the importer (Article 13(3)); CE marking; where applicable, indication of use in potentially explosive atmospheres and the weight of parts handled with lifting equipment (Annex III, section 1.7.3); if the plate has not yet been fitted at the time of the test, state this in the justification

Test date: 08/08/2026

Tested by: Jonas Weber

Justification: Particulars checked on the finished plate, including the website and e-mail address as the digital contact in accordance with Article 10(6) of the Machinery Regulation. The plate is affixed after the declaration of conformity has been signed.

Technical documentation complete MANDATORY Passed

Operating instructions, circuit diagrams, declaration of conformity, risk assessment

Test date: 08/08/2026

Tested by: Jonas Weber

Handover to the operating company: instruction of the operating personnel (if agreed)

Note for the operating company Passed

Instructing employees is the duty of the employer. If the manufacturer carries it out under contract, it is documented here with the date and the signatures of the persons instructed.

Test date: 08/08/2026

Tested by: Jonas Weber

Justification: Factory personnel instructed at the reference cell. Training of the user's personnel is planned after delivery in 03/2027.

Release by the responsible person MANDATORY Passed

Signature of the CE coordinator / tester with date

Test date: 18/09/2026

Tested by: Jonas Weber

8. Protection against corruption (software, security)

Evidence under MR Annex III No. 1.1.9, 1.2.1, second paragraph, points (a), (b), (d) and (f) and 1.2.6; threat analysis to prEN 50742 (draft) Route A in the risk assessment, IEC 62443-3-3 as a reference for Route B. No presumption of conformity without an Official Journal reference. · MR (EU) 2023/1230 Annex III No. 1.1.9 / prEN 50742 (draft) / IEC 62443-3-3

Connecting other equipment and remote access do not lead to a hazardous situation MANDATORY

Passed

Annex III No. 1.1.9(1). For every interface (wired, wireless, remote access) it is demonstrated that no function of the connected equipment and no remote access can trigger a hazardous situation (threat analysis with measures per interface). Evidence: interface inventory, threat scenarios in the risk assessment, interface description for integrators. Route B reference: SR 5.1, SR 5.2, SR 1.13.

Test date: 15/09/2026

Tested by: Jonas Weber

Safety-relevant hardware is protected against unintentional and deliberate corruption MANDATORY

Passed

Annex III No. 1.1.9(2), first sentence. Hardware components that transmit signals or data for access to conformity-relevant software are physically and logically protected (locked enclosures, seals, coded switches, disabled ports). Evidence: design description, control cabinet layout, list of protected assemblies. Route B reference: SR 7.6, SR 7.7.

Test date: 15/09/2026

Tested by: Jonas Weber

Records of interventions in safety-relevant hardware are collected MANDATORY Passed

Annex III No. 1.1.9(2), second sentence. The machine records legitimate or illegitimate interventions in protected hardware components (opening, removal, connection events) with a timestamp. Evidence: control system event list, description of the logging, sample log from acceptance testing. Route B reference: SR 2.8, SR 2.11.

Test date: 15/09/2026

Tested by: Jonas Weber

Safety-relevant software and data are identified and protected MANDATORY Passed

Annex III No. 1.1.9(3). Software and data that are critical for conformity are identified as such (register, labelling in the system and documentation) and protected against unintentional or deliberate corruption (integrity check, access protection). Evidence: register of safety-relevant software and data with versions and checksums, description of the protective mechanisms. Route B reference: SR 3.4, SR 2.1.

Test date: 15/09/2026

Tested by: Jonas Weber

Installed safety-relevant software can be identified on the machine at any time MANDATORY Passed

Annex III No. 1.1.9(4). The machine identifies the software installed for safe operation (version, checksum) and makes this information available at any time in an easily accessible form (e.g. an info page on the HMI without login). Evidence: screenshot of the version display, comparison with the acceptance record, description in the operating instructions. Route B reference: SR 3.4.

Test date: 15/09/2026

Tested by: Jonas Weber

Records of interventions in software and configuration are collected MANDATORY Passed

Annex III No. 1.1.9(5). Legitimate or illegitimate interventions in the software, as well as changes to the installed software or its configuration, are logged (user, time, content, version). Evidence: change and event log of the control system, export capability, sample log. Route B reference: SR 2.8, SR 2.9, SR 6.1.

Test date: 15/09/2026

Tested by: Jonas Weber

The control system withstands reasonably foreseeable malicious attempts by third parties

MANDATORY Open

Annex III No. 1.2.1, second paragraph, point (a). Authentication, authorisation, hardening and segmentation are designed to fend off malicious attempts by third parties that could lead to a hazardous situation; no default passwords, minimal services. Evidence: security concept (zones, roles, password policy), hardening evidence, test log. Route B reference: SR 1.1, SR 1.5, SR 2.1, SR 7.7.

Tracing log available for up to five years after uploading MANDATORY Passed

Annex III No. 1.2.1, second paragraph, point (f). Data on interventions and the versions of uploaded safety software remain accessible for up to five years after uploading, for the conformity evidence, on a reasoned request by an authority (storage concept, export, retention). Evidence: storage and retention concept, export procedure, manufacturer/operator responsibility stated in the operating instructions. Route B reference: SR 2.9, SR 6.1.

Test date: 15/09/2026

Tested by: Jonas Weber

Failure, restoration or change of the communication network connection does not lead to a hazardous situation

MANDATORY Passed

Annex III No. 1.2.6. Loss of communication, reconnection or a change of network do not lead to unintended start-up, uncontrolled parameter changes or prevented stopping. Evidence: test log of communication failure in all operating modes, description of the behaviour in the operating instructions. Route B reference: SR 7.1, SR 7.2.

Test date: 15/09/2026

Tested by: Jonas Weber

Operating instructions include software identification, update procedure and network/remote access requirements

MANDATORY Passed

Annex III No. 1.7.4.2 in conjunction with No. 1.1.9(4) and No. 1.1.2(e). The operating instructions describe how the installed safety-relevant software is identified, the update procedure with a subsequent functional test, the requirements for the operator's network and the approval of remote access, and the retention of the logs. Evidence: software/security chapter of the operating instructions.

Test date: 18/09/2026

Tested by: Jonas Weber

A process for security updates and vulnerability reports is defined MANDATORY Passed

Annex III No. 1.1.9(3) and No. 1.2.1, second paragraph, point (b) (protection over the lifetime, General principles No. 1). The manufacturer has defined how vulnerabilities in safety-relevant software are reported, assessed and remedied, and how updates are distributed to operators (contact point, deadlines, responsibilities). Note: compliance with the Cyber Resilience Act (EU) 2024/2847 can make it easier to demonstrate Annex III No. 1.1.9 and 1.2.1 (CRA recital 53), but it does not establish a presumption of conformity with the MR (a contrario from Article 20(9) MR); the manufacturer demonstrates the coverage. Evidence: process description (e.g. following IEC 62443-4-1 practices DM and SUM), contact point stated in the operating instructions. Route B reference: IEC 62443-4-1 DM, IEC 62443-4-1 SUM.

Test date: 15/09/2026

Tested by: Jonas Weber

9. Electromagnetic compatibility (EMC)

Evidence under the EMC Directive 2014/30/EU (Art. 2, 3, 14, 15 to 19; Annexes I to III) and MD Annex I No. 1.2.1, 1.5.10 and 1.5.11 or MR Annex III; classification, environment class, route of evidence and procedure in the risk assessment module. This check does not replace the electrical safety verification to EN 60204-1 (Section 1). · 2014/30/EU Annex I / EN IEC 61000-6-1 to -6-4 / EN 61800-3 / EN 61326-3-1

Classification as apparatus or fixed installation documented MANDATORY Passed

Art. 2, Art. 3 No. 1 to 3, Art. 19. It is recorded whether the machine is made available on the market as apparatus, is operated as a fixed installation on a permanent basis at a predetermined location, or is intended solely for incorporation into a given fixed installation. Conformity assessment, declaration and CE marking depend on this. Any exclusion under Art. 2 must be substantiated with reasons. Evidence: classification in the risk assessment, technical documentation.

Classification: Apparatus: assembly made available on the market as a functional unit, not a fixed installation

Test date: 18/08/2026

Tested by: Jonas Weber

Environment class defined and justified MANDATORY Passed

Annex I No. 1; EN IEC 61000-6-1 to -6-4. The electromagnetic environment is defined (industrial environment, or residential, commercial and light-industrial environment) and matches the intended installation site. It determines which generic standards for immunity and emission apply. Where the machine is used in both environments, the stricter requirement applies in each case. Evidence: definition in the risk assessment, statement in the operating instructions.

Environment class: Industrial environment (installation in the production hall), generic standards EN IEC 61000-6-2 and -6-4

Test date: 18/08/2026

Tested by: Jonas Weber

Electromagnetic compatibility assessment available MANDATORY Passed

Annex I No. 1; Annex II No. 2. The assessment covers all relevant emission and immunity phenomena, all conditions that are normal in intended operation and all configurations that the manufacturer designates as representative. Where the case is argued through components and installation rules instead of being measured, the reasoning is traceable for each phenomenon. Evidence: test report from a laboratory, or a documented assessment supported by component evidence.

Evidence: Test report RSZ-2600-EMV-001, measurement on the overall installation

Test date: 18/08/2026

Tested by: Jonas Weber

Manufacturers' declarations for the interference-relevant components complete MANDATORY

Passed

Annex II No. 2 and 3. For frequency inverters, servo amplifiers, power supplies, control systems, sensors and other interference-relevant equipment, the manufacturers' EMC declarations or test reports together with the standards applied are available. For drives, the category to EN 61800-3 is recorded. Evidence: component list with declarations and standards applied.

Test date: 18/08/2026

Tested by: Jonas Weber

Component manufacturers' installation requirements met and documented MANDATORY Passed

Annex II No. 2; Annex I No. 2 for fixed installations. Screening and screen termination, mains and motor filters, earthing and equipotential bonding, segregated cable routing, maximum motor cable lengths and control cabinet construction comply with the component manufacturers' requirements. The implementation is documented, not merely asserted. Evidence: installation description, circuit diagram, photographs of the screen termination.

Test date: 18/08/2026

Tested by: Jonas Weber

Immunity of safety-related functions demonstrated Open

MD Annex I No. 1.2.1 or MR Annex III No. 1.2.1; EN 61000-6-7, EN 61326-3-1. Where safety functions depend on electronic systems, the generic standard is not sufficient: the increased immunity has to be demonstrated to EN 61000-6-7 or EN 61326-3-1. Where this does not apply, mark it as not applicable. Evidence: test report with increased test levels, evidence of the safe state in the event of a disturbance.

Conformity assessment procedure carried out MANDATORY Passed

Art. 14; Annex II, Annex III. Internal production control to Annex II, or EU type-examination with conformity to type to Annex III. Where Annex III is used, the name and identification number of the notified body and the certificate are available. The technical documentation is complete. Evidence: technical documentation and, where applicable, the certificate of the notified body.

Procedure: Internal production control (Annex II, Module A)

Test date: 18/08/2026

Tested by: Jonas Weber

Information in the operating instructions complete MANDATORY Passed

Art. 18(1) and (2); EN 61800-3. The operating instructions state the intended electromagnetic environment, the installation requirements and the limits of the intended use. Where compliance in residential areas is not ensured (emissions according to the generic standard for industrial environments), they clearly indicate this restriction of use, where appropriate also on the packaging (Article 18(2)). For drives of category C2, this includes the note that installation and commissioning are to be carried out by qualified personnel and that radio interference may occur in residential areas; drives of categories C3 and C4 are not intended for the first environment. Evidence: the installation and electrical connection chapter of the operating instructions.

Test date: 18/09/2026

Tested by: Jonas Weber

EU declaration of conformity names the EMC Directive and the standards applied MANDATORY

Passed

Art. 15, Art. 16, Art. 17; Art. 19(1). The declaration lists Directive 2014/30/EU and the harmonised or other standards applied; the CE marking thereby also covers EMC. For fixed installations no declaration is required; instead, the documentation under Art. 19(1) has to be kept available. Evidence: declaration of conformity module, documentation of the fixed installation.

Test date: 18/08/2026

Tested by: Jonas Weber

10. Cybersecurity (CRA)

Evidence under the Cyber Resilience Act (Regulation (EU) 2024/2847) (Articles 13, 14, 28, 30, 31 and 32; Annexes I, II, V, VII and VIII). The reporting obligations under Article 14 have applied since 11 September 2026, including to products already placed on the market; the remaining obligations apply to products placed on the market on or after 11 December 2027 or substantially modified on or after that date (Article 71(2), Article 69(2) CRA). Only the classification and the reporting process are therefore marked as mandatory; the other eight items must be met as soon as the remaining obligations apply to the product. Classification and procedure are kept in the risk assessment; the cybersecurity risk assessment, the requirements matrix of Annex I and the reporting process in the CRA report. This check does not replace the evidence on protection against corruption under Annex III No. 1.1.9 of the Machinery Regulation (under the Machinery Directive, the state of the art via Annex I No. 1.2.1). · Regulation (EU) 2024/2847, Articles 13, 14, 31 and 32 / Annexes I, II, V, VII and VIII

Scope and classification determined MANDATORY Passed

Articles 2 and 7, Annexes III and IV CRA. It is recorded whether the product has a data connection within the meaning of Article 2(1), whether an exclusion under Article 2(2) to (7) applies and which category of Annex III or IV the core functionality falls into. Evidence: Classification in the risk assessment module or in the CRA report, with date and responsible person.

Test date: 15/09/2026

Tested by: Jonas Weber

Cybersecurity risk assessment is available Passed

Article 13(2) to (4), Annex VII No. 3 CRA. The risks have been identified and assessed, the essential requirements of Annex I Part I have been examined against them, and the assessment forms part of the technical documentation. It is updated during the support period. Evidence: CRA report with risk table and requirements matrix.

Test date: 15/09/2026

Tested by: Jonas Weber

Essential cybersecurity requirements implemented Passed

Article 13(1) and (3), Annex I Part I CRA. For every requirement of Annex I Part I No. 1 and No. 2(a) to (m) it is recorded whether it applies on the basis of the risk assessment, how it has been implemented and what evidence supports that. Evidence: Requirements matrix with justification, implementation and evidence for each requirement.

Test date: 15/09/2026

Tested by: Jonas Weber

Justification: Requirements matrix fully documented. Part I(2)(a) (vulnerability matching) and (l) (logging concept) are in progress and will be completed before placing on the market.

Vulnerability handling in place Passed

Article 13(7) and 13(8) first subparagraph, Annex I Part II Nos 1 to 8 CRA. The requirements of Annex I, Part II are met: software bill of materials (SBOM), remediation of vulnerabilities without delay, regular testing, publication of information about fixed vulnerabilities, coordinated vulnerability disclosure policy, information sharing with a contact address for reports, secure distribution of updates and their dissemination without delay and, as a rule, free of charge, with advisory messages for users. Evidence: Procedure description, SBOM in a machine-readable format, contact point for reports.

Test date: 15/09/2026

Tested by: Jonas Weber

Justification: Process established. The first penetration test under Part II(3) is still pending.

Support period determined and stated, updates available Passed

Article 13(8), (9) and (19), Annex II No. 7 CRA. The support period reflects the expected product lifetime and is at least five years, or the expected lifetime where that is shorter; five years is the floor, not a default. The end date is indicated clearly at the time of purchase, at least by month and year, and every security update provided remains available after it has been issued for at least ten years or for the remainder of the support period, whichever is longer. Evidence: Statement on the product, on its packaging or in the instructions for use; archive of the security updates delivered.

Support period: 12 years from placing on the market, until 03/2039

Test date: 15/09/2026

Tested by: Jonas Weber

Due diligence for bought-in components carried out Open

Article 13(5) and (6) CRA. When integrating third-party components, including open-source ones, it has been verified that they do not compromise the cybersecurity of the product; vulnerabilities in such components are reported and remedied. Evidence: Component list with origin, version, verification and the source of security information.

Test date: 15/09/2026

Tested by: Jonas Weber

Reporting process under Article 14 in place MANDATORY Passed

Articles 14 and 16 CRA. Responsibility, availability and reporting channel for actively exploited vulnerabilities and severe incidents are defined: early warning within 24 hours, notification within 72 hours, final report, information to the users concerned. Evidence: Written procedure naming the CSIRT, access to the reporting platform, availability.

Test date: 15/09/2026

Tested by: Jonas Weber

Information and instructions for the user complete Passed

Article 13(18), Annex II CRA. The information set out in Annex II accompanies the product, including the name and contact details of the manufacturer, the contact point for vulnerabilities, the product identification, the intended purpose with the security environment and security properties, circumstances leading to significant cybersecurity risks, where applicable, the internet address of the EU declaration of conformity, technical security support, the end of the support period and instructions on commissioning, updates and secure decommissioning. Evidence: Cybersecurity chapter of the instructions for use or the accompanying information.

Test date: 15/09/2026

Tested by: Jonas Weber

Conformity assessment carried out and declaration drawn up Not applicable

Article 13(12) and (20), Articles 28, 30 and 32, Annexes V and VIII CRA. The procedure under Article 32 has been carried out in line with the classification, the EU declaration of conformity is available, the CE marking has been affixed and a copy or a simplified declaration accompanies the product. Evidence: Declaration of conformity and, where applicable, the certificate of the notified body.

Test date: 15/09/2026

Tested by: Jonas Weber

Justification: Placing on the market on 15 March 2027, i.e. before 11 December 2027: the main obligations of the Cyber Resilience Act do not apply to this unit (Article 69(2) and Article 71(2) CRA), so there is neither a conformity assessment nor a declaration under this Regulation. The reporting obligations under Article 14 apply (Article 69(3) CRA).

Technical documentation drawn up and kept Open

Article 13(13), Article 31, Annex VII CRA. The technical documentation contains the information required by Annex VII and is kept for ten years from the placing on the market or for the support period, whichever is longer. Evidence: Technical documentation with description, risk assessment, requirements, standards and test reports.

Test date: 15/09/2026

Tested by: Jonas Weber

6. Functional safety

Performance level according to EN ISO 13849-1

This module does not replace SISTEMA. It determines the required performance level (PLr) and documents functional safety in the CE dossier. The safety-critical calculation of the achieved PL (category, MTTFd, DCavg, CCF, PFH) and the manufacturers' component data (libraries according to VDMA 66413) must be carried out in or obtained from SISTEMA (IFA/DGUV, free of charge). The SISTEMA result is then entered here for the verification PL ≥ PLr; the SISTEMA report belongs in the technical documentation as evidence.

Safety function	Hazards	Required	Achieved (SISTEMA)	Verification
SF-04 Enable of the 180-degree rotary movement of the turntable only when the rotation range is clear Dual-channel monitoring of the light curtain, clamping pressure (pressure switch) and table position in the safety PLC; the rotation command is enabled only when the protective field is clear and the clamping pressure is confirmed, rotation speed safely limited	No. 1, No. 4, No. 5, No. 6, No. 11, No. 30, No. 31, No. 32	PLr e Risk graph S2/F2/P2	PL e · Cat. 4 · PFH 2.7e-8 1/h · MTTFd high · DCavg high · CCF 85	**fulfilled (PL ≥ PLr)**
SF-01 Safe stop (stop category 1) upon opening of the maintenance door Interlocking with guard locking in accordance with EN ISO 14119 (de-energisation principle), dual-channel evaluation in the safety PLC, STO on robot and turntable drive, safe shutdown of the welding power source, guard locking released only after standstill monitoring	No. 13, No. 16, No. 17, No. 19, No. 31, No. 1, No. 2, No. 3, No. 4, No. 6, No. 8, No. 11, No. 18, No. 23	PLr d Risk graph S2/F1/P2	PL d · Cat. 3 · PFH 4.7e-7 1/h · MTTFd high · DCavg medium · CCF 75	**fulfilled (PL ≥ PLr)**
SF-02 Safe stop upon interruption of the light curtain at the loading station Light curtain type 4 in accordance with EN IEC 61496-1/-2, resolution 30 mm, safety distance in accordance with EN ISO 13855, evaluation in the safety PLC, STO on robot and turntable drive	No. 9, No. 16, No. 31, No. 1, No. 13, No. 32	PLr e Risk graph S2/F2/P2	PL e · Cat. 4 · PFH 2.5e-8 1/h · MTTFd high · DCavg high · CCF 85	**fulfilled (PL ≥ PLr)**
SF-03 Emergency stop of the overall installation, stop category 1 Emergency stop devices at the control desk, at the maintenance door and on the teach pendant, dual-channel to the safety PLC; acts on robot, turntable, welding power source and pneumatics of the entire cell	No. 1, No. 4, No. 6, No. 7, No. 21, No. 31	PLr d Risk graph S2/F1/P2	PL d · Cat. 3 · PFH 4.2e-7 1/h · MTTFd high · DCavg medium · CCF 75	**fulfilled (PL ≥ PLr)**

Safety function	Hazards	Required	Achieved (SISTEMA)	Verification
SF-05 Safely reduced speed of 250 mm/s with enabling device in set-up mode Lockable operating mode selector switch, safe speed monitoring (SLS) of robot and turntable to 250 mm/s, three-position enabling device on the teach pendant; emergency stop remains effective	No. 3, No. 18, No. 31, No. 1, No. 2, No. 4, No. 6, No. 8, No. 11, No. 30	PLr d Risk graph S2/F2/P1	PL d · Cat. 3 · PFH 4.5e-7 1/h · MTTFd high · DCavg medium · CCF 75	**fulfilled (PL ≥ PLr)**

Specification and validation per safety function

SF-04 Enable of the 180-degree rotary movement of the turntable only when the rotation range is clear

Safety requirements specification (EN ISO 13849-1, clause 5)

Triggering event	Rotation command for the 180-degree rotation of the turntable.
Reaction of the machine	The rotation command is only executed when the protective field of the light curtain is clear, the clamping pressure is confirmed by the pressure switch and the robot is demonstrably outside the rotation range; the rotation speed is safely limited. If a condition ceases to be met during rotation, the turntable is stopped.
Safe state	Turntable at standstill, rotary movement blocked, drive torque-free.
Operating modes in which the function is effective	Automatic; in set-up mode the table only rotates at safely reduced speed with the enabling device actuated (SF-05).
Permissible response time	If the light curtain responds during rotation, the overall response time of SF-02 applies (at most 250 ms).
Behaviour on loss of energy	The turntable remains stationary, the clamps remain closed via the pressure retaining valve; no automatic rotation after power is restored.
Conditions for restarting	New rotation command only after cycle start at the control desk and with the enabling conditions met.
Demand rate	In every cycle, approximately every 90 seconds (F2).
Fault reaction (behaviour when a fault is detected)	Fault of the pressure switch, of the robot's safe position feedback or in the enabling circuit: no release for turning, a turning movement in progress is stopped; restart only after the fault has been rectified and acknowledged.
Review of the specification before development (date, person)	18 June 2026, M. Beispiel (CE officer) with electrical design and control engineering and mechanical design; result recorded in validation plan RSZ-2600-VAL-001.

Validation (EN ISO 13849-2)

Validation under EN ISO 13849-2 carried out	Yes
Date of validation	18/08/2026
Method applied	Validation in accordance with EN ISO 13849-2 as per validation plan RSZ-2600-VAL-001. Analysis: fault list in accordance with EN ISO 13849-2 Annex B for pressure switch and clamping circuit and Annex D for light curtain, position monitoring and safety PLC, comparison of category 4, MTTFd, DCavg and CCF with SISTEMA project RSZ-2600-SF04. Testing at the reference cell: rotation attempts with one enabling condition not met in each case (protective field interrupted, clamping pressure lowered, robot in the rotation range), fault simulation per channel (interruption and cross-circuit of pressure switch and position signals, welding of each contactor in the feedback circuit), test of the safely limited rotation speed. Result: PL e achieved, no deviation from the specification.
Person carrying out the validation	Jonas Weber

SF-01 Safe stop (stop category 1) upon opening of the maintenance door

Safety requirements specification (EN ISO 13849-1, clause 5)

Triggering event	Request to open the maintenance door (release of the guard locking) or loss of the interlocking signal of the maintenance door.
Reaction of the machine	Stop category 1 in accordance with EN 60204-1 for robot and turntable followed by STO, safe shutdown of the welding power source; the guard locking only releases the door once the arc has been extinguished and robot and turntable are at standstill (standstill monitoring).
Safe state	Robot and turntable at standstill and torque-free, welding power source switched off, maintenance door held locked until standstill.
Operating modes in which the function is effective	Automatic: opening leads to a stop, automatic mode only with the door closed and locked. Set-up: movements with the door open only via SF-05 (enabling device, 250 mm/s); the welding power source remains safely switched off while the door is open.
Permissible response time	Not relevant for distances: the guard locking only releases after standstill, so no safety distance in accordance with EN ISO 13855 needs to be calculated.
Behaviour on loss of energy	The guard locking based on the de-energised principle remains locked; leaving the cell is possible at any time via the escape release on the inside; no automatic start after power is restored.
Conditions for restarting	Close the door, guard locking effective, acknowledgement at the control desk outside the cell, then cycle start (restart interlock in accordance with EN ISO 14118). The lockout device for personal padlocks prevents closing while a person inside the cell is secured.
Demand rate	Rare: only for maintenance, servicing and troubleshooting, not in the production cycle (F1).
Fault reaction (behaviour when a fault is detected)	If the safety PLC detects a fault in the door or guard locking circuit (open circuit, cross-circuit, discrepancy between the two channels) or a welded contactor in the feedback circuit, it stops the robot and turntable via the intact channel, keeps the door locked until standstill and inhibits restart until the fault has been rectified and acknowledged.
Review of the specification before development (date, person)	18 June 2026, M. Beispiel (CE officer) with electrical design and control engineering and mechanical design; result recorded in validation plan RSZ-2600-VAL-001.

Validation (EN ISO 13849-2)

Validation under EN ISO 13849-2 carried out	Yes
Date of validation	18/08/2026
Method applied	Validation in accordance with EN ISO 13849-2 as per validation plan RSZ-2600-VAL-001. Analysis: fault list in accordance with EN ISO 13849-2 Annex D for guard locking, safety PLC and contactors, comparison of category 3, MTTFd, DCavg and CCF with SISTEMA project RSZ-2600-SF01. Testing at the reference cell: functional test against the specification in Automatic and Set-up, fault simulation per channel (interruption and cross-circuit of the door and guard locking signals, welding of each contactor in the feedback circuit), test of standstill monitoring, restart interlock and escape release. Result: PL d achieved, no deviation from the specification.
Person carrying out the validation	Jonas Weber

SF-02 Safe stop upon interruption of the light curtain at the loading station

Safety requirements specification (EN ISO 13849-1, clause 5)

Triggering event	Interruption of the protective field of the Type 4 light curtain (resolution 30 mm) at the loading opening.
Reaction of the machine	Safe stop of robot and turntable with stop category 1 in accordance with EN 60204-1 followed by STO, evaluation in the safety PLC.
Safe state	Robot and turntable at standstill, drives torque-free via STO.
Operating modes in which the function is effective	Continuously effective in Automatic and Set-up, no muting.
Permissible response time	Overall response time T of at most 250 ms to standstill; resulting S = 528 mm in accordance with EN ISO 13855:2024, implemented with 600 mm.
Behaviour on loss of energy	Drives de-energised; no automatic start after power is restored (restart interlock).
Conditions for restarting	Protective field clear, acknowledgement at the control desk outside the hazard zone with a view of the loading opening, then cycle start.
Demand rate	High: the operator stands at the boundary of the protective field in every cycle (approximately 90 seconds) (F2).
Fault reaction (behaviour when a fault is detected)	Fault of the light curtain (output or cross-circuit fault) or in the shutdown path: safe stopping as on interruption of the protective field, the light curtain goes into its lockout state; restart only after the fault has been rectified and acknowledged.
Review of the specification before development (date, person)	18 June 2026, M. Beispiel (CE officer) with electrical design and control engineering and mechanical design; result recorded in validation plan RSZ-2600-VAL-001.

Validation (EN ISO 13849-2)

Validation under EN ISO 13849-2 carried out	Yes
Date of validation	18/08/2026
Method applied	Validation in accordance with EN ISO 13849-2 as per validation plan RSZ-2600-VAL-001. Analysis: fault list in accordance with EN ISO 13849-2 Annex D for light curtain, safety PLC and shut-down paths, comparison of category 4, MTTFd, DCavg and CCF with SISTEMA project RSZ-2600-SF02. Testing at the reference cell: functional test with the test rod over the full height of the protective field in Automatic and Set-up, fault simulation per channel (interruption and cross-circuit of the two outputs of the light curtain, welding of each contactor in the feedback circuit), measurement of the overall stopping time T = 250 ms and of the implemented distance 600 mm against S = 528 mm, check for reaching under and reaching round the sides. Result: PL e achieved, no deviation from the specification.
Person carrying out the validation	Jonas Weber

SF-03 Emergency stop of the overall installation, stop category 1

Safety requirements specification (EN ISO 13849-1, clause 5)

Triggering event	Actuation of an emergency stop device at the control desk, at the maintenance door or on the teach pendant.
Reaction of the machine	Stop category 1 in accordance with EN 60204-1 for all sub-machines of the assembly: controlled stop of the robot along its path, active braking of the turntable, followed by disconnection of energy via two positively driven contactors; welding power source de-energised, pneumatics of the cell switched off, the clamps remain closed via the pressure retaining valve.
Safe state	All hazardous movements of the assembly stopped, drives de-energised, welding power source de-energised.
Operating modes in which the function is effective	All operating modes (Automatic and Set-up); the emergency stop also remains effective in set-up mode.
Permissible response time	Not relevant to safety distances: the emergency stop is a complementary protective measure, no safety distance in accordance with EN ISO 13855 has to be calculated. The robot and turntable come to a standstill after stop category 1 with the same overrun as measured for SF-02 (250 ms at most).
Behaviour on loss of energy	The disconnection of energy corresponds to the safe state; no automatic start after power is restored.
Conditions for restarting	Release the actuated device, acknowledgement at the control desk, then cycle start.
Demand rate	Rare: only in a hazardous situation or in the event of a fault (F1).
Fault reaction (behaviour when a fault is detected)	Discrepancy between the two emergency stop channels or a welded contactor in the feedback circuit: stopping via the intact channel, restart inhibited until the fault has been rectified and acknowledged at the control desk.
Review of the specification before development (date, person)	18 June 2026, M. Beispiel (CE officer) with electrical design and control engineering and mechanical design; result recorded in validation plan RSZ-2600-VAL-001.

Validation (EN ISO 13849-2)

Validation under EN ISO 13849-2 carried out	Yes
Date of validation	18/08/2026
Method applied	Validation in accordance with EN ISO 13849-2 as per validation plan RSZ-2600-VAL-001. Analysis: fault list in accordance with EN ISO 13849-2 Annex D for emergency stop devices, safety PLC and contactors, comparison of category 3, MTTFd, DCavg and CCF with SISTEMA project RSZ-2600-SF03. Testing at the reference cell: actuation of each device in Automatic and Set-up with effect on all sub-machines, fault simulation per channel (interruption and cross-circuit per device, welding of each contactor in the feedback circuit), test of release and restart interlock. Result: PL d achieved, no deviation from the specification.
Person carrying out the validation	Jonas Weber

SF-05 Safely reduced speed of 250 mm/s with enabling device in set-up mode

Safety requirements specification (EN ISO 13849-1, clause 5)

Triggering event	Selection of set-up mode at the lockable operating mode selector; in set-up mode, exceeding 250 mm/s at robot or turntable and releasing or fully pressing the enabling device.
Reaction of the machine	Movements of robot and turntable only with the three-position enabling device actuated and at no more than 250 mm/s (safe speed monitoring); on exceedance, release or full pressing a controlled stop (stop category 1). In the Set-up position all other operating modes are blocked, the emergency stop remains effective.
Safe state	Robot and turntable at standstill or at a safely monitored speed of no more than 250 mm/s.
Operating modes in which the function is effective	Set-up (teaching, program test, troubleshooting).
Permissible response time	Not relevant to safety distances: in set-up mode the speed is limited to 250 mm/s and movement is only possible with the enabling device actuated, no safety distance in accordance with EN ISO 13855 has to be calculated. On release, full depression or overspeed, the robot and turntable come to a standstill after stop category 1 with the same overrun as measured for SF-02 (250 ms at most).
Behaviour on loss of energy	Drives stopped; no automatic start after power is restored (restart interlock).
Conditions for restarting	Renewed actuation of the enabling device in the middle position; change to Automatic only with the key, with the maintenance door closed and after acknowledgement at the control desk.
Demand rate	Continuous during every set-up operation (F2).
Fault reaction (behaviour when a fault is detected)	Fault of the safe speed monitoring or discrepancy between the contacts of the enabling device: the robot and turntable stop, set-up mode remains inhibited until the fault has been rectified and acknowledged.
Review of the specification before development (date, person)	18 June 2026, M. Beispiel (CE officer) with electrical design and control engineering and mechanical design; result recorded in validation plan RSZ-2600-VAL-001.

Validation (EN ISO 13849-2)

Validation under EN ISO 13849-2 carried out	Yes
Date of validation	18/08/2026
Method applied	Validation in accordance with EN ISO 13849-2 as per validation plan RSZ-2600-VAL-001. Analysis: fault list in accordance with EN ISO 13849-2 Annex D for operating mode selector, enabling device, speed monitoring and safety PLC, comparison of category 3, MTTFd, DCavg and CCF with SISTEMA project RSZ-2600-SF05. Testing at the reference cell: measurement of the speed at the TCP (no more than 250 mm/s), deliberate exceedance with stop, release and full pressing of the enabling device, blocking of the other operating modes, fault simulation per channel (interruption and cross-circuit of the signals of enabling device and selector). Result: PL d achieved, no deviation from the specification.
Person carrying out the validation	Jonas Weber

7. Cybersecurity

Cyber Resilience Act (Regulation (EU) 2024/2847), contribution to the technical documentation under Annex VII CRA

For this product only the reporting obligations under Article 14 CRA apply under the Regulation (Article 69(3) CRA); the other obligations only apply after a substantial modification on or after 11 December 2027 (Article 69(2) CRA). The sections on scope, inventory, risks, requirements, components, vulnerabilities, support period and user information document voluntary preparation; items marked “Open” there are not obligations in force.

Confidential: this document contains security-relevant information on the attack surface of the product. Share it only with persons and bodies that need the information for the conformity assessment or market surveillance.

Classification, status of obligations and conformity assessment

Articles 2, 7, 8, 32, 69 and 71, Annexes III and IV CRA

Last changed: 17/09/2026, 01:18

Scope (Article 2(1) CRA)	Covered: the product falls under the Cyber Resilience Act (Article 2(1) CRA). Which obligations apply today depends on the date of placing on the market.
Core functionality (Article 7(1) CRA)	Robot-assisted MAG welding of steel assemblies in series production. The software controls the robot, turntable, welding process and fume extraction. Networking, VPN and access functions come from purchased components and are not the core functionality of the cell; they are recorded as components with their own classification.
Classification (Annexes III and IV CRA)	Default product (not listed in Annex III or IV)
Classification confirmed	Yes
Obligations in force	The product is placed on the market before 11 December 2027. Of the Cyber Resilience Act, only the reporting obligations under Article 14 then apply (Article 69(3) CRA); the essential cybersecurity requirements, the CRA conformity assessment and the CRA CE marking only apply once the product is substantially modified on or after 11 December 2027 (Article 69(2) CRA). Cybersecurity requirements under other legal acts are unaffected, such as those of the Radio Equipment Directive via Delegated Regulation (EU) 2022/30 until 10 December 2027 and Annex III No. 1.1.9 of the Machinery Regulation from 20 January 2027.
Reporting obligations (Article 14 CRA)	The reporting obligations under Article 14 CRA have applied since 11 September 2026, including for products placed on the market earlier (Article 69(3) CRA).
EU declaration of conformity (Article 28 CRA)	No declaration under the Regulation: for placing on the market before 11 December 2027 only the reporting obligations under Article 14 apply (Article 69(3) CRA), as long as the product is not substantially modified afterwards (Article 69(2) CRA).
Date of placing on the market	15 March 2027 (planned)

- The date of placing on the market applies per unit. If further units of the same design are placed on the market on or after 11 December 2027, the remaining obligations of the Regulation apply to them. According to Commission guidance C(2026) 5252, paragraphs 33 to 39 (content of the draft approved on 27 July 2026), a series designed earlier then needs no redesign if the risk assessment demonstrates appropriate measures; conformity assessment, EU declaration of conformity and CE marking remain mandatory.

Basis of the assessment 5 of 5 documented

Article 13(3), second sentence, CRA

Last changed: 17/09/2026, 01:18

Intended purpose	Robot-assisted MAG welding of steel assemblies up to 40 kg in series production, installed stationary in a production hall. The cell is integrated into the user's production network (orders from the MES) and is maintained remotely by the manufacturer over a VPN connection that the user enables for each session.
Reasonably foreseeable use	Connecting the cell network directly to the office or internet network without the gateway; leaving remote maintenance permanently enabled; shared user accounts across shifts; importing programs from private USB drives; connecting further devices to the cell network; continued operation after the end of the support period without security updates.
Operating environment	Production hall with restricted access. Cell network (PROFINET) inside the locked control cabinet, separated from the user's production network by the gateway with firewall; connection to the MES via OPC UA in a dedicated network segment. Internet access only through the VPN gateway and only for enabled maintenance sessions. Operation by trained staff with personal accounts; service by the manufacturer and electrically skilled persons appointed by the user.
Assets to be protected	Safety functions and safety program of the safety PLC; control software and welding programs; user accounts and VPN certificates; event log; personal data of the operators; the user's production network into which the cell is integrated.
Conditions of use	Operation only with the supplied gateway and in line with the network requirements of the operating instructions; remote maintenance only after enabling it at the control desk; the manufacturer's security updates are installed promptly with the cell stopped.
Expected product lifetime	12 years
Justification of the lifetime	Mechanics and drives are designed for 12 years in two-shift operation, which matches the service life of the predecessor cells at the user's site. The suppliers of the robot controller and the safety PLC guarantee spare parts until at least 2039.

Interface and asset inventory

Basis of the assessment under Article 13(2) CRA; asset types modelled on EN 18031, supplemented by safety function and operational data

Last changed: 17/09/2026, 01:18

The inventory describes the attack surface of the product: every data connection with a device or network and the assets reachable through it. It is also the basis of the assessments on protection against corruption and on radio equipment.

Interfaces

Designation	Type	Protocol	Reachability	Safety function
Cell network to robot, turntable and welding power source	Network / fieldbus / line integration	PROFINET IO with PROFIsafe	On site only (physical access)	Yes
Connection to the user's MES	Network / fieldbus / line integration	OPC UA (Sign & Encrypt) over Ethernet	Local network of the installation	No
Remote maintenance via VPN gateway	Remote access / remote maintenance	IPsec VPN over the user's internet connection	Reachable via the internet	No
HMI panel at the control desk	Operator panel (HMI) with user and parameter management	Touch operation with roles and user accounts	On site only (physical access)	No
USB port on the HMI panel	USB / removable media	USB 2.0 for backups and program import	On site only (physical access)	No

Designation	Type	Protocol	Reachability	Safety function
Programming access to the safety PLC and the robot controller	Engineering / programming access	Engineering port (Ethernet) in the control cabinet	On site only (physical access)	Yes

Assets

Designation	Type	Protection goals	Interfaces
Safety functions SF-01 to SF-05 and the safety program of the safety PLC	Safety function of the machine	Integrity, Availability	Cell network to robot, turntable and welding power source, Programming access to the safety PLC and the robot controller
Control, HMI and gateway software including version and checksums	Security asset (keys, passwords, security functions of the control system)	Integrity, Availability	Programming access to the safety PLC and the robot controller, Remote maintenance via VPN gateway, USB port on the HMI panel, HMI panel at the control desk
User accounts, roles and VPN certificates	Security asset (keys, passwords, security functions of the control system)	Confidentiality, Integrity	HMI panel at the control desk, Remote maintenance via VPN gateway, Connection to the user's MES
Welding programs and process parameters (current, voltage, wire feed, paths)	Operational and process data (recipes, parameters, production data)	Confidentiality, Integrity	Connection to the user's MES, HMI panel at the control desk, USB port on the HMI panel
Event log of logins, parameter changes and remote maintenance sessions	Operational and process data (recipes, parameters, production data)	Integrity, Availability	HMI panel at the control desk, Remote maintenance via VPN gateway
Operator user names and login times	Privacy asset (personal data)	Confidentiality, Integrity	HMI panel at the control desk, Connection to the user's MES
Network configuration of the cell and the transition to the user network (gateway, firewall rules)	Network asset (network functions and their configuration)	Integrity, Availability	Connection to the user's MES, Remote maintenance via VPN gateway

Cybersecurity risk assessment 7 of 7 documented

Article 13(2) and (3) CRA

Last changed: 19/09/2026, 15:37

The CRA does not prescribe a method, but it does prescribe a minimum content. Article 13(2) CRA requires an assessment of the cybersecurity risks and that its outcome be taken into account during the planning, design, development, production, delivery and maintenance phases; Article 13(3) CRA requires the assessment to be documented and updated during the support period. This assessment documents it qualitatively as impact × likelihood in four levels; this follows the definition of cybersecurity risk as a combination of the magnitude of loss or disruption and the likelihood of occurrence (Article 3(37) CRA). This is NOT the risk assessment under EN ISO 12100: health and safety consequences of an attack are part of the impact here under Article 13(2) CRA; the protective measure against the safety-related consequence and its evidence additionally belong in the risk assessment (Annex III No. 1.1.9 of the Machinery Regulation or the state of the art under the Machinery Directive). The two risk numbers must not be confused or added together.

As at 15 September 2026, no harmonised standard for the Cyber Resilience Act has been cited in the Official Journal; there is therefore currently no presumption of conformity under Article 27(1) CRA. Once a standard appears, the method must be aligned with it.

From a risk number of 4, this assessment requires a documented measure. That is a convention of this assessment, not a limit set by the CRA: a risk rated lower must also be minimised under Article 13(2) CRA.

Risk classes (convention of this assessment, not set by the CRA): 1 to 3 low, 4 to 7 medium, 8 to 11 high, 12 and above very high.

Scale

Level	Impact	Likelihood
1	low: no appreciable damage, operation continues	unlikely: only with considerable effort and physical access
2	noticeable: individual functions disrupted, data corrupted or leaked	possible: a targeted attack with expert knowledge is conceivable
3	serious: production stopped, trade secrets or personal data affected	likely: known attack paths, tools freely available
4	very serious: safety function, health or a third-party network affected	very likely: reachable from the network, automated attacks known

Threat 1: Unauthorised access through remote maintenance with stolen credentials; programs or parameters of the standard controller are changed.

via Remote maintenance via VPN gateway; Asset: Control, HMI and gateway software including version and checksums
Category: Unauthorised access
Impact × likelihood: 3 × 3 = 9 (High)
Measures: VPN with multi-factor login and personal accounts; enabling only at the control desk, time-limited, with a "Remote maintenance active" indicator; no remote access path to the safety PLC; every session is logged.
Residual risk: 3 × 1 = 3 (Low); Remaining: insiders with a valid account; limited by logging and dual-control approval of safety-related changes. Safety-related consequences of remote access are assessed in the risk assessment to EN ISO 12100 (hazard no. 44).
Requirements: Part I No. 2(d); Part I No. 2(j); Part I No. 2(l)
Status: complete

Threat 2: A known vulnerability in the VPN gateway firmware is exploited to reach the user's production network.

via Remote maintenance via VPN gateway; Asset: Network configuration of the cell and the transition to the user network (gateway, firewall rules)
Category: Vulnerability in a component
Impact × likelihood: 3 × 3 = 9 (High)
Measures: Software bill of materials for every software version; subscription to the gateway supplier's security advisories; check against public vulnerability databases before every delivery; security updates via the customer portal; the gateway does not route traffic between the cell network and the user network.
Residual risk: 3 × 1 = 3 (Low); Remaining: time between disclosure and installation of the update by the user.
Requirements: Part I No. 2(a); Part I No. 2(c); Part I No. 2(i); Part II No. 1; Part II No. 2
Status: complete

Threat 3: Manipulated order or parameter data from the MES network change welding parameters; the welds become defective.

via Connection to the user's MES; Asset: Welding programs and process parameters (current, voltage, wire feed, paths)
Category: Manipulation
Impact × likelihood: 3 × 2 = 6 (Medium)
Measures: OPC UA only in Sign & Encrypt mode with certificates; received parameters are checked against released limits; changes to welding programs only with the set-up role.
Residual risk: 3 × 1 = 3 (Low); Safety-related consequences of falsified data are also assessed in the risk assessment (hazard no. 42).
Requirements: Part I No. 2(e); Part I No. 2(f)
Status: complete

Threat 4: Malware reaches the HMI panel from a USB drive while backups or programs are imported.

via USB port on the HMI panel; Asset: Control, HMI and gateway software including version and checksums

Category: Malware

Impact × likelihood: 3 × 2 = 6 (Medium)

Measures: USB port usable only after login, autorun disabled; only signed update packages are installed; programs are checked for checksum and format before they are accepted.

Residual risk: 2 × 1 = 2 (Low); The operating instructions tell users to use checked storage media only.

Requirements: Part I No. 2(f); Part I No. 2(j)

Status: complete

Threat 5: Passwords are shared or observed (shoulder surfing) at the HMI panel; an operator obtains the rights of a higher role.

via HMI panel at the control desk; Asset: User accounts, roles and VPN certificates

Category: Unauthorised access

Impact × likelihood: 2 × 3 = 6 (Medium)

Measures: Personal accounts instead of group accounts; password change enforced at first login; automatic logout; logins and role changes are logged.

Residual risk: 2 × 2 = 4 (Medium); Sharing passwords remains an organisational matter for the user; covered in the operating instructions.

Requirements: Part I No. 2(b); Part I No. 2(d); Part I No. 2(l)

Status: complete

Threat 6: An additional device overloads or disturbs the cell network (denial of service); communication with the safety PLC is lost.

via Cell network to robot, turntable and welding power source; Asset: Safety functions SF-01 to SF-05 and the safety program of the safety PLC

Category: Availability

Impact × likelihood: 3 × 2 = 6 (Medium)

Measures: Cell network inside the locked control cabinet without free ports; separated from the user network by the gateway; PROFIsafe monitoring switches to the safe state on communication loss, restart only after acknowledgement.

Residual risk: 2 × 1 = 2 (Low); Safety-related consequences are assessed in the risk assessment to EN ISO 12100 (hazard no. 38).

Requirements: Part I No. 2(h); Part I No. 2(k)

Status: complete

Threat 7: The safety program is overwritten or put into stop mode through the programming access.

via Programming access to the safety PLC and the robot controller; Asset: Safety functions SF-01 to SF-05 and the safety program of the safety PLC

Category: Manipulation

Impact × likelihood: 4 × 2 = 8 (High)

Measures: Programming access only inside the locked control cabinet; individual password for the safety program; version and checksum on the HMI panel; acceptance test of the safety functions after every change.

Residual risk: 4 × 1 = 4 (Medium); Remaining: intervention by authorised persons; the evidence on protection against corruption is part of the risk assessment (hazard no. 43).

Requirements: Part I No. 2(d); Part I No. 2(f); Part I No. 2(k)

Status: complete

Requirements relating to the properties of the product 14 of 14 documented

Annex I Part I CRA

Last changed: 19/09/2026, 15:37

Annex I Part I No. 1 applies without qualification. The requirements of No. 2(a) to (m) apply “where applicable” on the basis of the cybersecurity risk assessment; whether and how they apply must be stated in the assessment (Article 13(3), third sentence, CRA) and belongs in the technical documentation (Annex VII point 3 CRA). Where one of them is not applicable, this must be clearly justified there (Article 13(4) CRA).

Reference	Requirement	Applicable	Status	Justification	Implementation	Evidence
Part I No. 1	Appropriate cybersecurity level based on risks	always applies	fulfilled		Cybersecurity risk assessment with seven threats across all digital interfaces; the measures are implemented in design, commissioning and service.	CRA report with risk table and requirements matrix
Part I No. 2(a)	No known exploitable vulnerabilities	yes	in progress		The software bill of materials is checked against public vulnerability databases before every delivery; open findings are fixed before delivery.	Vulnerability check report per software version (first report before placing on the market)
Part I No. 2(b)	Secure by default configuration, reset	yes	fulfilled		Delivered with remote maintenance disabled, closed ports on the gateway and an enforced password change; reset to factory settings via the service menu.	Commissioning checklist IBN-SEC-01
Part I No. 2(c)	Security updates, automatic updates with opt-out	yes	fulfilled		Security updates as signed packages via the customer portal, installed by the user with the cell stopped. Automatic installation is not provided because an update during production would stop the cell; the user is informed of available updates by e-mail.	Update concept UPD-01
Part I No. 2(d)	Protection from unauthorised access	yes	fulfilled		Personal accounts with roles on the HMI panel, VPN with multi-factor login, OPC UA with certificates; failed logins and remote maintenance sessions are logged and shown on the HMI panel.	Role concept ROL-01, log extract from acceptance
Part I No. 2(e)	Confidentiality of data	yes	fulfilled		OPC UA in Sign & Encrypt mode, encrypted VPN tunnel; passwords are stored as hashes only.	Configuration record of gateway and OPC UA server
Part I No. 2(f)	Integrity of data, commands, programs, configuration	yes	fulfilled		Signed update packages, checksums of the control software on the HMI panel, change log for parameters and programs.	Software version acceptance report

Reference	Requirement	Applicable	Status	Justification	Implementation	Evidence
Part I No. 2(g)	Data minimisation	yes	fulfilled		Only production data and the user names needed for login and logging are processed; no data is sent to the manufacturer outside enabled maintenance sessions.	Data flow diagram DFP-01
Part I No. 2(h)	Availability of essential functions, DoS resilience	yes	fulfilled		Cell network separated from the user network, bandwidth limit on the gateway; the cell keeps working with the last released programs without MES or internet connection.	Network load and connection loss test, report NET-T-02
Part I No. 2(i)	Minimise impact on other devices and networks	yes	fulfilled		The gateway allows only OPC UA to the MES and the VPN connection to the manufacturer and does not route traffic between the cell network and the user network.	Firewall rule set FW-01
Part I No. 2(j)	Limit attack surfaces	yes	fulfilled		Unneeded services and ports disabled, programming access inside the locked control cabinet, USB usable only after login.	Hardening checklist HRT-01
Part I No. 2(k)	Exploitation mitigation	yes	fulfilled		No remote access path to the safety controller, safe state on communication loss, backup and restore with checksum comparison.	Validation report of the safety functions, restore test
Part I No. 2(l)	Security logging and monitoring with opt-out	yes	in progress		Event log of logins, role and parameter changes, software uploads and remote maintenance sessions. The design of the opt-out mechanism is still being clarified because the same log provides the evidence under Annex III, section 1.1.9 of the Machinery Regulation (status 17 September 2026).	Logging concept LOG-01 (draft)
Part I No. 2(m)	Secure data deletion and transfer	yes	fulfilled		"Factory settings" permanently deletes user accounts, certificates, programs and logs; backups are written to USB in encrypted form.	Reset test, report RST-01

Third-party components 1 of 5 documented

Article 13(5) and (6) CRA

Last changed: 19/09/2026, 15:33

Anyone integrating components sourced from third parties into a product exercises due diligence: the components must not compromise the cybersecurity of the product. This also applies to free and open-source software that has not been made available on the market in the course of a commercial activity (Article 13(5) CRA). If a vulnerability is identified in a component, it must be reported to the person or entity manufacturing or maintaining the component; a fix developed in-house must be shared with them (Article 13(6) CRA).

Component 1: Controller of the articulated robot

Manufacturer: Robot manufacturer (supplier)
Version: Controller software 5.2
Type: Hardware
CRA status: under review
Class / note: Core functionality robot control; according to the supplier, no category of Annex III or IV.
Evidence of due diligence: Supplier questionnaire on vulnerability handling and support period evaluated; subscribed to the supplier's security advisories; declaration of CRA conformity for deliveries from 11 December 2027 requested.
SBOM reference: Supplier SBOM requested
Last check: 10/09/2026

Component 2: Safety PLC with engineering software

Manufacturer: Controls manufacturer (supplier)
Version: Firmware 3.1
Type: Hardware
CRA status: under review
Class / note: Core functionality safety control, no category of Annex III or IV.
Evidence of due diligence: Manufacturer's security manual evaluated and hardening recommendations applied; subscribed to security advisories; declaration of CRA conformity requested.
SBOM reference: RSZ-2600-SBOM-001, safety PLC section
Last check: 10/09/2026

Component 3: Industrial router with VPN (remote maintenance gateway)

Manufacturer: Network equipment vendor (supplier)
Version: Firmware 8.4
Type: Hardware
CRA status: under review
Class / note: Important product of class I under Annex III No. 5 (VPN) and No. 12 (routers); for deliveries from 11 December 2027 the supplier must demonstrate a conformity assessment under Article 32(2) CRA.
Evidence of due diligence: Firmware maintenance committed in writing until 2036, replacement with the successor model planned within the support period; hardened according to the supplier's guide.
SBOM reference: RSZ-2600-SBOM-001, gateway section
Last check: 10/09/2026

Component 4: HMI panel with visualisation software

Manufacturer: Automation manufacturer (supplier)
Version: Runtime 17
Type: Hardware
CRA status: under review
Class / note: Core functionality operating and monitoring, no category of Annex III or IV.
Evidence of due diligence: Supplier questionnaire evaluated; support for the runtime committed until 2037; subscribed to security advisories.
SBOM reference: RSZ-2600-SBOM-001, HMI panel section
Last check: 10/09/2026

Component 5: OPC UA communication library (open source)

Manufacturer: Open-source project

Version: 1.4

Type: Software, free and open-source software

CRA status: not covered by the CRA

Class / note: Free and open-source software not supplied by the project in the course of a commercial activity (Recital 18 CRA); the due diligence obligation when integrating it lies with the manufacturer of the cell (Article 13(5) CRA).

Evidence of due diligence: Version checked against public vulnerability databases; maintenance activity and security policy of the project reviewed; updates are adopted with every software version; vulnerabilities found are reported to the project (Article 13(6) CRA).

SBOM reference: RSZ-2600-SBOM-001

Last check: 10/09/2026

- No. 1: Open: whether the component meets the requirements has not been established yet (Article 13(5) CRA).
- No. 2: Open: whether the component meets the requirements has not been established yet (Article 13(5) CRA).
- No. 3: Open: whether the component meets the requirements has not been established yet (Article 13(5) CRA).
- No. 4: Open: whether the component meets the requirements has not been established yet (Article 13(5) CRA).

Vulnerability handling 12 of 12 documented

Annex I Part II CRA

Last changed: 19/09/2026, 15:33

Storage location of the bill of materials	Manufacturer's PDM system, document RSZ-2600-SBOM-001, updated for every released software version
Format of the bill of materials	CycloneDX 1.6 (JSON)
Provision of the bill of materials to the user	no
Contact address for reporting vulnerabilities (Part II No. 6, Article 13(17) CRA)	security@muster-maschinenbau.example
Coordinated vulnerability disclosure policy (Part II No. 5 CRA)	https://www.muster-maschinenbau.example/security/disclosure
Publication of information about fixed vulnerabilities (Part II No. 4 CRA)	https://www.muster-maschinenbau.example/security/advisories

Requirements of Annex I Part II

Reference	Requirement	Status	Implementation	Evidence	Note
Part II No. 1	Identify vulnerabilities and components, SBOM	fulfilled	Software bill of materials in CycloneDX format for every released software version, covering at least the top-level dependencies; component list with suppliers and versions.	RSZ-2600-SBOM-001	

Reference	Requirement	Status	Implementation	Evidence	Note
Part II No. 2	Remediate without delay, separate security updates	fulfilled	Remediation by severity with fixed target times; where technically feasible, security updates are provided separately from functionality updates.	VA-SEC-04, section 5	Qualification in the wording: security updates need only be delivered separately from functionality updates “where technically feasible”. For subsequent substantially modified versions of a software product, Article 13(10) CRA allows the obligation to be limited to the version most recently placed on the market, provided users of the earlier version have free access to the latest version without additional adaptation costs.
Part II No. 3	Regular security testing and review	in progress	Annual penetration test on a reference cell and a vulnerability check before every delivery; the first test is planned before placing on the market.	Test plan SEC-PP-01	
Part II No. 4	Publish information on fixed vulnerabilities	fulfilled	Security advisories with description, affected versions, impact, severity and remediation at https://www.muster-maschinenbau.example/security/advisories; publication is delayed only in justified cases until users have been able to install the update.	VA-SEC-04, section 6	Qualification in the wording: in duly justified cases where the risks of publication outweigh the security benefits, publication may be delayed until users have had the opportunity to apply the patch. The justification belongs in the implementation description.
Part II No. 5	Coordinated vulnerability disclosure policy	fulfilled	Coordinated vulnerability disclosure policy published at https://www.muster-maschinenbau.example/security/disclosure.	Published policy, Rev. A	
Part II No. 6	Vulnerability information sharing, contact address	fulfilled	Contact address security@muster-maschinenbau.example; subscribed to the security advisories of the suppliers of robot controller, safety PLC and gateway.	VA-SEC-04, section 3	
Part II No. 7	Secure update distribution mechanisms	fulfilled	Signed update packages with checksum via the customer portal (TLS); the installer verifies the signature before installing.	Update concept UPD-01	Qualification in the wording: security updates are, where applicable, installed automatically. For products in professional and industrial environments where an automatic update could disrupt operations, users would not normally expect them (see recital 56 CRA); the decision is to be justified here.

Reference	Requirement	Status	Implementation	Evidence	Note
Part II No. 8	Free security updates with advisories	fulfilled	Security updates are free of charge during the support period and come with advisory messages on content and recommended actions, separate from paid feature upgrades.	General service terms, section on security updates	Qualification in the wording: for a tailor-made product, the manufacturer and the business user may agree otherwise on free-of-charge distribution. Any such agreement is to be named here; the duty to distribute without delay together with advisories remains.

- The eight requirements of Annex I, Part II apply without the qualification “where applicable” of Part I (introductory sentence of Annex I, Part II; see recital 54 CRA) and therefore cannot be deselected once the obligations of the Regulation apply to the product; for each point, record how it is implemented and what evidence supports it (Annex VII, point 2(b) and point 6 CRA). Some points carry restrictions in their own wording; they appear as a note on the row and concern the implementation, not the applicability.

Support period 4 of 4 documented

Article 13(8), (9) and (19) CRA

Last changed: 17/09/2026, 01:18

Support period determined	12 years
Check against Article 13(8) CRA	The support period meets the minimum of five years and the expected lifetime. The reasons for setting it belong in the technical documentation (Article 13(8), fifth subparagraph, and Annex VII No. 4 CRA).
Factors taken into account	The support period matches the expected period of use of 12 years. Taken into account were the users' expectations in series production, the service life of comparable welding cells and the firmware maintenance committed by the suppliers of the robot controller, safety PLC and gateway (evidence in the component list).
Calculated end (assumption of this assessment: start at placing on the market, plus period)	03/2039
End date stated	03/2039
Indication of the end date at the time of purchase	Order confirmation, supplementary plate next to the rating plate and the Cybersecurity chapter of the operating instructions
Availability of security updates already provided (Article 13(9) CRA)	Security updates are provided in the manufacturer's customer portal with release notes and checksum and remain available there for at least ten years after release, and in any case until the end of the support period.

Reporting of actively exploited vulnerabilities and severe incidents 4 of 4 documented

Article 14 CRA

Last changed: 17/09/2026, 01:18

Deadlines under Article 14(2) and (4) CRA: early warning without undue delay and in any event within 24 hours of becoming aware; notification without undue delay and in any event within 72 hours of becoming aware, unless the relevant information has already been provided; final report for a vulnerability within 14 days after a corrective or mitigating measure is available, for a severe incident within 1 month after the notification. The deadlines are calculated without shifting to working days, which is the stricter reading.

Responsible for notifications	Product Security Officer, reachable via security@muster-maschinenbau.example and the service on-call team, including weekends

Deputy	Head of Electrical Engineering
Member State of the main establishment	Germany
CSIRT designated as coordinator	CERT-Bund at the Federal Office for Information Security (BSI)
Access to the single reporting platform (Article 16 CRA)	set up
Internal procedure	Procedure VA-SEC-04 "Handling vulnerabilities and security incidents", Rev. B
Information to the users concerned (Article 14(8) CRA)	Security advisory by e-mail to the registered contacts of every user and publication at https://www.muster-maschinenbau.example/security/advisories, also machine-readable in CSAF format

Information and instructions to the user 7 of 7 documented

Annex II, Annex VII No. 1(d) CRA

Last changed: 17/09/2026, 01:18

The following information follows Annex II CRA. For this product (placed on the market before 11 December 2027) it only has to accompany the product after a substantial modification on or after 11 December 2027 (Article 69(2) CRA). For a machine it belongs in the cybersecurity chapter of the instructions for use.

Annex II No. 1 CRA: Name and contact details of the manufacturer

Muster Maschinenbau GmbH
Beispielstraße 1, 12345 Musterstadt, Germany
service@muster-maschinenbau.example
https://www.muster-maschinenbau.example

Annex II No. 2 CRA: Single point of contact for vulnerabilities and disclosure policy

security@muster-maschinenbau.example
https://www.muster-maschinenbau.example/security/disclosure

Annex II No. 3 CRA: Unique identification of the product

Robotic welding cell RSZ-2600
RSZ-2600
Serial number on the rating plate on the right-hand side wall of the control cabinet; software version on the HMI panel under "Info"

Annex II No. 4 CRA: Intended purpose, security environment and security properties

Robot-assisted MAG welding of steel assemblies up to 40 kg in series production, installed stationary in a production hall.
Operation in a production network separated from the office and internet networks; connection to the MES only through the supplied gateway; remote maintenance only through the VPN gateway after enabling it at the control desk; control cabinet and programming ports locked.
Control of robot, turntable, welding process and fume extraction; receiving orders and reporting production data via OPC UA; backups via USB; remote maintenance by the manufacturer.
Personal user accounts with roles; encrypted and signed OPC UA connection; VPN with multi-factor login; event log of logins, parameter changes and remote maintenance sessions; version and checksum of safety-related software on the HMI panel; no remote access to the safety controller.

Annex II No. 5 CRA: Circumstances that may lead to significant cybersecurity risks

Connecting the cell network directly to the office or internet network; remote maintenance left permanently enabled; shared passwords; files from unknown sources via USB; security updates not installed; continued operation after the end of the support period.

Annex II No. 6 CRA: Internet address of the EU declaration of conformity

no entry (where applicable)

Annex II No. 7 CRA: Technical security support and end date of the support period

Security updates for control, HMI and gateway software via the customer portal; security advisories by e-mail; support from the manufacturer's service when integrating the cell into the user network.

End of the support period: 03/2039

Annex II No. 8 CRA: Detailed instructions

(a) Secure commissioning and use: Change the initial password at the first login (the controller enforces this) and create personal accounts for all operators; integrate the gateway according to the manufacturer's network plan and allow only OPC UA to the MES and the VPN connection to the manufacturer; back up the accepted configuration and record its checksum in the acceptance report.

(b) Effect of changes on the security of data: Additional network connections, changed firewall rules, changes to the safety program or connecting further machines can impair cybersecurity and the safety functions. Make such changes only after consulting the manufacturer and test the safety functions afterwards.

(c) How to install security-relevant updates: Download security updates from the customer portal, compare the checksum and install them via USB on the HMI panel with the cell stopped, set-up mode selected and the maintenance door closed, or during an enabled remote maintenance session; then check version and checksum on the HMI panel.

(d) Secure decommissioning and removal of user data: Before decommissioning, back up welding programs and logs, reset the cell via "Factory settings" (this deletes user accounts, certificates, programs and logs) and ask the manufacturer to block the remote maintenance access.

Annex II No. 9 CRA: Access to the software bill of materials, if provided

no entry (where applicable)

- Note: no internet address of the EU declaration of conformity is given; it only has to be stated “where applicable” (Annex II No. 6 CRA). Where the main obligations apply, under Article 13(20) CRA the product is accompanied by a copy of the EU declaration of conformity or a simplified declaration; the simplified declaration states the internet address at which the full text is available (Annex VI CRA).

State of standardisation on the market

Article 27 CRA

As at 15 September 2026 no harmonised standard for the Cyber Resilience Act is cited in the Official Journal of the European Union. There is therefore currently no presumption of conformity under Article 27(1) CRA, and for important products of class I the route via internal control (module A) with harmonised standards applied in full is not yet open in practice. The delegated act designating European certification schemes for the presumption of conformity (Article 27(9) CRA) has not been adopted either. Check the state of the Official Journal before the conformity assessment.

This overview describes the state of standardisation, not the standards applied to this product. The list of harmonised standards, common specifications or other technical specifications applied under Annex VII No. 5 CRA is kept in the checklist of the technical documentation.

Identifier	Title	Source	Note
Standardisation request M/606, C(2025) 618	Commission standardisation request for the Cyber Resilience Act of 3 February 2025	primary source	41 standards, request valid until 30 November 2027; it expressly names machinery (Directive 2006/42/EC and Regulation (EU) 2023/1230).
EN 40000-1-1 to EN 40000-1-4 (drafts)	Horizontal series of standards: vocabulary, principles of cyber resilience, vulnerability handling, generic security requirements	secondary source	Under development; as at 15 September 2026 not cited in the Official Journal, hence no presumption of conformity.
prEN 50770-1 to prEN 50770-6 (drafts)	Vertical standards for operational technology products: firewalls, network management, network interfaces, VPN, routers and switches, SIEM	secondary source	Under development on the basis of the IEC 62443 series; as at 15 September 2026 not cited in the Official Journal.

Identifier	Title	Source	Note
IEC 62443-4-1, -4-2 and -3-3	Secure development lifecycle, component requirements, system requirements	secondary source	Technically central, but as at 15 September 2026 not cited in the Official Journal as a harmonised standard for the Cyber Resilience Act. Usable as another technical specification applied, to be listed in the technical documentation (Annex VII No. 5 CRA), without presumption of conformity.
EN 18031-1, EN 18031-2 and EN 18031-3:2024	Cybersecurity requirements for radio equipment (Radio Equipment Directive)	secondary source	Cited with restrictions under the Radio Equipment Directive (Implementing Decision (EU) 2025/138), relevant until 10 December 2027; not a route to presumption of conformity under the Cyber Resilience Act.

This report documents the manufacturer's information under the Cyber Resilience Act (Regulation (EU) 2024/2847). It is not a risk assessment under EN ISO 12100: safety-related consequences of an attack are listed there with their risk estimation in the hazard list, while the cybersecurity risk assessment under Article 13(2) CRA is kept here. The two risk numbers must not be confused or added.

Calculation rules of this assessment (count of entries, measure threshold, risk classes, deadlines calculated without shifting to working days) are marked as such and are not requirements of the Regulation. Uncertain legal positions carry a status date.

The count of sections and entries is a convention of this documentation, not a requirement of the Regulation; it shows where the documentation still has gaps.

8. Operating instructions

Annex III No. 1.7.4 MR

Extract of the chapter texts. Figures, tables and the automatically generated sections (residual hazards, applied standards) are in the separate export of the instructions and in chapters 1 and 2 of this dossier.

1 Important basic information

These operating instructions apply to the robotic welding cell RSZ-2600 (serial number RSZ2600-2026-0001, year of construction 2026) and are addressed to the user as well as to the personnel responsible for operation, set-up, maintenance and dismantling. They form part of the machine, must be accessible to personnel at all times and must be handed over in the event of a change of location or resale. This chapter describes the scope of delivery, the limits of the machine, the external interfaces and the legal basis of this documentation.

1.1 Scope of Delivery and Limits of the Machine

Scope of delivery: The RSZ-2600 is delivered as a fully functional assembly of machinery. The scope of delivery includes:

- Articulated-arm industrial robot with 6 axes (reach 2600 mm, payload 12 kg) including robot controller and teach pendant
- Two-station turntable with fixed dividing centre wall, welding curtain and pneumatic workpiece clamps
- MAG welding power source 400 A at 60 per cent duty cycle with wire feed unit, water-cooled welding torch with cooling unit, and torch cleaning station
- Welding fume extraction unit 1800 m³/h with pre-spark separator, filter cartridge, temperature monitoring of the filter cartridge, motorised shut-off dampers, and smoke and CO detectors
- Perimeter guard (safety fence) 2200 mm high with maintenance door, Type 4 light curtain, safety PLC, control desk and control cabinet
- Network gateway with firewall and remote maintenance access
- Machine-integrated workplace lighting in accordance with EN 1837 and height-adjustable standing platform at the loading station
- Operating instructions with the accompanying documents listed in Chapter 12 (including the EU declaration of conformity, installation plan, circuit diagrams, pneumatic diagram, spare parts list, test plan for the safety functions and maintenance record form)

Not included in the scope of delivery:

- Workpiece-specific clamping fixtures (unless separately agreed); for the requirements for the user's clamping fixtures see Chapter 3.1
- The customer-supplied shielding gas supply
- The customer-supplied media connections
- An optional exhaust air duct for the extraction unit
- The lifting aid for workpieces over 15 kg at the loading station (customer-supplied, load capacity at least 40 kg)

Limits of use: MAG welding of steel assemblies (unalloyed and low-alloy steel) up to 40 kg workpiece weight and a maximum workpiece envelope of 800 x 600 x 400 mm. Series production exclusively with predefined, approved welding programs. Manual loading and unloading at the respective front station by trained specialist personnel, cycle time approximately 90 seconds. Not intended for aluminium, galvanised or coated workpieces, not for manual welding inside the cell, and not for workpieces with residual stress from preceding processes.

Spatial limits: Floor area approximately 6.5 x 4.0 m, height 2.6 m. Robot working envelope reach 2600 mm, completely enclosed by safety fence 2200 mm in height and the fixed dividing centre wall of the turntable. Rotation range of the turntable 180 degrees. Loading station in front of the loading opening, Type 4 light curtain with 30 mm resolution, safety distance calculated and documented in accordance with EN ISO 13855. One maintenance door at the rear. Interfaces to upstream and downstream processes are exclusively manual.

Time limits: Expected service life 12 years at 2 shifts, annual maintenance by the manufacturer, half-yearly inspection of safety functions, inspection of the guard locking and the light curtain in accordance with EN ISO 14119 and EN ISO 13855 at every maintenance visit. Wear parts: welding torch, contact tips, gas nozzle, wire feed rollers, filter cartridge of the extraction unit, welding curtain.

Environmental limits: Dry indoor area of a production hall, 5 to 40 degrees C, relative humidity up to 70 per cent non-condensing, mains supply 400 V AC 50 Hz TN-S, connected load 32 kVA, compressed air 6 bar oil-free, installation on a level industrial concrete floor. No hazardous area, no outdoor use.

Limits of the assembly: The cell comprises the robot (partly completed machinery with EU declaration of incorporation), turntable, welding power source (CE-marked equipment), extraction unit and fence, door and sensor components. The interfaces between these parts have been assessed in the risk assessment of the assembly and taken into account in the EU declaration of conformity of the assembly.

1.2 Responsibilities (Manufacturer / User)

The responsibilities of the manufacturer and the user are divided as follows:

Responsibilities of the manufacturer: Design, construction and conformity of the assembly of machinery including risk assessment, validation of safety functions and technical documentation; initial commissioning with documented acceptance; annual maintenance in accordance with the agreement; supply of spare parts and technical support.

Responsibilities of the user: Operation of the machine exclusively within the scope of the intended use; selection and qualification of personnel and their regular, documented instruction (at least annually); provision of personal protective equipment and supervision of its use; workplace-related risk assessment in accordance with the German Occupational Safety and Health Act (ArbSchG) and the German Ordinance on Industrial Safety and Health (BetrSichV), including noise and welding fumes (German Technical Rule for Hazardous Substances TRGS 528); periodic inspection of the electrical equipment in accordance with DGUV Regulation 3 (German accident insurance regulation on electrical installations and equipment); half-yearly inspection of the safety functions and maintenance in accordance with Chapter 10 including the keeping of maintenance records; provision of customer-supplied media (electrical supply, compressed air, shielding gas) in the required quality; provision and periodic inspection of a lifting aid for workpieces over 15 kg at the loading station (load capacity at least 40 kg); occupational health surveillance in the case of exposure to welding fumes; forwarding of the fire alarm of the extraction unit (smoke and CO detectors) to

a permanently staffed location in accordance with the fire protection concept of the building; reporting of safety-relevant events and faults to the manufacturer.

Modifications to the machine: Conversions and retrofits are only permissible following written approval by the manufacturer. Substantial modifications within the meaning of the Machinery Regulation may necessitate a new conformity assessment.

1.3 External Interfaces

The machine has the following supply and media interfaces:

- Electrical power supply: 400 V AC, 3/N/PE, 50 Hz, TN-S system, connected load 32 kVA, customer-supplied fuse protection 63 A gG, supply at the main switch of the control cabinet.
- Compressed air supply: 6 bar, oil-free, connection G 1/2 at the machine's service unit.
- Shielding gas supply (customer-supplied): Mixed gas M21 in accordance with EN ISO 14175 (82 per cent argon, 18 per cent CO2), connection at the welding power source, flow rate approximately 15 l/min at the torch.
- Welding fume extraction: Extraction unit integrated into the cell, 1800 m³/h with filter cartridge in recirculation mode; optional customer-supplied exhaust air connection.
- Signal interfaces: Potential-free signalling contacts (operational status and collective fault message) for connection to a higher-level control system. There are no safety-related interfaces to adjacent installations; interlinking with upstream and downstream processes is exclusively manual.
- Data interfaces: OPC UA to the user's MES (receipt of orders, feedback of production data) and VPN remote maintenance by the manufacturer, both exclusively via the gateway supplied; USB port on the HMI panel for data backups and updates. For details see Chapter 13 (Cybersecurity).

The requirements for the customer-supplied execution of the connections are described in Chapter 7 (Installation Conditions).

1.4 Legal Notes and Applied Standards

The manufacturer declares the conformity of the machine with the following Union harmonisation legislation:

- Machinery Regulation (EU) 2023/1230
- EMC Directive 2014/30/EU

The safety objectives set out in Directive 2014/35/EU are met in accordance with Annex III, section 1.5.1, of the Machinery Regulation. The EU declaration of conformity is enclosed with these operating instructions; the CE marking is affixed to the rating plate.
These operating instructions were drawn up in accordance with Annex III, sections 1.7.4 to 1.7.4.2, of Regulation (EU) 2023/1230. This English version is a translation; in case of doubt the German version prevails.
Unauthorised conversions and modifications to the machine, in particular to the guards and protective devices and the safety controller, are not permissible. They may invalidate the conformity of the machine and result in the loss of warranty; the manufacturer accepts no liability for damage arising therefrom. Only spare parts that meet the requirements specified by the manufacturer may be used.
This documentation is protected by copyright. Reproduction and disclosure to third parties are only permissible to the extent required for the operation, maintenance or resale of the machine.
The complete list of applied standards is set out at the end of this chapter.

1.5 Documentation (Structure, Abbreviations, Technical Terms)

Structure: These operating instructions are divided into 13 chapters and follow the life cycle of the machine from delivery to disposal. Safety-related information is presented together in Chapter 2 and additionally at the beginning of the respective activity chapters.

Presentation of warnings: Warnings are graded according to the level of hazard. DANGER identifies an immediately hazardous situation which will result in death or serious injury. WARNING identifies a potentially hazardous situation which may result in death or serious injury. CAUTION identifies a situation which may result in minor to moderate injury. NOTICE indicates information on preventing damage to property.

Abbreviations: CMR = carcinogenic, mutagenic or toxic for reproduction; EMC = electromagnetic compatibility; EMF = electromagnetic fields; ESPE = electro-sensitive protective equipment; HMI = human machine interface (operator interface); LOTO = lockout/tagout (isolation and securing against re-energisation); MAG = metal active gas welding; MES = manufacturing execution system; MR = Machinery Regulation (EU) 2023/1230; OPC UA = Open Platform Communications Unified Architecture (protocol of the data interface to the MES); PL = performance level in accordance with EN ISO 13849-1; PLC = programmable logic controller; PLr = required performance level; PPE = personal protective equipment; SLS = safely reduced speed (Safely-Limited Speed); SRP/CS = safety-related part of a control system; TCP = tool centre point; VPN = virtual private network (encrypted connection for remote maintenance); WLL = working load limit of a lifting accessory.

Associated documents: Assembly instructions of the robot manufacturer, operating instructions for the welding power source, wire feed unit and welding fume extraction unit, electrical and pneumatic circuit diagrams, EU declaration of conformity and inspection and acceptance reports. These documents must be kept together with these operating instructions.

2 Safety

This chapter contains the fundamental safety information for all life-cycle phases of the robotic welding cell RSZ-2600. It covers:

- the intended use
- the reasonably foreseeable misuse
- the installed guards and protective devices
- the safety labelling on the machine

In addition, the activity-related safety instructions in Chapters 5 to 11 apply. The complete overview of all residual risks with protective measures from the risk assessment is appended at the end of this chapter and must be observed by all persons working at or with the machine.

2.1 Intended Use

The robotic welding cell RSZ-2600 is intended exclusively for the automated MAG welding of steel assemblies made from unalloyed and low-alloy steel with a workpiece weight of up to 40 kg and a maximum workpiece envelope of 800 x 600 x 400 mm in series production using specified, approved welding programs. Loading and unloading are carried out manually at the respective front station of the two-station turntable by trained specialist personnel at a cycle time of approximately 90 seconds. Personnel access to the robot working area is not provided for during automatic operation.

Design as an assembly of machinery: (1) Articulated-arm industrial robot, 6 axes, reach 2600 mm, payload 12 kg, supplied by the robot manufacturer as partly completed machinery with an EU declaration of incorporation in accordance with Annex V, Part B, and assembly instructions in accordance with Annex XI. (2) Two-station turntable with a vertical axis of rotation and 180-degree rotation, fixed dividing centre wall with welding curtain, pneumatic workpiece clamps. (3) MAG welding power source 400 A at 60 per cent duty cycle, CE-marked, with wire feed and torch cleaning station. (4) Welding fume extraction 1800 m³/h with filter cartridge. All components are controlled jointly and placed on the market as a single unit.

The intended use also includes compliance with these operating instructions, the specified maintenance intervals, and the ambient and connection conditions set out in Chapters 3 and 7. The machine is intended for stationary installation in a dry production hall indoors. Any other or additional use is considered non-intended; the user alone is liable for any damage resulting therefrom. Non-intended uses include in particular: welding of aluminium, galvanised or coated workpieces; manual welding inside the cell; machining of workpieces outside the approved geometry and weight limits; operation in potentially explosive atmospheres or outdoors.

2.2 Reasonably Foreseeable Misuse

Entering the robot working area through the loading opening despite the light curtain, for example by climbing over, crawling under or reaching through between the beams; manipulation or bridging of the light curtain, for example by taping over it or fixing an object in the protective field; bypassing the guard locking of the maintenance door using a substitute actuator or by fixing the door position; remaining in the rotation range of the turntable during rotation; adjusting or reworking the workpiece during automatic operation without stopping the machine; leaving the operating mode selector switch in the Set-up position during production operation; continuous actuation or fixing of the enabling device; working in the cell without personal protective equipment, in particular without welding goggles or protective shield; operation with the welding fume extraction switched off or blocked; cleaning the cell with the system switched on; maintenance work on the pneumatics without pressure relief and without safeguarding against unintentional restart; manual lifting of workpieces exceeding 15 kg without the user-supplied lifting aid; operation by uninstructed personnel or by temporary workers without induction; insertion of workpieces outside the approved workpiece geometry resulting in collisions; opening the welding power source before the discharge time has elapsed.

2.3 Observance of the Operating Instructions

Familiarity with these operating instructions is a fundamental prerequisite for the safe handling of the machine. Before carrying out any work at or with the machine, the designated personnel must have read and understood the relevant chapter as well as Chapter 2 (Safety). The operating instructions must be kept in the immediate vicinity of the machine and must be accessible to personnel at all times.

Personnel qualifications: Operation by instructed personnel only; set-up, teaching and fault-finding by trained set-up personnel with robot training only; maintenance by qualified specialist personnel only; work on the electrical equipment by electrically skilled persons only; work on the welding equipment and extraction system by personnel qualified for this purpose only. Persons undergoing training may only work on the machine under the constant supervision of an experienced specialist.

The user must ensure that responsibilities are clearly defined, that instructions are provided regularly and in documented form, and that only authorised personnel have access to the machine. In addition to these

operating instructions, the applicable regulations on occupational health and safety and accident prevention as well as the user's internal instructions must be observed.

2.4 Safety Labelling

The following safety and information signs are permanently affixed to the machine. They must be kept in a legible condition and replaced if damaged.

Warning signs (ISO 7010): 'Warning; Electricity' (W012) on the control cabinet, on the welding power source and at the welding area; 'Warning; Hot surface' (W017) on the turntable, on the torch cleaning station and on the removal side of the loading station; 'Warning; Optical radiation' (W027) at the loading opening and maintenance door; 'Warning; Automatic start-up' (W018) at all access points to the robot working area and at the control desk; 'Warning; Crushing' (W019) at the rotation range of the turntable; 'Warning; Crushing of hands' (W024) on the turntable, at the loading station and on the side plates and frame of the light curtain; 'Warning; Overhead load' (W015) on the turntable, at the loading station and at the lifting points of the transport-relevant assemblies; 'Warning; Sharp element' (W022) on the torch holder and on the wire feed unit; 'Warning; Magnetic field' (W006) at the maintenance door, at the loading station and on the welding power source; 'Warning; Slippery surface' (W011) at the access to the loading station and to the maintenance aisle; 'Warning; Floor-level obstacle' (W007) at the tripping points in the maintenance aisle.

'General warning sign' (W001) with supplementary text: 'Fire hazard from welding spatter' on the safety fence; 'Harmful welding fume' at the welding area; 'Harmful dust' and 'Fire hazard from sparks in the filter' on the filter housing of the extraction unit; 'Residual pressure in the clamping fixture' on the clamping fixtures and on the compressed air shut-off valve; 'Risk of tipping before anchoring' on two opposite sides of the base frame (for assembly and relocation). At the installation site of the customer-supplied shielding gas supply, the user affixes warning sign W001 with the supplementary text 'Risk of asphyxiation from shielding gas'.

Prohibition signs: supplementary prohibition sign 'No access for unauthorised persons' (German ASR A1.3, D-P006) at the maintenance door and on the control cabinet; 'No access for people with active implanted cardiac devices' (ISO 7010, P007) at all access points, as electromagnetic fields are generated during MAG welding; 'No reaching in' (ISO 7010, P015) on the turntable and at the loading opening.

Mandatory signs (ISO 7010): 'Wear eye protection' (M004) at the loading station and at the maintenance door; 'Wear ear protection' (M003) at the loading station; 'Wear protective gloves' (M009) on the removal side of the loading station and at the maintenance door; 'Wear safety footwear' (M008) throughout the entire working area; 'Wear protective clothing' (M010) at the maintenance door; 'Wear respiratory protection' (M017) at the welding area and on the filter housing of the extraction unit.

Additional markings: Rating plate with CE marking on the right-hand side wall of the control cabinet; labelling of the emergency stop devices; notice regarding the discharge time on the welding power source; centre of gravity and lifting point markings on the transport-relevant assemblies; yellow-and-black floor markings in accordance with the German Technical Rule for Workplaces ASR A1.3 for traffic routes and the swing area of the maintenance door.

Text signs: 'Manual handling up to 15 kg only, use the lifting aid above this' at the loading station; 'Attach your personal padlock before entering' and 'Stop work if the lighting fails' at the maintenance door; 'Check earth clamp before commencing welding' on the clamping fixtures; 'Do not open in the event of a fire alarm' on the maintenance flap of the filter housing; 'Change cable routing only in accordance with electrical

circuit diagram RSZ-2600-EPL-001' and 'Parameter changes by authorised specialist personnel only; subsequent validation test required' on the control cabinet; 'Before intervention: vent to 0 bar and lock shut-off valve' on the compressed air shut-off valve; text sign stating the area of effect of the emergency stop devices (the emergency stop acts on all sub-machines of the cell) at the control desk.

2.5 Guards and Protective Devices

The guards and protective devices described below are permanently installed on the RSZ-2600. They must not be removed, modified or bypassed. The machine may only be operated with all guards and protective devices fully assembled and in working order.

Fixed and movable guards: Perimeter guard (safety fence), height 2200 mm, with welding-light-opaque infill panels, welding protection viewing windows and base panel; design of safety distances in accordance with EN ISO 13857. Maintenance door at the rear as an interlocking guard with guard locking in accordance with EN ISO 14119 (spring applied, power released; coded actuator); the guard locking is released only once the arc has been extinguished and the robot and turntable are at a monitored standstill. From the inside, the maintenance door can be opened at any time without tools by means of the escape release; actuating it triggers a stop. The door handle is fitted with a lockout device for personal padlocks: each person entering the cell attaches their own padlock while the door is open and takes the key with them. As long as a padlock is attached, the door cannot be closed and automatic mode cannot be started. Movements are then possible only in set-up mode with the enabling device actuated and at safely reduced speed. Fixed dividing centre wall of the two-station turntable with welding curtain between the loading station and the welding area.

Electro-sensitive protective equipment: Type 4 light curtain in accordance with EN IEC 61496-1:2020 and EN IEC 61496-2:2020 with 30 mm resolution at the loading opening; the protective field covers the loading opening completely and is continuously effective (no muting), and the remaining openings are closed off by fixed guards in accordance with EN ISO 13857:2019, Table 4; safety distance calculated and documented in accordance with EN ISO 13855. An intrusion into the protective field triggers a safe stop of the robot and turntable.

Safety controller and safety functions: A safety PLC evaluates all guards and protective devices. Principal safety functions in accordance with EN ISO 13849-1: SF-01 interlock and guard locking of the maintenance door with safe shutdown of the welding power source when the door is open (PL d, Category 3); SF-02 light curtain at the loading opening (PL e, Category 4); SF-03 emergency stop (PL d, Category 3); SF-04 release of the rotary movement of the turntable (PL e, Category 4); SF-05 safely reduced speed in set-up mode, maximum 250 mm/s at the TCP (PL d). Monitoring of the clamping pressure of the workpiece clamps is integrated as a release condition into safety function SF-04; the turntable only rotates upon confirmed clamping pressure (see risk assessment No. 5). Validation of the safety functions is documented in accordance with EN ISO 13849-2.

Emergency stop: Emergency stop devices in accordance with EN ISO 13850 at the control desk, at the maintenance door and at the teach pendant. The emergency stop acts on all sub-machines of the cell (robot, turntable, welding power source, wire feed) and initiates a controlled stop (stop category 1 in accordance with EN 60204-1). Restart is only possible after resetting the actuated emergency stop device and manual acknowledgement at the control desk.

Operating mode selection and set-up mode: Lockable operating mode selector switch with the operating modes Automatic and Set-up; the key remains with the authorised person. In set-up mode, the speed is

safely limited to 250 mm/s and movements are only possible when the three-position enabling device on the teach pendant in accordance with EN ISO 10218-1 is actuated; releasing or fully depressing the device triggers a controlled stop (stop category 1).

Restart prevention and start-up warning: After the activation of a protective device, after an emergency stop and after voltage restoration, the restart prevention function prevents automatic restart. Acknowledgement is carried out exclusively at the control desk outside the hazard zone with a line of sight to the loading opening. Before automatic start-up, a start-up warning sounds; the signal tower indicates the operating status.

Energy isolation: Main switch with lockable OFF position in accordance with EN 60204-1 for safe isolation (LOTO); lockable compressed air shut-off valve with exhaust function and residual pressure indicator at the maintenance access point; warning notice regarding the discharge time of the welding power source prior to opening.

Pneumatic safety: Pressure switch on the clamping circuit, which releases the rotary movement of the turntable only upon confirmed clamping pressure; workpiece presence sensor at each station, which reports the workpiece position; pilot-operated non-return valve (pressure-holding valve) in the clamping line, which keeps the workpiece clamped in the event of a pressure drop, with a manual override for controlled pressure release in the event of a fault.

Additional protective measures: Collision protection coupling on the welding torch with immediate safety stop in the event of a collision; impact protection in the area of the turntable and deflector plate below the turntable as a catching device; cooling lockout period for each welding program with red signal light at the removal station; temperature monitoring at the torch neck with release indication on the HMI panel; welding fume extraction 1800 m³/h with monitoring of extraction performance, pre-spark separator, temperature monitoring of the filter cartridge, motorised shut-off dampers, and smoke and CO detectors (operational interlocks without a PL requirement); machine-integrated workplace lighting with failure message on the HMI panel; floor markings for traffic routes and cable bridges with over-run protection in the vicinity of the cell.

The effectiveness of the guards and protective devices must be checked in accordance with the requirements set out in Chapter 9 (daily inspections) and Chapter 10 (recurring inspections). Any defects identified must be reported immediately; the machine must be shut down until repairs have been carried out.

2.6 Residual Risks and Protective Measures

Despite the guards and protective devices described, residual risks remain on the machine that cannot be fully eliminated by design. The complete overview of all 42 residual risks, structured by life-cycle phase, together with the associated protective measures, has been taken from the risk assessment and is appended at the end of this chapter. The protective measures are listed there for each hazard in the order of EN ISO 12100: inherently safe design (Step 1), safeguarding and complementary protective measures (Step 2), information for use (Step 3).

Overview of principal residual risks: Crushing and impact hazard from the robot and turntable during work with guards and protective devices open (set-up, fault-finding); optical radiation from the arc as well as hot surfaces and weld spatter in the vicinity of the stations; hazard from welding fume with insufficient extraction; electrical hazard at the control cabinet and welding power source; stored pneumatic energy in

the clamping circuit; noise exposure at the loading station (84 dB(A)); electromagnetic fields in the vicinity of the welding process.

Personal protective equipment: When operating the machine, the following must be worn as a minimum: S3 safety footwear in accordance with EN ISO 20345, close-fitting flame-retardant work clothing, safety goggles with side protection and hearing protection. When handling workpieces, protective gloves must also be worn, and heat-protective gloves when removing welded workpieces. Protective gloves do not protect against crushing. Reach into the rotation range only when the turntable has been stopped. During set-up, maintenance and cleaning work in the cell, additionally: welding goggles or protective shield when in visual contact with the arc, welder's gloves when working on components that are still warm. The PPE is provided by the user, who must also supervise its use.

Action in the event of danger: In the event of recognisable hazards, immediately actuate the emergency stop, isolate the machine at the main switch and inform the supervisor. A person shut inside the cell leaves it by means of the escape release of the maintenance door. If a person is trapped by the robot or the turntable: actuate the emergency stop and initiate the internal emergency response chain. Without drive power, the robot axes can be moved using the brake release device in accordance with the robot manufacturer's instructions; support the affected axis beforehand, because it can drop once the brake has been released. With the machine isolated, the turntable can be rotated by hand after the motor brake has been released. The rescue is carried out only by instructed set-up and maintenance personnel. Fires at the electrical equipment must only be fought with CO2 or powder extinguishers, never with water. For action in the event of a fire in the extraction unit, see Chapter 9.5. In the event of accidents, provide first aid and follow the internal emergency response chain.

3 Technical data

- Machine/installation: Robotic welding cell RSZ-2600 (assembly of machinery)
- Type/model: RSZ-2600
- Serial number: RSZ2600-2026-0001
- Year of construction: 2026
- Machine type: Assembly of machinery within the meaning of Article 3(1)(d) MR
- Operating modes: Automatic, Set-up
- Rating plate: on the right-hand side wall of the control cabinet; information shown: manufacturer, type, serial number, year of construction, electrical connection values, weight, CE marking

Equipment

Dimensions and weights: Floor area of the cell approximately 6.5 x 4.0 m; height 2.6 m; total weight approximately 4,600 kg. Heaviest individual assemblies: two-station turntable approximately 1,900 kg, robot with base approximately 850 kg, control cabinet approximately 350 kg, welding power source with wire feed unit approximately 120 kg, welding fume extraction unit approximately 250 kg, safety fence segments total approximately 400 kg; control desk, cabling, media installation and small parts approximately 730 kg.

Workpiece data: maximum workpiece weight 40 kg; maximum workpiece envelope 800 x 600 x 400 mm; materials: unalloyed and low-alloy steel; cycle time approximately 90 seconds.

Electrical equipment: rated voltage 400 V AC, 3/N/PE, 50 Hz; TN-S system; connected load 32 kVA; supply-side fusing 63 A gG; control voltage 24 V DC; residual current protective device Type B; electrical

equipment designed in accordance with EN 60204-1.

Welding technology: MAG welding power source 400 A at 60 per cent duty cycle; maximum no-load voltage 80 V; protection class I, degree of protection IP23S; wire feed unit for wire diameters 1.0 to 1.2 mm; water-cooled welding torch with cooling unit and temperature monitoring at the torch neck; torch cleaning station with spray unit and wire cutter; shielding gas mixed gas M21 in accordance with EN ISO 14175 (supplied by customer), flow rate approximately 15 l/min.

Robot: articulated-arm industrial robot with 6 axes; reach 2,600 mm; payload 12 kg; repeatability +/- 0.05 mm; safely reduced speed in set-up mode maximum 250 mm/s at TCP.

Turntable: two-station turntable with vertical axis of rotation, rotation 180 degrees; load capacity 2 x 40 kg plus clamping fixtures; rotation time approximately 3 seconds; pneumatically closing workpiece clamps with pressure switch, pilot-operated non-return valve (pressure-holding valve) and workpiece presence sensor at each station.

Workpiece-specific clamping fixtures of the user: maximum 60 kg per station; interfering contour in accordance with installation plan RSZ-2600-LAY-001; electrically insulated from the table frame; clamps pneumatically closing with pressure-holding valve and connected to the clamping pressure monitoring (SF-04); the manufacturer approves new fixtures before they are first used.

Pneumatics: operating pressure 6 bar; compressed air quality oil-free in accordance with ISO 8573-1; connection G 1/2; average air consumption approximately 90 Nl/min.

Workplace lighting: machine-integrated in accordance with EN 1837; 500 lx at the loading station, 200 lx in the maintenance aisle; failure message on the HMI panel.

Welding fume extraction: extraction capacity 1,800 m³/h; filter cartridge welding fume class W3 (separation efficiency at least 99 per cent, tested in accordance with EN ISO 21904-2; requirement from the risk assessment in accordance with the German Technical Rule for Hazardous Substances TRGS 528); recirculation mode, optional exhaust air connection; monitoring of extraction capacity with fault message; pre-spark separator upstream of the filter cartridge; temperature monitoring of the filter cartridge, motorised shut-off dampers, and smoke and CO detectors in the filter housing and in the exhaust air duct; filter housing with bag-in/bag-out change system for replacing the cartridge; run-on of the extraction fan for at least 10 minutes after the end of welding.

Noise emission (declaration in accordance with EN ISO 4871): A-weighted emission sound pressure level at the loading station LpA = 84 dB(A), measurement uncertainty K = 2.5 dB, determined in accordance with EN ISO 11202; A-weighted sound power level LWA = 96 dB(A), uncertainty KWA = 3 dB, determined in accordance with EN ISO 3746 (accuracy grade 3). Operating conditions during the measurement: automatic mode with an approved welding program at a cycle time of approximately 90 seconds, welding fume extraction in operation, maintenance door closed; the measuring position is the loading station in front of the loading opening (standing person). The C-weighted peak sound pressure level at the loading station does not exceed 130 dB(C). The figures quoted are emission levels and are not necessarily safe working levels. The user is required to provide hearing protection from a daily noise exposure level of 80 dB(A); from 85 dB(A) there is an obligation to wear hearing protection and to provide appropriate marking.

Operating environmental conditions: ambient temperature +5 to +40 degrees C; relative humidity up to 70 per cent, non-condensing; installation altitude up to 1,000 m above sea level; indoor dry locations only; no

potentially explosive atmosphere; air velocity in the area of the loading opening below 0.5 m/s so that the shielding gas coverage is not disturbed.

4 Description of the machine

The RSZ-2600 is a robot-assisted MAG welding cell for arc welding of steel assemblies with a workpiece weight of up to 40 kg in series production. It is a one-off special-purpose machine and is placed on the market as an assembly of machinery with a shared control system as a single unit. The basic principle: whilst the operator loads and unloads workpieces at the front station of the two-station turntable, the robot welds at the second station behind the fixed dividing centre wall. The 180-degree rotation of the turntable alternates the stations at a cycle time of approximately 90 seconds. This chapter describes the structure of the system with its main assemblies, the operator workstations and the functional sequence.

4.1 Structure and Main Assemblies

The system consists of the following main assemblies:

(1) Articulated-arm industrial robot: 6 axes, reach 2,600 mm, payload 12 kg, mounted on a steel base; supplied by the robot manufacturer as partly completed machinery with an EU declaration of incorporation in accordance with Annex V, Part B; with robot controller and teach pendant.

(2) Two-station turntable: vertical axis of rotation with 180-degree rotation, fixed dividing centre wall with welding curtain, pneumatically closing workpiece clamps with pressure switch, pilot-operated non-return valve (pressure-holding valve) with manual override and workpiece presence sensor at each station; deflector plate below the turntable as a catching device; load capacity 2 x 40 kg plus clamping fixtures (maximum 60 kg per station, for requirements see Chapter 3.1).

(3) Welding equipment: MAG welding power source 400 A at 60 per cent duty cycle (CE-marked equipment), wire feed unit on the robot arm, hose assembly, water-cooled welding torch with cooling unit, temperature monitoring at the torch neck and collision protection coupling, torch cleaning station with nozzle cleaning, spray unit and wire cutter.

(4) Welding fume extraction: Extraction unit 1,800 m³/h with pre-spark separator, filter cartridge and capture hood above the welding area; monitoring of extraction capacity; temperature monitoring of the filter cartridge, motorised shut-off dampers, and smoke and CO detectors in the filter housing and in the exhaust air duct; filter housing with bag-in/bag-out change system for low-dust cartridge replacement and with a closable extinguishing agent inlet opening.

(5) Guards and protective devices: Perimeter guard (safety fence) 2,200 mm high with welding-light-opaque infill panels, welding protection viewing windows and base panel; maintenance door at the rear with interlocking, guard locking, escape release from the inside and lockout device for personal padlocks; type 4 light curtain at the loading opening.

(6) Control system: Control cabinet with main switch, safety PLC, system controller and network gateway with firewall for the data connection and remote maintenance (see Chapter 13); signal exchange between all sub-machines via the shared control system.

(7) Control desk: HMI panel with program display, pushbutton for cycle start and acknowledgement, operating mode selector switch, remote maintenance key switch, emergency stop device; signal tower (green/yellow/red) on the cell roof; red signal light for the cooling lockout period at the removal station.

(8) Media supply: Compressed-air service unit with lockable maintenance shut-off valve with exhaust function and residual pressure indicator; connection for the customer-supplied shielding gas supply with solenoid valve (normally closed), which shuts off the gas supply on a machine stop, on an emergency stop and during breaks in operation.

(9) Workplace lighting: machine-integrated lighting in accordance with EN 1837 with 500 lx at the loading station and 200 lx in the maintenance aisle; failure message on the HMI panel.

4.2 Operator Workstations

Loading station (front side): The operator's workstation for loading and unloading workpieces at the respective front station of the turntable. Access is through the loading opening monitored by the light curtain. The operator stands outside the robot working area; the fixed dividing centre wall shields against the arc and weld spatter. A height-adjustable standing platform adapts the working height to the body height of the operator (working height approximately 900 to 1100 mm above the standing surface); before starting work, adjust the platform so that the gripping points are at about elbow height.

Control desk (adjacent to the loading opening): HMI panel for program selection and status display, pushbutton for cycle start and acknowledgement, lockable operating mode selector switch, remote maintenance key switch, emergency stop device. There is a line of sight from the control desk to the loading opening.

Teach pendant (set-up personnel): Hand-held unit of the robot controller with emergency stop and three-position enabling device for teaching and traversing in set-up mode. Use is reserved for trained set-up personnel.

Maintenance access (rear side): Maintenance door with interlock and guard locking; access for maintenance and set-up work only when the system has been shut down or in set-up mode. No workstation inside the cell is provided during automatic operation.

4.3 Functional Description

Sequence of an automatic cycle:

1. The operator loads the workpiece into the clamping fixture at the front station. The pneumatic clamps close; the pressure switch confirms the clamping pressure and the presence sensor confirms the workpiece position.

2. The operator leaves the protective field of the light curtain and presses the cycle start pushbutton at the control desk. The control system checks that the protective field is clear and that all safety functions have been acknowledged.

3. After an acoustic start warning, the turntable rotates 180 degrees: the freshly loaded station rotates into the welding area and the station with the finished welded workpiece rotates towards the operator.

4. The robot executes the released welding program at the rear station. The welding fume extraction runs under process control; torch cleaning is carried out under program control at defined intervals.

5. In parallel, the operator removes the finished workpiece at the front station and loads the next blank. Removal is released only once the cooling lockout period stored for the welding program has elapsed and the red signal light at the removal station has gone out. The cycle time is approximately 90 seconds.

6. After the program has ended and the cycle start has been actuated again, the sequence repeats. In the event of faults (for example, arc interruption, wire end, extraction fault), the system stops in a controlled manner; the fault is displayed on the HMI and the signal tower switches to red.

In set-up mode (key switch), the turntable and robot may only be traversed using the enabling device and at safely reduced speed; the automatic cycle is inhibited. When the maintenance door is open, the welding power source is safely shut down (SF-01); wire can then be fed only in inching mode at reduced threading speed.

5 Delivery, transport, unpacking

This chapter describes the safe delivery, in-plant transport and unpacking of the RSZ-2600 robotic welding cell. The system is delivered in the following pre-assembled transport units: (1) robot with steel base in the locked transport position on a transport frame with fork pockets; (2) two-station turntable with secured rotary axis on a transport frame; (3) control cabinet with control desk; (4) MAG welding power source with wire feed unit and torch cleaning station on a pallet; (5) welding fume extraction unit on a pallet; (6) safety fence segments, maintenance door and light curtain in mesh containers. All units are film-wrapped and secured against shifting; small parts and documentation are located in a labelled accessory box in the control cabinet transport frame.

Safety Instructions for Transport and Handling

Transport and handling of the machine and its assemblies may only be carried out by trained specialist personnel who are familiar with the loads involved. Wear appropriate personal protective equipment for all transport and unpacking work, in particular S3 safety footwear in accordance with EN ISO 20345 and suitable protective gloves.

WARNING: Falling, tipping or swinging loads when heavy assemblies are lifted and moved. Death or serious injury may result. Never stand beneath suspended loads and secure the transport area against unauthorised access.

Inspect the machine immediately upon delivery for externally visible transport damage and for completeness. Document any damage identified and report it before installation. The exact scope of delivery is to be taken from the shipping documents.

Weights, Centre-of-Gravity Positions and Transport Equipment

The masses and centre-of-gravity positions of the individual assemblies are decisive for the selection of transport equipment, lifting equipment and lifting accessories:

- Total mass of the system: approximately 4,600 kg (distributed across several transport units)
- Two-station turntable: approximately 1,900 kg, centre of gravity centrally above the rotary axis, centre-of-gravity position marked on the frame
- Robot with steel base: approximately 850 kg, top-heavy; observe the centre-of-gravity marking on the transport frame
- Control cabinet: approximately 350 kg
- Welding fume extraction unit: approximately 250 kg
- MAG welding power source with wire feed unit: approximately 120 kg
- Safety fence segments, total: approximately 400 kg

- Control desk, cabling, media installation and small parts: approximately 730 kg (distributed across several packages)

Permitted transport equipment: forklift truck with sufficient residual load capacity (at least 2.5 t) and sufficient fork length for the turntable and robot; overhead crane with tested lifting accessories (load capacity at least 2 t) for positioning in confined spaces; pallet truck only for pallet units up to 300 kg. Lifting equipment, industrial trucks and lifting accessories must be rated and tested for the actual load to be moved. Use only lifting accessories that are in perfect condition and approved, and observe their load capacity.

Lifting Points and Safe Lifting

Use only the designated lifting and load attachment points for lifting:

- Robot with base: four marked crane eyes on the steel base; never attach lifting accessories to the robot arm, the cabling or the hose assembly. Alternatively, transport by forklift using the fork pockets of the transport frame.
- Turntable: fork pockets in the base frame or four crane eyes at the frame corners; the dividing centre wall is not load-bearing and must not be used as a lifting point.
- Control cabinet: crane eyes on the top of the cabinet (remove before commissioning and replace with blanking plugs).
- Pallet units (power source, extraction unit): transport by forklift or pallet truck on the pallet.

NOTICE: Lifting accessories attached to the robot arm, the cabling, the hose assembly or the dividing centre wall of the turntable. Gear units, cables and the dividing centre wall will be damaged. Use only the marked crane eyes and fork pockets.

Attach the load in such a way that tipping, shifting or swinging is ruled out (sling angle of the lifting accessories not more than 60 degrees to the vertical, use edge protection). Lift slowly and without jerking, guide the load in a controlled manner and set it down without impact. Secure the load against slipping and tipping during in-plant transport. Load securing in accordance with EN 12195-1 applies to transport on road vehicles.

Transport Securing Devices

All transport securing devices are marked in red. The following must be removed before commissioning: (1) locking bolts of the turntable rotary axis on the base frame; (2) transport locking devices on the robot axes (the robot is in the marked transport position; release is carried out in accordance with the manufacturer's instructions only after the base has been anchored); (3) tensioning straps and edge protection on the transport frames; (4) locking clips on the maintenance door and fence elements. Sequence: remove transport securing devices only after the respective assembly has been aligned and anchored at its final installation location (see Chapter 8). Retain all transport securing devices for a later transport or decommissioning; the designated storage location is the base compartment of the control cabinet.

Unpacking

Unpack the machine and its assemblies on a suitable, load-bearing and level surface. When opening the packaging, proceed in such a way that neither the machine nor personnel are put at risk, and avoid damage to attachments, lines and guards and protective devices. Dispose of the packaging material properly and in

accordance with local regulations. After unpacking, check completeness again against the shipping documents.

Storage Prior to Installation

If the machine is to be stored temporarily before installation, the permissible storage conditions in accordance with Chapter 6 must be observed: dry, enclosed spaces, -10 to +50 degrees C, maximum relative humidity 60 per cent, non-condensing. The packaging and protective covers must remain on the machine until installation. For a storage period exceeding 12 months, the additional inspections in accordance with Chapter 6.2 apply.

6 Storage conditions

This chapter describes the conditions for the storage of the robotic welding cell RSZ-2600 as well as its components and assemblies between delivery, installation and any subsequent intermediate storage. The aim is to prevent damage caused by inadmissible ambient conditions, corrosion and excessively long standstill periods.

Permissible storage conditions: storage temperature -10 to +50 degrees C; relative humidity maximum 60 per cent, non-condensing. The machine is to be stored dry, clean and protected from the weather in enclosed spaces. Condensation, direct moisture, large temperature fluctuations and aggressive atmospheres (for example air containing salt or chlorine) are to be avoided.

The machine contains electrical equipment, pneumatic components as well as a MAG welding power source with wire feed and a welding fume extraction system with filter cartridge. These assemblies are particularly sensitive to moisture and contamination. The robot controller and control cabinet are to be covered against dust; the doors are to be kept closed. During intermediate storage, the protective covers and packaging provided by the manufacturer are to be retained or restored. Welding wire is to be stored dry and in the original packaging.

Corrosion Protection

Bare and uncoated metal surfaces, in particular the clamping surfaces of the turntable, guides and clamping fixtures, are to be treated with acid-free anti-corrosion oil or preservative wax prior to storage. The corrosion protection is to be renewed if the storage period exceeds 6 months. Any corrosion protection present upon delivery must not be removed without necessity; prior to commissioning it is to be removed without residue from functional surfaces. During extended storage, the condition of the corrosion protection is to be checked quarterly and renewed as required.

Maximum Storage Period and Periodic Inspections

The maximum permissible storage period without special measures is 12 months. During storage, quarterly inspections are to be carried out: condition of the corrosion protection, dryness and cleanliness of the storage location, integrity of packaging and protective covers.

If the storage period of 12 months is exceeded, the following are to be carried out prior to commissioning: visual inspection of all assemblies for corrosion and damage; inspection or replacement of the buffer batteries of the robot controller (loss of axis references possible); insulation measurement of the electrical equipment; inspection of the pneumatic components for hardened seals; functional check of all safety

devices in accordance with Chapter 8 (initial commissioning). In case of doubt, the manufacturer is to be consulted.

7 Installation conditions

Installation site: at the user's plant in accordance with installation plan RSZ-2600-LAY-001. The machine is intended for stationary installation in a dry production hall. This chapter describes the requirements regarding space requirements, foundation, ambient conditions and utility connections that the user must ensure on site prior to delivery.

7.1 Space Requirements and Dimensions

Footprint of the cell: approximately 6.5 x 4.0 m; height 2.6 m. A clear space of at least 1.0 m must be provided all around the cell for operation, maintenance and escape routes; at least 1.2 m in front of the maintenance door at the rear (door swing radius plus working space). In front of the loading opening, an operating and staging area of at least 2.0 m depth must be kept clear for workpiece staging and material flow. In this area the user provides a lifting aid with a load capacity of at least 40 kg for workpieces over 15 kg (for example a balancer or a pillar jib crane); it is not part of the scope of delivery. Required clear hall height: at least 3.2 m (installation and maintenance work on the cell roof). The access routes must be checked prior to delivery: largest transport unit (turntable) approximately 2.4 x 1.8 x 2.0 m, 1,900 kg. Traffic routes and hazard zones must be marked in accordance with the German Technical Rule for Workplaces ASR A1.8.

7.2 Foundation / Load-Bearing Capacity

The machine is installed on a level industrial concrete floor; a separate foundation is not required. Requirements: concrete grade at least C25/30, floor slab thickness at least 200 mm, flatness +/- 5 mm relative to the installation area, area load at least 10 kN/m². The robot base and turntable base frame are anchored to the floor using heavy-duty anchors (M16, anchorage depth in accordance with the anchor manufacturer's approval); the dynamic forces of the robot (overturning moment at the base up to approximately 8 kNm) must be absorbed by the anchorage. The floor must be free of cracks in the anchorage area; minimum edge distances of the anchors must comply with the anchor approval. Floor coverings or coatings must not impair force transfer. In the event of deviating floor conditions, the load-bearing capacity must be assessed on site by a competent person engaged by the customer.

7.3 Ambient Conditions

The following ambient conditions must be maintained at the installation site: ambient temperature +5 to +40 degrees C; relative humidity up to 70 per cent, non-condensing; installation altitude up to 1,000 m above sea level; dry indoor environment, no potentially explosive area, no aggressive or heavily dust-laden atmosphere. Draughts in the area of the loading opening must be avoided (air velocity below 0.5 m/s), as they disturb the shielding gas coverage of the welding process and impair the effectiveness of the fume extraction; hall doors and ventilation outlets must be arranged accordingly. The installation area must be low in vibration (no immediate proximity to presses or punching machines with strong floor vibrations), so that the repeatability of the robot and the function of the safety sensors are not impaired.

Electromagnetic environment: The cell is intended for industrial environments (immunity in accordance with EN IEC 61000-6-2, emission in accordance with EN IEC 61000-6-4, evidence in test report RSZ-2600-EMV-001). It is not intended for residential environments or for connection to a public low-voltage network that

also supplies residential buildings. Cable routing, cable shield connections and equipotential bonding in accordance with electrical circuit diagram RSZ-2600-EPL-001 may only be changed by qualified personnel with EMC knowledge; welding current cables and control cables remain in separate cable ducts. After replacing the welding power source, the robot controller or safety components, repeat the functional test of safety functions SF-01 to SF-05.

7.4 Utility Connections

The following utility connections must be provided by the customer on site for the operation of the machine:

- Electrical: 400 V AC, 3/N/PE, 50 Hz, TN-S system; connected load 32 kVA; fusing 63 A gG provided by the customer on site; supply cable 5 x 16 mm² Cu (reference value, observe installation method) to the main switch of the control cabinet; clockwise phase rotation required; foundation earth electrode or equipotential bonding in accordance with VDE regulations.
- Compressed air: 6 bar (+/- 0.5 bar), oil-free in accordance with ISO 8573-1; connection G 1/2 at the service unit; minimum flow rate 200 Nl/min; shut-off valve provided by the customer on site near the machine recommended.
- Shielding gas: mixed gas M21 in accordance with EN ISO 14175 (82 per cent argon, 18 per cent CO2) from a central ring main or cylinder bank; flow pressure 2 to 4 bar, flow rate approximately 15 l/min; secure cylinders against tipping.
- Extraction: The welding fume extraction operates in recirculation mode; optionally, an exhaust air duct (connection DN 250) may be provided by the customer on site. The user is responsible for ensuring adequate hall ventilation in accordance with the German Technical Rule for Hazardous Substances TRGS 528.
- Lighting: The user provides the hall lighting on site. The workplace lighting of the cell is part of the scope of delivery (machine-integrated in accordance with EN 1837, 500 lx at the loading station, 200 lx in the maintenance aisle, failure message on the HMI panel).

8 Assembly and installation, initial commissioning

Assembly, installation and initial commissioning are carried out by the manufacturer or by specialist personnel commissioned by the manufacturer. This chapter describes the requirements and procedures; it also serves the user as a reference for a later relocation within the plant, which may only be carried out in consultation with the manufacturer.

8.1 Safety

Assembly, installation and initial commissioning of the RSZ-2600 robotic welding cell may only be carried out by trained specialist personnel with qualifications in mechanical engineering, electrical engineering, pneumatics and welding technology. The robot is supplied by the robot manufacturer as partly completed machinery with an EU declaration of incorporation in accordance with Annex V, Part B, and assembly instructions in accordance with Annex XI; the associated assembly instructions of the robot manufacturer must be observed additionally for all work on this component.

Before commencing all mechanical and electrical work, the machine must be safely isolated from the energy supply: switch off the main switch and secure it in the OFF position with a padlock (LOTO), shut off the compressed air at the isolating valve of the service unit and vent it, check for absence of pressure at the

residual pressure indicator, and have an electrically skilled person verify the absence of voltage. The user's key and lock procedure must be applied.

DANGER: Electrical voltage of 400 V at the supply cable, control cabinet and welding power source. Touching live parts will result in death or serious injury. Work on the electrical equipment may be carried out only by electrically skilled persons and only after isolating, securing against re-energisation and verifying the absence of voltage; after isolating, wait at least 1 minute for the welding power source to discharge; for the robot drives, the waiting time specified by the robot manufacturer applies.

WARNING: Unexpected movements of the robot axes and the turntable when the energy supply is connected for the first time and during assembly. Death or serious injury may result. Before switching on, make sure that no persons are present in the robot working area or in the rotation range of the turntable.

In addition to the electrical hazard, the pneumatic system as a pressurised system, the hazardous substances of the MAG welding process and the noise exposure must also be taken into account. Before work on the clamping circuit and on the pneumatic workpiece clamps, the clamps must be opened first, because the pressure-holding valve traps the clamping pressure in the cylinder; the pneumatic circuit must then be depressurised and the residual pressure indicator checked for 0 bar. During the work, at a minimum the following must be worn: S3 safety footwear in accordance with EN ISO 20345, protective gloves, and a safety helmet for overhead work; for welding trials, additional welding protective equipment in accordance with Chapter 2.6.

The technical documents required for assembly, in particular the general arrangement drawing and overview drawing, electrical and pneumatic circuit diagrams, and the safety circuit diagrams, must be made available before work commences.

8.2 Assembly and Installation

The RSZ-2600 robotic welding cell is erected as an assembly of machinery. A floor area of approximately 6.5 x 4.0 m with a height of 2.6 m must be provided for installation; the requirements regarding foundation, load-bearing capacity and environment in accordance with Chapter 7 must be met.

Assembly sequence:
1. Align the turntable at the position indicated on the installation plan (check levelness with a precision spirit level) and anchor it with four heavy-duty anchors M16; tightening torque in accordance with the anchor approval (reference value 110 Nm).
2. Position the robot base, measure it relative to the turntable in accordance with the installation plan and anchor it with four heavy-duty anchors M16; only then release the transport locking devices on the robot axes.
3. Install the control cabinet with control desk as well as the welding power source and extraction unit; mount the torch cleaning station on the base.
4. Assemble the safety fence segments, base panels, maintenance door with interlock/guard locking and light curtain in accordance with the installation plan; maintain safety distances in accordance with EN ISO 13857 and EN ISO 13855 as shown in the drawing.
5. Electrical installation by an electrically skilled person in accordance with the circuit diagrams: supply cable to the main switch, equipotential bonding of all assemblies, wiring of the sub-machines and safety circuits; check the phase sequence (clockwise rotating field).
6. Connect the pneumatics in accordance with the pneumatic diagram (6 bar, connection G 1/2); carry out a leak test.

7. Connect the shielding gas supply and purge the lines; connect the extraction system and align the capture hood.

After all connections have been made, the following must be checked: secure seating of all fastenings and anchorages, complete enclosure, function of the interlocked maintenance door with guard locking, correct alignment of the light curtain, and complete removal of all transport securing devices (Chapter 5.4).

Reduction of noise and vibration: fit the fence infill panels, the base panels and the cover of the turntable drive completely; they are part of the noise reduction. Do not bridge the elastic bearing elements of the turntable drive with rigid connections. No further measures against noise or vibration are required during installation.

8.3 Initial Commissioning

Initial commissioning may only take place after assembly and installation have been fully completed and all guards and protective devices have been correctly fitted and connected. Before the energy supply is connected for the first time, it must be ensured that no persons are present in the robot working area, in the rotation range of the turntable or within the safety fence.

As part of initial commissioning, the safety-relevant tests in accordance with the manufacturer's test plan must be carried out and documented in the acceptance report:

- Protective conductor test and insulation measurement in accordance with EN 60204-1 (electrical test report)
- Effectiveness of the emergency stop circuit at all emergency stop devices (control desk, maintenance door, teach pendant)
- Function of the light curtain including overrun measurement and verification of the safety distance in accordance with EN ISO 13855
- Function of the interlocked maintenance door with guard locking, of the escape release, of the lockout device for personal padlocks and of the restart prevention function
- Function of the pressure monitoring on the clamping circuit, of the pressure-holding valve in the clamping line with its manual override, and of the workpiece presence sensors
- Function of the enabling device, operating mode selector switch and safely reduced speed (measurement at the TCP, maximum 250 mm/s)
- Effectiveness of the welding fume extraction system (volumetric flow measurement) and function of the temperature monitoring of the filter cartridge, the shut-off dampers, the smoke and CO detectors and the run-on
- Function of the cooling lockout period with signal light at the removal station, of the temperature monitoring at the torch neck and of the workplace lighting (500 lx at the loading station, 200 lx in the maintenance aisle, failure message)
- Validation of all safety functions in accordance with EN ISO 13849-2 (documentation in the safety verification record)

Trial runs then follow: first a dry cycle without a workpiece in set-up mode, then automatic cycles with a workpiece and evaluation of the welding results. The welding programs used must have been approved; the intended use in accordance with Chapter 2.1 must be observed.

The results of the initial commissioning must be documented in the test and acceptance reports. The machine is handed over to the user and production operation is commenced only after the successful

completion of all safety function tests, documented acceptance and instruction of the operating personnel.

9 Operation

This chapter is addressed to the operator and the set-up personnel of the robotic welding cell RSZ-2600. A documented induction and knowledge of Chapter 2 (Safety) are prerequisites for all activities. The operator works exclusively at the loading station and at the control desk; activities inside the cell are reserved for set-up and maintenance personnel. The prescribed personal protective equipment in accordance with Chapter 2.6 must be worn during all work.

9.1 Safety

The following safety rules apply to operation:

- The machine may only be operated with all guards fully fitted and functional. The daily checks in accordance with Chapter 9.4 must be carried out before the start of each shift.
- Never reach into the robot working area, bypass guards, or tamper with the light curtain. No one may remain within the rotation range of the turntable while it is rotating. Protective gloves do not protect against crushing; reach into the rotation range only when the turntable has been stopped.
- Workpieces shall only be inserted and removed when the front station is stationary. Remove welded workpieces only after the cooling lockout period has elapsed (red signal light at the removal station has gone out) and handle them only with heat-protective gloves; in the weld seam area they reach several hundred °C after welding.
- Handle workpieces up to 15 kg by hand and workpieces over 15 kg only with the user-supplied lifting aid at the loading station (for example a balancer or crane system, load capacity at least 40 kg); the maximum mass per workpiece is 40 kg.
- Do not look directly into the arc, including via reflections; the welding curtain, the infill panels of the safety fence and the viewing windows must be undamaged.
- Operation is only permitted with the welding fume extraction system in effective operation. If the extraction system develops a fault, the cell stops in a controlled manner; it cannot be restarted until the fault has been rectified.
- Faults, damage, and unusual noises must be reported immediately; the machine must be stopped in the event of safety-relevant deficiencies and secured against restart.
- Only the operator shall remain in the area of the loading opening; other persons must keep the marked operating area clear.

WARNING: Hot workpieces and clamping fixtures after welding (several hundred °C in the weld seam area). Serious burns to the hands and forearms may result. Remove workpieces only after the cooling lockout period has elapsed and only while wearing heat-protective gloves, and do not touch them with unprotected skin.

The cooling lockout period is stored for each welding program. While it is running, removal remains inhibited and the red signal light at the removal station is lit.

9.2 Controls and Indicators

Main switch (on the control cabinet): disconnects the overall installation on all poles; can be locked in the OFF position for maintenance and repair.

Control desk adjacent to the loading opening:

- HMI panel: program selection, piece counter, display of operating status and fault messages in plain text, display of maintenance intervals.
- Cycle start pushbutton (green): starts the automatic cycle when the protective field is clear and no fault is pending.
- Acknowledgement/Reset pushbutton (blue, illuminated): acknowledgement following activation of a guard, after resetting the emergency stop device, and after fault rectification; flashes when acknowledgement is required.
- Emergency stop device (red on yellow background): stops the overall installation in hazardous situations.
- Operating mode selector switch (key switch): positions Automatic and Set-up; the key remains with the authorised person.
- Remote maintenance key switch (positions Off and Enable): enables a remote maintenance session by the manufacturer (see Chapter 13.3); the key remains with the person responsible at the user's company.

Signal tower on the cell roof: green = automatic operation running; yellow = system waiting (end of cycle, material shortage, acknowledgement required); red = fault or emergency stop; additionally, an acoustic start-up warning prior to every automatic start.

Teach pendant (set-up personnel only): hand-held unit of the robot controller with display, jog keys, three-position enabling device, and its own emergency stop.

Further indicators: pressure gauge of the service unit (compressed air), residual pressure indicator at the maintenance access, flow indicator for the shielding gas at the welding power source, differential pressure indicator of the filter cartridge at the extraction unit; red signal light at the removal station (lit during the cooling lockout period); on the HMI panel, the release indication for torch replacement and torch cleaning (temperature monitoring at the torch neck) and the messages for failure of the workplace lighting and for overtemperature or fire alarm of the extraction unit.

9.3 Operating Modes

The machine has the operating modes Automatic and Set-up. They are selected with the operating mode selector switch:

Automatic mode (selector switch in Automatic position): normal operation for series production. All guards are active; the maintenance door is locked; access is exclusively through the light curtain monitored loading opening. The cycle runs automatically after release by the cycle start pushbutton.

Set-up mode (selector switch in Set-up position, key switch): operating mode for teaching, program testing and fault-finding by trained set-up personnel. Movements of the robot and turntable are only possible with the three-position enabling device on the teach pendant actuated and at safely reduced speed (maximum 250 mm/s at the TCP). When the maintenance door is open, the welding power source is safely shut down (SF-01); wire can then be fed only in inching mode at reduced threading speed. The key remains with the authorised person; after completing the work, it is mandatory to switch back to the Automatic position.

WARNING: Movements of the robot and turntable while persons are inside the cell in set-up mode. Crushing and impact with serious injury may result. Enter the cell only with the teach pendant in your hand, secure the maintenance door against closing with your personal padlock in the lockout device, and do not actuate the enabling device until no other person is within the range of movement.

Maintenance (not an operating mode): mechanical, electrical and pneumatic maintenance work is carried out with the machine isolated and secured against restart (main switch locked, compressed air relieved); see Chapter 10.

The further life-cycle phases of transport and installation (Chapters 5 and 8), cleaning (Chapter 10.2) and fault-finding (Chapter 10.4), and decommissioning and dismantling (Chapter 11) are described in the respective chapters indicated. Cleaning work shall always be carried out with the machine stopped and isolated.

9.4 Start-up and Change-over

Daily start-up (observe the sequence):
1. Visual inspection: safety fence with infill panels and viewing windows, welding curtain, light curtain, and maintenance door undamaged; no persons or foreign objects in the cell; operating area clear; workplace lighting working (no failure message on the HMI panel); standing platform adjusted to your own body height.
2. Open media supplies: open compressed air isolating valve (6 bar at the service unit), open shielding gas supply (flow approximately 15 l/min), check wire stock.
3. Switch on the main switch; wait for the control system to complete its start-up sequence.
4. Functional check of the light curtain using the test rod (interruption of each beam zone must trigger a message); once a week, additionally a functional check of one emergency stop device (a different device each time, see Chapter 10.2).
5. Check that the extraction system is ready for operation (no fault message on the HMI, differential pressure indicator in the green range); the extraction system starts under process control.
6. Select the welding program on the HMI, acknowledge fault messages, release the system using cycle start.

Change-over and product change (set-up personnel only): program change on the HMI; replacement of workpiece-specific clamping fixtures only with the system stopped and the clamping circuit depressurised (first open the clamps, then shut off and vent the compressed air, see Chapter 10.4); use only clamping fixtures approved by the manufacturer in accordance with Chapter 3.1; after every change-over, carry out a first-off inspection and document the approval. Replace wear parts on the torch (contact tip, gas nozzle) according to the specified service life.

Teaching new programs (set-up personnel only): exclusively in set-up mode with the enabling device and reduced speed; new programs must be verified first in set-up mode at reduced speed and then in an automatic cycle without a workpiece; the release must be documented.

9.5 Shutdown

Shutdown during normal operation (end of shift):
1. Allow the current cycle to complete; do not abort mid-welding process.
2. Remove the finished workpiece; move the system to the home position via the HMI.
3. Allow the extraction system to run on (automatic run-on of at least 10 minutes, fire protection requirement of the risk assessment); afterwards carry out a visual check of the filter housing for unusual heating or the smell of burning.
4. Close the shielding gas supply; close the compressed air isolating valve during prolonged standstill.
5. Switch off the main switch. For weekend or operational shutdowns, additionally lock the main switch.

Emergency shutdown: actuate the emergency stop device. All sub-machines are brought to a controlled stop (stop category 1); the signal tower changes to red.

Restart after emergency stop:
1. Identify and eliminate the cause of the hazardous situation; ensure that no persons are inside the cell.
2. Reset the actuated emergency stop device (by rotating or pulling).
3. Acknowledge at the control desk; then initiate cycle start. A workpiece for which the welding process was interrupted must be marked as a rework part and inspected.

Behaviour following a power failure: After power is restored, the system remains stopped due to the restart prevention feature. Before acknowledgement, the system status must be checked (workpiece position, torch position, clamping pressure); then acknowledge and restart as after an emergency stop. If the torch is trapped or has collided, call the set-up personnel. The rescue of a trapped person is described in Chapter 2.6.

Action in the event of compressed air failure: The pressure-holding valve keeps the workpieces clamped; the pressure switch inhibits the rotary movement of the turntable and the machine stops in a controlled manner. Stop the machine, restore the compressed air supply (6 bar at the service unit) and remove the workpiece only once the clamping pressure has been confirmed again. Then acknowledge and restart as after an emergency stop.

WARNING: Fire in the filter housing of the extraction unit caused by sparks and glowing particles, possibly with a delay after the end of the shift. Serious burns and smoke poisoning may result. Do not open the filter housing in the event of a fire alarm, leave the area and call the fire service.

Fire in the extraction unit: If the temperature monitoring of the filter cartridge or a smoke or CO detector responds, the control system switches off the extraction fan, closes the motorised shut-off dampers and stops the cell in a controlled manner. Leave the area immediately, call the fire service and inform your supervisor. Do not open the filter housing, because incoming air can fan smouldering material into flame; extinguishing agent is introduced only by the fire service through the closable extinguishing agent inlet opening of the filter housing. Restart is permitted only after the fault has been rectified and the maintenance department has given its approval. The extraction unit must not be operated with a defective temperature sensor or an ineffective shut-off damper.

10 Maintenance

This chapter is addressed to the specialist maintenance personnel responsible for the maintenance of the robotic welding cell RSZ-2600. Maintenance work is to be carried out with the machine at a standstill. Before mechanical, electrical and pneumatic work, the machine is to be isolated via the main switch, which can be locked in the OFF position, and secured against restart; the pneumatic supply is to be depressurised. Before work on the clamps, the clamps are to be opened first, because the pressure-holding valve traps the clamping pressure in the cylinder; the compressed air is then to be shut off and vented and the residual pressure indicator checked for 0 bar. If a clamp cannot be opened, the pressure is to be released in a controlled manner using the manual override of the pressure-holding valve (for the procedure see Chapter 10.4). The functional checks of the protective devices in accordance with Chapter 10.2 are carried out with the machine switched on, from outside the cell. Additionally, observe the manufacturer's documentation for purchased components, in particular the assembly instructions of the robot manufacturer as well as the documentation for the MAG welding power source, the wire feed, the torch cleaning station and the welding fume extraction system.

DANGER: Electrical voltage of 400 V in the control cabinet and in the welding power source. Touching live parts will result in death or serious injury. Work on the electrical equipment may be carried out only by electrically skilled persons; beforehand, switch off and lock the main switch, wait at least 1 minute for the welding power source to discharge (robot drives: waiting time specified by the robot manufacturer) and verify the absence of voltage.

10.1 Maintenance Record

All inspection, maintenance and repair work carried out is to be documented in a traceable manner. The maintenance record serves as evidence of proper maintenance of the robotic welding cell RSZ-2600 and is to be retained for the entire service life of the machine. For each operation, the following information is to be entered in the maintenance record as a minimum: date, work carried out, spare parts and consumables used, name of the specialist personnel performing the work, and any irregularities identified. Safety-relevant inspections of the guards and protective devices, such as the light curtain, the maintenance door with guard locking and the emergency stop circuit, are to be noted separately. A form for the maintenance record (RSZ-2600-WNW-001) is supplied with the machine (see Chapter 12); alternatively, an equivalent in-house system (for example maintenance software) may be used. The maintenance record is to be retained at least until the machine is decommissioned; the user is responsible for this.

10.2 Inspection and Maintenance Schedule

The inspection and maintenance schedule specifies which tasks are to be carried out on the machine and at what intervals. The maintenance requirements of the respective manufacturer's documentation apply additionally for purchased components.

Daily (operator): visual inspection of the guards and protective devices; functional check of the light curtain using a test rod; check of extraction capacity (differential pressure indicator), shielding gas flow rate and compressed air pressure; check torch nozzles for spatter deposits; check the shielding gas hoses, the welding and earth cables and the earth clamp for damage and secure seating; check that the workplace lighting is working; clean the working area and remove spatter from the floor at the loading station.

Weekly (operator/set-up personnel): emergency stop functional check (alternating between each emergency stop device); check contact tip and gas nozzle of the torch, replace if worn; clean wire feed rollers and wire guide; drain condensate from the service unit; check the welding curtain, the infill panels of the safety fence and the viewing windows for damage.

Monthly (set-up personnel/maintenance): clean torch cleaning station and refill spray agent; check pneumatic fittings and hoses for leaks; inspect extraction filter cartridge, replace if differential pressure is in the red zone; functional check of the guard locking, the escape release and the lockout device of the maintenance door; check robot cables and hose assembly for chafing points; empty the pre-spark separator of the extraction unit (treat the dust as when replacing the filter cartridge); check the coolant level of the cooling unit and, if necessary, top up with coolant as specified by the torch manufacturer.

Every six months (maintenance): documented functional check of all safety functions (SF-01 to SF-05) in accordance with the enclosed test plan for the safety functions (RSZ-2600-PPS-001, see Chapter 12); check anchoring of the robot base and turntable (tightening torques); visual inspection of the electrical equipment; visual inspection of the screen terminations and the equipotential bonding; insulation measurement of the welding circuit by an electrically skilled person; functional check of the temperature sensor and the shut-off dampers and of the smoke and CO detectors of the extraction unit.

Annually (manufacturer): major service in accordance with the maintenance contract, including robot maintenance as specified by the manufacturer (gearbox lubrication, robot controller batteries), calibration check of the robot, inspection of the interlock and guard locking in accordance with EN ISO 14119, recalculation or inspection of the safety distance of the light curtain in accordance with EN ISO 13855, inspection of the welding power source in accordance with EN 60974-4.

WARNING: Welding fume dust when the filter cartridge is replaced. Inhalation can cause permanent damage to the respiratory tract. Wear an FFP3 particle filtering half mask in accordance with EN 149, safety goggles and disposable gloves; do not raise dust.

Replacing the filter cartridge (maintenance): wait for the extraction run-on to finish, then isolate the machine; using the bag-in/bag-out change system of the filter housing, remove the saturated cartridge into the change bag and seal the bag tightly straight away; clean the filter housing with an industrial vacuum cleaner of dust class H in accordance with EN 60335-2-69, do not blow it out and do not sweep; fit a new cartridge of welding fume class W3 and check that the seal is seated correctly; after switching on again, check the differential pressure indicator; disposal in accordance with Chapter 11.3.

Cleaning the cell (set-up personnel/maintenance): only with the machine isolated and secured against restart; remove spatter mechanically; pick up dust with an industrial vacuum cleaner of dust class H, do not blow it off with compressed air and do not sweep; do not use flammable cleaning agents; clean the viewing windows and the front screens of the light curtain with a soft cloth; after cleaning, carry out the functional check of the light curtain.

Additionally, the user's statutory inspection obligations under the German Ordinance on Industrial Safety and Health (BetrSichV) and DGUV Regulation 3 (German accident insurance regulation on electrical installations and equipment) apply (periodic inspection of the electrical equipment). Damaged or worn components of the guards and protective devices are to be repaired or replaced before the machine is returned to service.

10.3 Lubrication Schedule

The lubrication schedule specifies which lubrication points on the machine are to be supplied at which intervals with which lubricants:

- Robot gearboxes (axes 1 to 6): lubrication exclusively within the scope of the annual manufacturer's service in accordance with the robot manufacturer's specifications (gearbox grease as specified in the robot documentation).
- Slewing ring and bearing of the turntable: lubricate every six months with multipurpose grease KP2K-30 in accordance with DIN 51502 (2 grease nipples on the base frame, approximately 10 g each).
- Guides and joints of the pneumatic workpiece clamps: apply a thin coat of acid-free machine oil monthly; do not use excessive quantities (spatter deposits).
- Hinges and interlock of the maintenance door: lubricate every six months with multipurpose grease.
- Torch cleaning station: refill the spray agent tank monthly (silicone-free anti-spatter agent).

The pneumatic components are designed for oil-free air and are not to be oiled. Use only the lubricants specified or equivalent lubricants approved by the manufacturer. Used consumables and lubricants are to be disposed of properly and in an environmentally responsible manner in accordance with Chapter 11.3. The machine is to be isolated for all lubrication work; wear suitable protective gloves.

Fault-finding

Diagnosis: fault messages are read from outside the cell, with the machine switched on, at the HMI panel, the signal tower and the indicators. Interventions inside the cell with the machine switched on (for example moving the robot clear or checking the program path) are permitted only for set-up personnel in set-up mode with the enabling device and safely reduced speed. Access is exclusively via the maintenance door; each person entering secures the door with their personal padlock in the lockout device. Mechanical, electrical and pneumatic work starts only after isolation: for work on the clamps, first remove the workpiece and open the clamps; switch off and lock the main switch (LOTO); shut off the compressed air at the maintenance shut-off valve, wait for venting to finish, check that the residual pressure indicator shows 0 bar and secure the valve with a padlock; wait at least 1 minute for the welding power source to discharge; for the robot drives, the waiting time specified by the robot manufacturer applies.

WARNING: Unexpected start-up of the robot and turntable and stored compressed air in the clamping circuit during fault-finding. Crushing with serious injury may result. Before entering the cell, stop the machine and secure the maintenance door with your personal padlock. Before working on the clamps, open the clamps first, because the pressure-holding valve traps the clamping pressure in the cylinder. Then shut off and vent the compressed air and check that the residual pressure indicator shows 0 bar. If a clamp cannot be opened, release the pressure in a controlled manner using the manual override of the pressure-holding valve.

Fault	Possible cause	Remedy
System does not start in automatic mode	Safety circuit open (maintenance door, light curtain), emergency stop actuated	Close the maintenance door, clear the light curtain, reset the emergency stop device, acknowledge at the control desk
Light curtain triggers for no apparent reason	Contamination or misalignment of the optics	Clean the front screens of the transmitter and receiver, check alignment (alignment indicator), then carry out functional check
Turntable does not rotate	Clamping pressure below setpoint, workpiece presence sensor not responding, protective field occupied	Check compressed air supply (6.0 bar), check workpiece clamping, clear the rotation range
Compressed air failure (clamping pressure drops, fault message on the HMI panel)	On-site compressed air supply failed, shut-off valve closed, leak in the clamping circuit	Stop the machine; the pressure-holding valve keeps the workpieces clamped. Restore the compressed air supply (6.0 bar), check for leaks, remove the workpiece only once the clamping pressure has been confirmed, then acknowledge at the control desk
Guard locking of the maintenance door does not release	Robot or turntable has not yet reached safe standstill, arc not yet extinguished	Wait for standstill to complete (display at the control desk), then request again
Weld seam defective (spatter, porosity)	Wire feed disturbed, insufficient shielding gas, torch nozzle worn	Check wire feed and gas flow rate, replace nozzle/contact tip, check welding parameters
Insufficient extraction / fault message	Filter cartridge saturated, capture hood displaced	Replace filter cartridge (welding fume class W3, procedure in accordance with Chapter 10.2, disposal as hazardous waste in accordance with Chapter 11.3), correct hood position

Fault	Possible cause	Remedy
Robot stops with collision message	Collision protection coupling on the torch or collision detection of the robot triggered (torque/current monitoring)	Eliminate cause in the working area, check the torch and the collision protection coupling for damage, check program path, acknowledge message on the teach pendant
Removal remains inhibited, red signal light at the removal station is lit	Cooling lockout period of the welding program is running	Wait for the cooling lockout period to elapse; do not bypass the lockout period
Fault message for torch cooling, or no release for torch replacement	Coolant level too low, cooling unit faulty, torch neck still too hot	Check the coolant level and top up, check the cooling unit and hose assembly; replace the torch only after the release indication on the HMI panel
Overtemperature or fire alarm of the extraction unit	Glowing particles in the filter; temperature sensor, smoke detector or CO detector has responded	Proceed in accordance with Chapter 9.5 (Fire in the extraction unit); do not open the filter housing
Message: failure of the workplace lighting	Luminaire defective	Stop work in the affected area, have the luminaire repaired by an electrically skilled person

If a fault cannot be remedied using these measures, the manufacturer is to be contacted (for contact details see Chapter 12.1). Unauthorised interventions in safety functions are not permitted.

11 Dismantling and disposal

This chapter describes the principles for the final decommissioning, dismantling and environmentally sound disposal of the RSZ-2600 robotic welding cell. Dismantling is a separate life-cycle phase of the machine and may only be carried out by trained, qualified personnel. Also observe the information contained in the associated technical documents, in particular the general arrangement drawing and overview drawing as well as the electrical and pneumatic circuit diagrams.

Safety Instructions for Dismantling

WARNING: Stored energy (electrical energy, compressed air, moving masses) as well as hazardous substances and residues from the welding process. Death or serious injury may result. Before dismantling, isolate the machine, wait for the discharge time to elapse, vent the pneumatic system and lock movable assemblies in position.

Before commencing dismantling work, the machine must be safely stopped and disconnected from the energy supply on all poles: switch off the main switch and secure it with a lock in the OFF position; have the supply cable isolated by an electrically skilled person, secure it against re-energisation, verify the absence of voltage, earth and short-circuit it, and cover adjacent live parts (the five safety rules of EN 50110-1). Wait at least 1 minute before opening the welding power source and the control cabinet (measured discharge time of the welding power source: 1.9 s to ≤ 60 V; the waiting time includes a safety margin); for the robot drives, the waiting time specified by the robot manufacturer applies.

The pneumatic system must be depressurised: open the workpiece clamps before isolating the machine, because the pressure-holding valve traps the clamping pressure in the cylinder; then close the maintenance shut-off valve, vent the system via its exhaust position and check at the residual pressure indicator that the

pressure has been relieved. If a clamp cannot be opened, release the trapped pressure in a controlled manner using the manual override of the pressure-holding valve.

Movable assemblies with possible stored potential energy must be secured against unintentional movement before releasing fastenings: move the robot to the transport position and lock it with the stored transport locking device; lock the turntable with the locking pin of the rotary axis.

Use suitable lifting and transport equipment as well as personal protective equipment for handling and removal of heavy assemblies. Masses and lifting points of the assemblies: see Chapters 5.2 and 5.3.

Dismantling Sequence

Dismantling is carried out in the reverse order of assembly (Chapter 8.2):
1. Disconnect utilities: shielding gas, compressed air and extraction connection; drain and label lines.
2. Have the electrical connections disconnected and labelled by an electrically skilled person; disconnect the supply cable.
3. Dismantle the light curtain, maintenance door and safety fence segments.
4. Remove the welding power source with cooling unit, wire feed unit, torch cleaning station and extraction unit.
5. Lock the robot in the transport position, release the anchorage, lift the robot with its base.
6. Lock the turntable, release the anchorage, lift the turntable; finally remove the control cabinet and control desk.
The tightening and loosening torques of the connections are to be taken from the general arrangement drawing and the assembly documents. Chapters 5 and 6 apply to intermediate storage or onward transport.

Separation and Disposal of Operating Fluids

Prior to material separation, all operating and auxiliary materials must be drained, collected and separated in a proper manner. The following must be taken into account in particular: lubricating greases from the turntable slewing ring and robot gearboxes; the anti-spatter agent from the torch cleaning station; the coolant from the cooling unit and hose assembly of the water-cooled welding torch (collect it and dispose of it in accordance with the safety data sheet, do not discharge it into the sewer system); welding wire residues; the filter cartridge of the welding fume extraction unit as well as deposited welding fume dusts in the housing, pre-spark separator and pipework.

WARNING: Welding fume dust in the filter cartridge and in the dust deposits of the extraction unit. Inhalation can cause permanent damage to the respiratory tract. When handling the filter cartridge, wear an FFP3 particle filtering half mask in accordance with EN 149 and disposable gloves, and do not raise dust. Dispose of the filter cartridge and the dust deposits in dust-tight packaging as hazardous waste (code 15 02 02* of the European List of Waste, in Germany AVV 15 02 02*: filter materials contaminated by hazardous substances, or as classified by the disposal contractor).

Operating fluids, filter residues and components contaminated with hazardous substances must not enter household waste or the environment. Collect these materials separately and dispose of them through an authorised disposal facility. The safety data sheets of the substances used and the requirements of the regionally responsible licensed waste disposal company are applicable.

Material Separation and Recycling

After removing the operating fluids, the assemblies must be dismantled and the materials separated by type:

- Steel and cast iron (safety fence with infill panels, frames, turntable, base): scrap metal recovery
- Non-ferrous metals (copper cables, welding leads, contact tips): separate collection
- Electrical and electronic equipment (controls, drives, HMI, sensors, welding power source): separate collection and disposal as waste electrical and electronic equipment through authorised collection and recovery facilities
- Batteries and accumulators (buffer batteries of the robot controller): battery take-back system
- Plastics (covers, hoses, curtain): material or energy recovery
- Packaging and insulation material: local recovery channels

Observe the statutory and regulatory requirements applicable at the installation site during dismantling and disposal. In case of doubt, materials and operating fluids must be disposed of through a licensed waste disposal company; disposal must be documented.

12 Drawings and other information

The following documents are supplied with the machine:

- Installation plan (RSZ-2600-LAY-001)
- Circuit diagrams of the electrical equipment (RSZ-2600-EPL-001)
- Pneumatic diagram (RSZ-2600-PPL-001)
- Spare parts list (RSZ-2600-ET-001)
- Test plan for the safety functions SF-01 to SF-05 (RSZ-2600-PPS-001)
- Maintenance record form (RSZ-2600-WNW-001)
- EU declaration of conformity

The user receives the acceptance report of the initial commissioning, with the reference versions and checksums of the safety-related software (program of the safety PLC, safety configuration of the robot controller, parameterisation of the light curtain; see Chapter 13.2), at handover.

12.1 Drawings and Spare Parts

The installation plan (RSZ-2600-LAY-001) is supplied with the machine. The manufacturer provides the general arrangement drawing and the assembly drawings (drawing set RSZ-2600-ZG-001 ff.) on request for maintenance and for ordering spare parts.

Spare and wear parts: only original spare parts or equivalent parts approved by the manufacturer may be used. Principal wear parts: contact tips and gas nozzle of the welding torch, wire feed rollers, wire guide liner, welding curtain, extraction filter cartridge, base panel brushes and the seal kits for the pneumatic clamps. Ordering information: enclosed spare parts list RSZ-2600-ET-001; always state the type and serial number of the machine when placing orders.

Contact for spare parts and technical enquiries: Muster Maschinenbau GmbH, Beispielstraße 1, 12345 Musterstadt, Germany, e-mail service@muster-maschinenbau.example.

12.2 Electrical Documentation

The electrical documentation in accordance with EN 60204-1 is supplied with the machine: circuit diagrams (electrical circuit diagram RSZ-2600-EPL-001), terminal and cable schedules, control cabinet layout drawing, bill of materials for electrical equipment, PLC and safety PLC program documentation with signal list, as well as the test reports for the protective conductor test and insulation measurement. One copy of the circuit diagrams is kept in the control cabinet. Modifications to the electrical installation may only be carried out by electrically skilled persons and only with the approval of the manufacturer; the drawings are to be updated accordingly when modifications are made.

13 Cybersecurity

This chapter is intended for the user and for the specialists responsible for networks and maintenance. It describes how the robotic welding cell RSZ-2600 is integrated into the user's network, how the software version is checked and how remote maintenance and updates work. Where an intervention in the controller affects a safety function, the instructions in Chapter 2 (Safety) also apply.

Integration into the User's Network

Connect the cell to the user's network only through the supplied gateway. Do not connect any further devices or networks to the cell network inside the control cabinet.

- Place the gateway in a dedicated network segment for production equipment, not in the office network.
- Allow only the connections the cell needs: OPC UA from the MES to the cell and the VPN connection to the manufacturer's remote maintenance server.
- Do not set up a direct internet connection for the controller.
- Change firewall rules only after consulting the manufacturer.

Software Version and Evidence of Interventions

Version and checksum of the safety-related software are shown on the HMI panel under "Info" and can be viewed without logging in. The safety-related software comprises the program of the safety PLC, the safety configuration of the robot controller and the parameterisation of the light curtain; the reference versions and checksums are recorded in the acceptance report. Compare them with the acceptance report after every intervention, update and device replacement. The event log lists logins, parameter changes, software uploads and remote maintenance sessions with time stamp and user. If the values differ, do not release automatic mode and inform the manufacturer.

Remote Maintenance

Remote maintenance is disabled on delivery. A session can only be enabled with the remote maintenance key switch at the control desk and ends automatically after four hours; while it is active, the HMI panel shows "Remote maintenance active". A responsible person must be available on site. If you suspect unauthorised access, end the session immediately with the remote maintenance key switch and inform the manufacturer via the contact address for security reports.

Updates

During the support period until March 2039, the manufacturer provides security updates for the control, HMI and gateway software in the customer portal, with release notes and checksum. The manufacturer

informs the registered contacts about new updates by e-mail; the security advisories are also published at https://www.muster-maschinenbau.example/security/advisories. To install an update:

- Download the update from the customer portal and compare the checksum with the release notes.
- Stop the cell, select set-up mode, keep the maintenance door closed and install the update via USB on the HMI panel or in a remote maintenance session enabled on site.
- Afterwards compare the version and checksum under "Info" with the release notes and record them as the new reference in the acceptance report.
- Before releasing automatic mode, carry out and document the functional test of all safety functions SF-01 to SF-05 in accordance with the enclosed test plan RSZ-2600-PPS-001 (see Chapters 10.2 and 12).

Retaining Logs

The controller protects the event log against deletion and modification and keeps software uploads with the associated data for up to five years after uploading. The log can be exported in readable form at the HMI panel. Make sure the date and time of the controller are correct, otherwise the time stamps cannot be used. Pass the logs on to the new user if the cell is transferred and make them available to an authority upon reasoned request.

This document was prepared with AI assistance. Review of and responsibility for its content lie with the manufacturer.
#ce-copilot:ki-unterstuetzt; ai-disclosure=ai-assisted; generator=CE-Copilot; digitalsourcetype=compositeWithTrainedAlgorithmicMedia