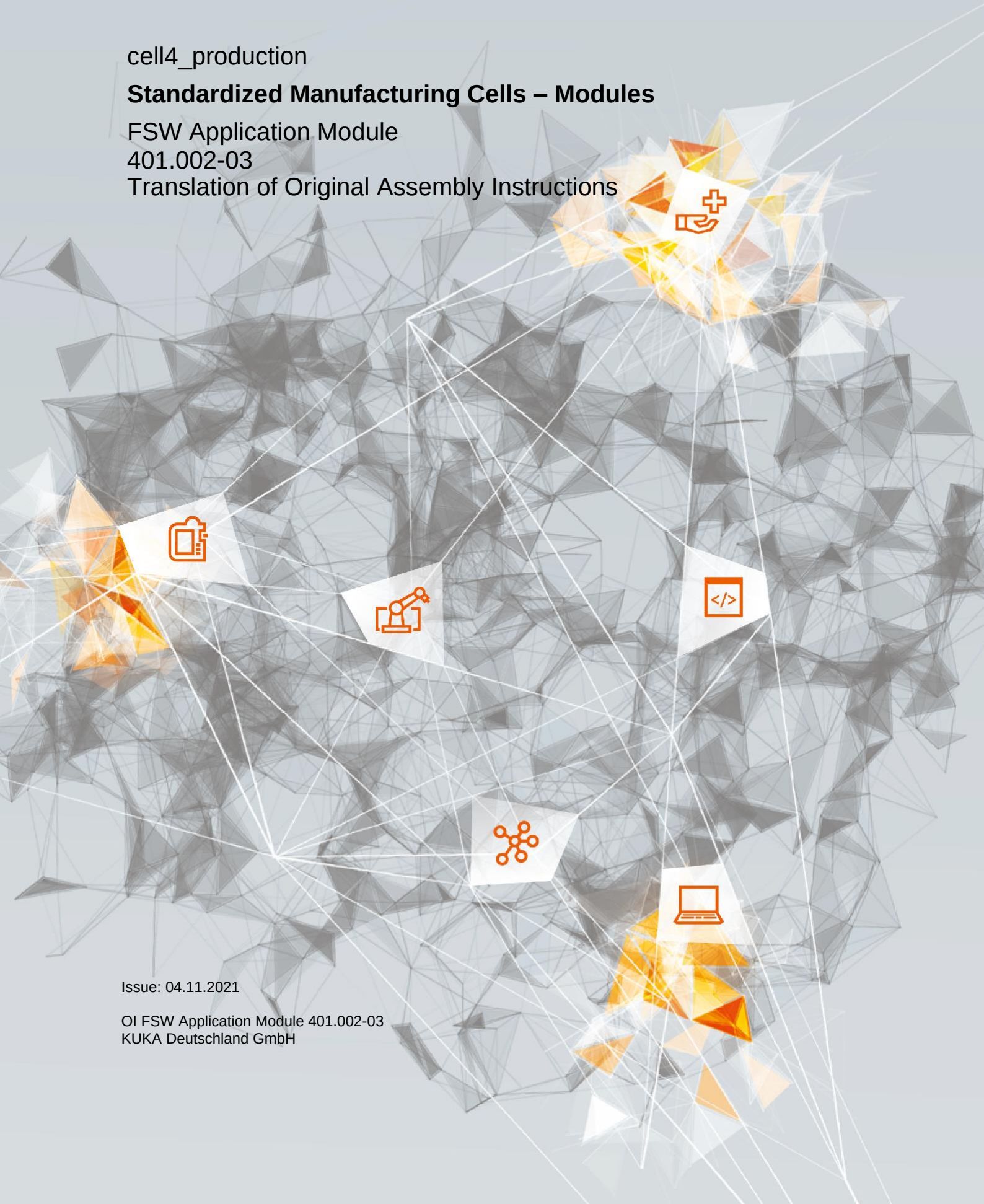
cell4_production

Standardized Manufacturing Cells – Modules

FSW Application Module
401.002-03
Translation of Original Assembly Instructions



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OI FSW Application Module 401.002-03
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Contents

1 Safety

1.1 General

1.1.1 Disclaimer

The device described in this document is an FSW robot system (FSW = Friction Stir Welding). The device described in these assembly instructions constitutes partly completed machinery.

The FSW robot system has been built in accordance with state-of-the-art standards and the recognized safety rules. Nevertheless, misuse may constitute a risk to life and limb or cause damage to the FSW robot system and to other material property.

The FSW robot system may only be used in perfect technical condition in accordance with its intended use and only by safety-conscious persons who are fully aware of the risks involved in its operation. Use of the FSW robot system is subject to compliance with this document and with the declaration of incorporation supplied together with the FSW robot system. Any functional disorders, especially those affecting safety, must be rectified immediately.

Safety information

Information about safety may not be construed against KUKA Deutschland GmbH. Even if all safety instructions are followed, it cannot be ensured that the FSW robot system will not cause any injuries or damage.

No modifications may be made to the FSW robot system without the authorization of KUKA Deutschland GmbH. No additional components (tools, software, etc.) not supplied by KUKA Deutschland GmbH may be integrated into the FSW robot system. The operator is however liable for any damage that occurs on the FSW robot system or to other property as a result of such components.

In addition to the Safety chapter, other relevant documents contain further safety instructions. These must also be observed. The fundamental safety information for the FSW robot system can be found in the “Safety” chapter of the operating instructions or assembly instructions of the robot controller.

The user must have read and understood the FSW robot system documentation including the safety chapter.

1.1.2 Intended use of the FSW robot system

The FSW robot system is intended exclusively for the use designated in the “Intended use” (see Section 2.1) of the assembly instructions.

Using it for other or additional purposes is considered as misuse (see Section 2.2) and is inadmissible. The manufacturer cannot be held liable for any resulting damage. The risk lies entirely with the user.

Operation within the limits of the intended use also involves observing the operating and assembly instructions for the individual components and, in particular, following maintenance regulations.

1.1.3 EC declaration of conformity and declaration of incorporation

This FSW robot system constitutes partly completed machinery as defined by the EC Machinery Directive. The FSW robot system may only be put into operation if the following preconditions are met:

- The FSW robot system is integrated into a machine or overall system.
- Or: The FSW robot system constitutes a system together with other machines.
- Or: All safety functions and safeguards required for completed machinery as defined by the EC Machinery Directive have been added to the FSW robot system.
- The machinery or system conforms to the EC Machinery Directive. This has been ascertained by means of a conformity assessment procedure.

Declaration of conformity

The system integrator must create a declaration of conformity in accordance with the Machinery Directive for the overall machine or system. The declaration of conformity forms the basis for the system's CE conformity mark. The FSW robot system must be operated in accordance with the applicable national laws, regulations and standards.

The FSW robot system is CE certified under the EMC Directive and the Low Voltage Directive.

Declaration of incorporation

As partly completed machinery, the FSW robot system is supplied with a declaration of incorporation in accordance with Annex II B of the Machinery Directive 2006/42/EC. Integral parts of this declaration of incorporation include a list of the essential requirements stipulated in Annex I that have been complied with and the assembly instructions.

The declaration of incorporation declares that the partly completed machinery must not be put into operation until it has been installed in a machine or assembled with other parts to form a machine, that this machine conforms with the provisions of the EC Machinery Directive, and that the EC declaration of conformity is present in accordance with Annex II A.

The declaration of incorporation with its annexes remains with the system integrator as part of the technical documentation of the completed machinery.

1.1.4 System integrator

The FSW robot system must be integrated into a system by the system integrator in compliance with all safety requirements.

The system integrator is responsible for the following tasks:

- Installing the FSW robot system.
- Connecting the FSW robot system.
- Performing the risk assessment for the overall system.
- The risk inherent in the process must be considered in a risk assessment.

- If non-conductive tools and tool holders are used, the risk of electrostatic hazards must be considered in a separate risk assessment.
- Implementing the required safety functions and a guard.
- Measures against fire and dust explosion must be considered and initiated by the system integrator. The system integrator must include this hazard in the risk assessment of the process, evaluate it and implement corresponding safety measures.
- The risk arising from a power failure and liable to cause damage to the FSW spindle and manipulator must be considered in a risk assessment.
- The risk arising from damaged cables due to short circuit must be considered in a risk assessment, taking the working environment and the material to be machined into account.
- Issuing the declaration of conformity.
- Affixing the CE mark.
- Creation of the operating instructions for the system. Reference must be made in these operating instructions to the safety chapter of the assembly and operating instructions of the FSW robot system.

1.1.5 User

The user must observe the labor laws and regulations. This includes e.g.:

- The risk inherent in the process must be considered in a risk assessment.
- The user must comply with his monitoring obligations.
- The user must carry out safety instruction at regular intervals.
- The user must train personnel in operation of the FSW robot system at regular intervals.
- The user must draw up an emergency plan, e.g. for evacuation in the event of a fire.
- The user must not store flammable objects and fluids in the vicinity of the FSW robot system.
- A risk assessment must be carried out to confirm that the material approved by KUKA Deutschland does not constitute a hazard in a machining process.
- Only entrust work on the system to trained specialists who have been instructed in safety.

1.1.6 Triggers for stop reactions

Stop reactions of the industrial robot are triggered in response to operator actions or as a reaction to monitoring functions and error messages.

The following table shows the different stop reactions according to the operating mode that has been set.

Trigger	T1, T2	AUT, AUT EXT
Start key released	STOP 2	-
STOP key pressed	STOP 2	
Drives OFF	STOP 1	
“Motion enable” input drops out	STOP 2	
Power switched off via main switch or power failure	STOP 0	
Internal error in non-safety-oriented part of the robot controller	STOP 0 or STOP 1 (dependent on the cause of the error)	
Operating mode changed during operation	Safety stop 2	
Safety gate opened (operator safety)	-	Safety stop 1
Enabling switch released	Safety stop 2	-
Enabling switch pressed fully down or error	Safety stop 1	-
E-STOP pressed	Safety stop 1	
Error in safety controller or periphery of the safety controller	Safety stop 0	

1.2 Safety equipment and safeguards in the FSW robot system

1.2.1 Mode selector switch

The FSW robot system can be operated in the following modes:

- Manual Reduced Velocity (T1)
  - The drive of the FSW spindle can only be operated with the gate closed and locked.
- Manual High Velocity (T2)
  - The drive of the FSW spindle can only be operated with the gate closed and locked.
- Automatic (AUT)
- Automatic External (AUT EXT)

The operating mode is selected with the mode selector switch on the smartPAD. The switch is actuated using a key that can be removed. If the key is removed, the switch is locked and the operating mode can no longer be changed.

If the operating mode is changed during operation, the drives are immediately switched off. The manipulator stops with a STOP 0.

Operating mode	Use	Velocities
T1	For test operation, programming and teaching	■ Program verification: Programmed velocity, maximum 250 mm/s ■ Jog mode: Jog velocity, maximum 250 mm/s
T2	For test operation	■ Program verification: Programmed velocity
AUT	For industrial robots without a higher-level controller Only possible with the operator safety closed	■ Program mode: Programmed velocity ■ Jog mode: Not possible

Operating mode	Use	Velocities
AUT EXT	For industrial robots with higher-level controllers, e.g. PLC Only possible with the operator safety closed	■ Program mode: Programmed velocity ■ Jog mode: Not possible

1.2.2 Operator safety

Operator safety is active for all operating modes of the FSW robot system, which means that the FSW spindle cannot be operated with the safety gate open.

- **⚠ WARNING Risk of death, serious injuries or damage to property!**

  The operator safety signal must not be automatically reset when the safeguard (e.g. safety gate) is closed, but only after an additional manual acknowledgement signal has been given.

  Only in this way can it be ensured that automatic operation is not resumed inadvertently while there are still persons in the danger zone, e.g. due to the safety gate closing accidentally.

1.2.3 EMERGENCY STOP devices

The EMERGENCY STOP devices for the FSW robot system are the EMERGENCY STOP device on the smartPAD and on the gate switch with the optional safety PLC (with MGB gate switch). The EMERGENCY STOP device must be pressed in the event of a hazardous situation or emergency.

Reactions of the FSW robot system when the EMERGENCY STOP device is actuated:

- Operating modes Manual Reduced Velocity (T1) and Manual High Velocity (T2).
  - The manipulator drives switch off immediately. The manipulator stops with a STOP 0.
  - The drive of the FSW spindle is stopped under servo control.
  - The hydraulically actuated tool clamping system of the welding spindle unit is deactivated.
  - The recooling system for motor cooling is switched off.
- Automatic modes (AUT and AUT EXT).
  - The manipulator drives are switched off after 1 s. The manipulator stops with a STOP 1.
  - The drive of the FSW spindle is stopped under servo control.
  - The hydraulically actuated tool clamping system of the welding spindle unit is deactivated.
  - The recooling system for motor cooling is switched off.

Before operation can be resumed, the EMERGENCY STOP device must be turned to release it, and the stop message must be acknowledged on the smartPAD.

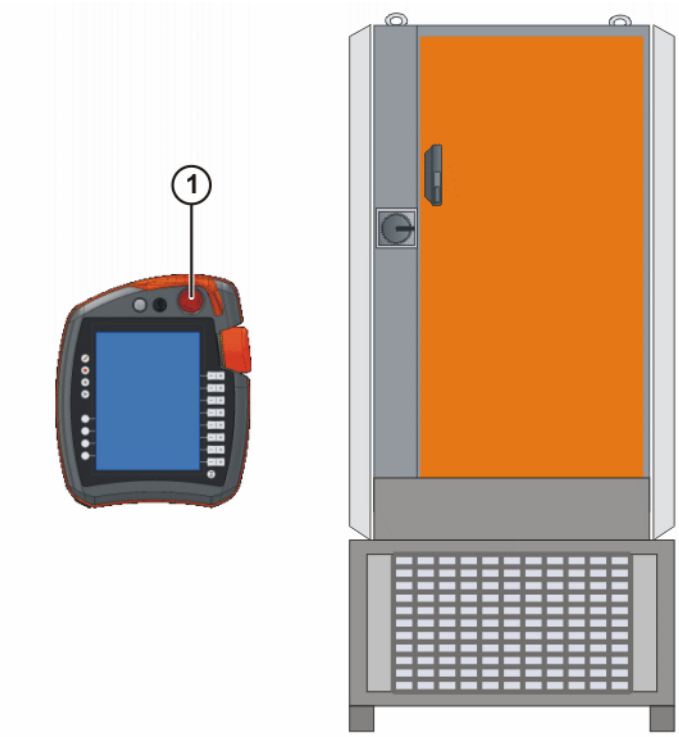

Fig. 1: EMERGENCY STOP device on the smartPAD

1. EMERGENCY STOP device on the smartPAD

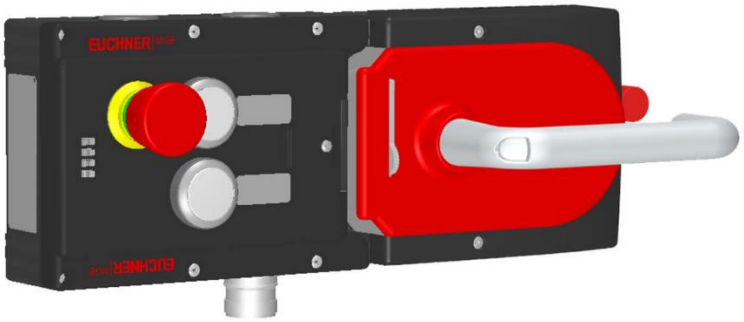

Fig. 2: MGB gate switch, EMERGENCY STOP device on the gate switch (optional)

⚠ WARNING Risk of death, serious injuries or damage to property!

- Tools or other devices that are connected to the manipulator must be integrated into the EMERGENCY STOP circuit on the system side if they could constitute a hazard.

1.2.4 External EMERGENCY STOP device

EMERGENCY STOP devices must be available at every workstation where a robot movement or other potentially hazardous situation may arise. This is the responsibility of the system integrator.

There must always be at least one external EMERGENCY STOP device installed. This ensures that there is an EMERGENCY STOP device available, even if the smartPAD has been disconnected.

1.3 Additional protective equipment

1.3.1 Labeling on the FSW robot system

All plates, labels, symbols and marks constitute safety-relevant parts of the FSW robot system. They must not be altered or removed.

⚠ WARNING Risk of serious injuries or damage to property!

If plates and labels, signs, symbols and markings are missing or damaged, this can result in human error.

Missing or damaged plates and labels, signs, symbols and markings must be replaced.

In accordance with the required occupational safety and risk assessment, the system integrator must attach warnings to the guard (“PPE must be worn”, “No entry for unauthorized persons”).

Labeling on the FSW robot system includes:

- Rating plates
- Warning signs
- Safety symbols
- Designation labels
- Cable markings
- Identification plates

NOTICE

Further information is contained in the corresponding documentation of the FSW robot system.

1.3.2 Guard

The workspace of the manipulator must be protected by a guard.

The guard must be designed by the system integrator and must satisfy the following requirements:

- It must not be possible for the tool to be ejected from the safeguarded area.
- It must not be possible for unauthorized persons to enter.

The following regulations must be observed and complied with.

- DIN EN ISO 12100 Safety of machinery – General principles for design – Risk assessment and risk reduction
- DIN EN 12417:2001+A1:2009/AC:2010 Machine tools - Safety - Machining centers
- DIN EN ISO 13857:2008 Safety of machinery (Safety distances)
- DIN EN ISO 14120:2015 Safety of machinery (Guards)

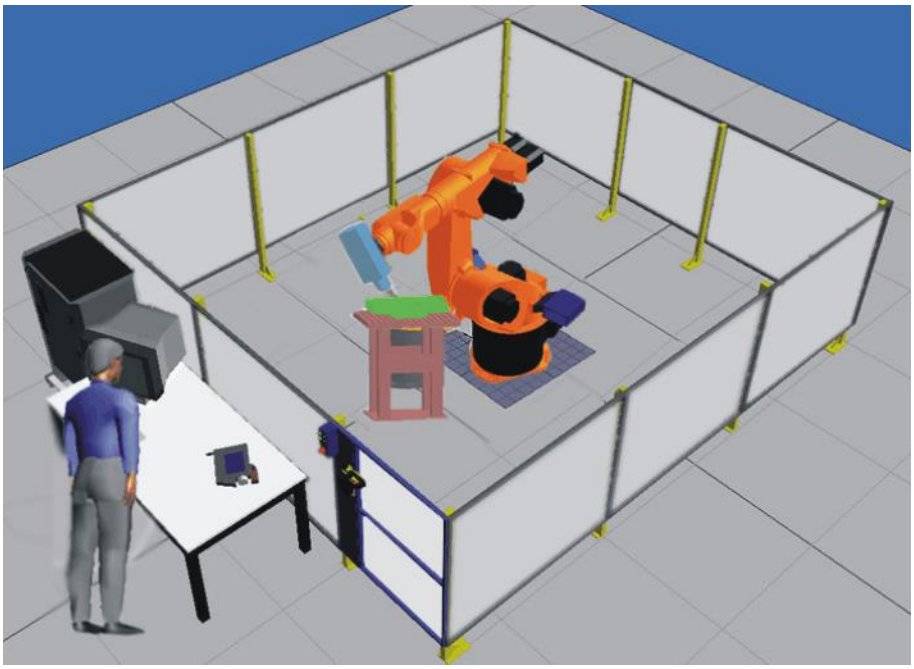

Fig. 3: Example: guard

Safety gates (optional)

The current standard provides for just one safety gate as the standard option!

The safety gates must meet the following requirements:

- Only one safety gate is provided.
- The system integrator must use a manipulation-proof gate lock.

The following gate lock must be installed for the safety gate:

  - Euchner MGB-L1HE-ARA gate lock

- Automatic operation must be prevented until the safety gate has been closed, locked and acknowledged.
- If the safety gate is opened in automatic operation, a safety stop 1 must be triggered.
- It must only be possible to open the safety gate if the FSW spindle is no longer rotating.

- **NOTICE**

  Further information is contained in the corresponding standards and regulations.

- **NOTICE**

  The safety gates are not included in the scope of supply and must be installed and integrated by the user in compliance with the relevant regulations, standards and directives.

1.4 Safety measures

1.4.1 General safety measures

⚠ WARNING Risk of death, serious injuries or damage to property!

- If work is performed on the FSW robot system in manual mode, the safety gate must be opened and secured to prevent unintentional closing (e.g. with a padlock).

  If it is necessary to carry out work with the robot controller and FSW controller switched on, the user must define additional safety measures to ensure the safe protection of personnel.

⚠ WARNING Risk of serious injuries!

- The tool and workpiece have sharp edges that can cause injuries. Contact with the hands must be avoided. Appropriate safety precautions must be taken:

  Personal protective equipment must be worn (e.g. protective gloves, safety footwear and long, closely fitting clothing)

⚠ WARNING Risk of serious injuries!

- The tool and workpiece can become very hot and cause burns on contact. If the tool is changed manually, suitable protective measures must be taken:

  Contact with the hands must be avoided.

  Personal protective equipment must be worn (e.g. protective gloves, safety footwear and long, closely fitting clothing)

⚠ WARNING Risk of serious injuries or damage to property!

- Rotating and moving parts (e.g. FSW spindle) can tangle or catch in hair and clothing, resulting in serious injuries. Freedom of motion and stability may be severely adversely affected. Contact must be avoided. Appropriate safety precautions must be taken:

  Wear personal protective equipment (e.g. hair net or other head covering, closely fitting clothing)

  Do not wear jewelry

⚠ WARNING Risk of death, serious injuries or damage to property!

- Risk of accident due to the rotating FSW tool and sharp cutting edges and/or tool breakage and the release of individual components.

  Appropriate safety precautions must be taken. See also Section 1.3.2.

Faults

In the case of faults in the FSW robot system, proceed as follows:

- Wear personal protective equipment
- Remove tool and workpiece
- In the case of work on live parts, switch off the robot controller and the FSW controller and secure them against being switched back on
- Identify the fault with an appropriate warning sign
- Document the faults
- Eliminate the fault and carry out a function test

1.4.2 Transportation

Manipulator

The prescribed transport position of the manipulator must be observed. Transportation must be carried out in accordance with the operating instructions or assembly instructions of the manipulator.

Robot controller

The robot controller must be transported and installed upright. Avoid vibrations and impacts during transportation in order to prevent damage to the robot controller.

Transportation must be carried out in accordance with the operating instructions of the robot controller.

Technology cabinet

Coolant must be drained prior to transportation. The technology cabinet must be transported and installed upright. Avoid vibrations and impacts during transportation in order to prevent damage to the technology cabinet.

Transportation must be carried out in accordance with the Friction Stir Welding assembly instructions for KR C4.

1.4.3 Start-up and recommissioning

Before starting up systems and devices for the first time, a check must be carried out to ensure that the systems and devices are complete and operational, that they can be operated safely and that any damage is detected.

The valid national and/or regional work safety regulations must be observed for this check. The correct functioning of all safety functions must also be tested.

- **NOTICE** **Risk of damage to property!**

  If the internal temperature in the cabinet of the FSW controller and robot controller differs greatly from the ambient temperature, condensation can form, resulting in damage to the electrical equipment.

Do not put the FSW controller and robot controller into operation until the internal temperature in the cabinet has adjusted to the ambient temperature.

When the FSW robot system is put back into operation following a power failure, the EMERGENCY STOP and operator safety functions must be reset.

⚠ WARNING Risk of serious injuries or damage to property!

- The chuck for the tool is not conductive. An electrostatic charge can cause serious injuries.

  If materials are used which generate a static charge when machined, the tool must be grounded using a slipring or similar device.

Electrical compartments must only be opened using suitable and approved tools or a key.

⚠ WARNING Risk of serious injuries or damage to property!

- The hydraulic fluid is under high pressure. Hydraulic fluid can be ejected from defective hoses or unions, causing severe injuries. Appropriate safety precautions must be taken:

  Personal protective equipment must be worn (e.g. protective gloves, safety footwear and long, closely fitting clothing)

⚠ WARNING Risk of serious injuries or damage to property!

- Contact with hydraulic oil or cooling fluid can cause injury:

  If a person comes into contact with hydraulic oil or cooling fluid during operation, the affected parts of the body must be rinsed with water (wash hands, rinse eyes)

- Work must generally be performed outside the danger zone. If work inside the danger zone is necessary, the user must define additional safety measures to ensure the safe protection of personnel.
- Switch off the robot controller and FSW controller and secure them (e.g. with a padlock) to prevent unauthorized persons from switching them on again. If it is necessary to carry out work with the robot controller and FSW controller switched on, the user must define additional safety measures to ensure the safe protection of personnel.

1.4.4 Manual mode

- In manual mode, the FSW spindle may only be operated with a closed guard.

1.4.5 Maintenance and repair

⚠ WARNING Risk of serious injuries or damage to property!

- The hydraulic fluid is under high pressure. Hydraulic fluid can be ejected from defective hoses or unions, causing severe injuries. Appropriate safety precautions must be taken:

  Personal protective equipment (e.g. protective gloves, safety footwear and long, closely fitting clothing) must be worn

⚠ WARNING Risk of serious injuries or damage to property!

- Contact with hydraulic oil or cooling fluid can cause injury:

  If a person comes into contact with hydraulic oil or cooling fluid during operation, the affected parts of the body must be rinsed with water (wash hands, rinse eyes)

Electrical compartments must only be opened using suitable and approved tools or a key.

- Work must generally be performed outside the danger zone. If work inside the danger zone is necessary, the user must define additional safety measures to ensure the safe protection of personnel.
- Switch off the robot controller and FSW controller and secure them (e.g. with a padlock) to prevent unauthorized persons from switching them on again. If it is necessary to carry out work with the robot controller and FSW controller switched on, the user must define additional safety measures to ensure the safe protection of personnel.

Tool/workpiece

The tool and workpiece must be removed before all maintenance, repair and cleaning work.

The FSW tool must be checked to ensure that it is fastened correctly, paying attention to any damage to the individual tool components.

Hazardous substances

The following safety measures must be implemented when handling cooling water:

- Avoid prolonged and repeated intensive contact with the skin.
- Avoid breathing in cooling water mist and vapors.
- Clean skin and apply skin cream.

⚠ WARNING Risk of serious injuries or damage to property!

- Glycol is added to the cooling water to prevent build-up of bacteria and viruses. Contact with cooling water can cause injuries.

  If a person comes into contact with cooling water or cooling water mist during operation, the affected parts of the body must be rinsed with water (wash hands, rinse eyes).

⚠ WARNING Risk of serious injuries or damage to property!

- It is imperative for the safety data sheet of the hydraulic oil to be observed.

NOTICE

- To ensure safe use of our products, we recommend that our customers regularly request up-to-date safety data sheets from the manufacturers of hazardous substances.

1.4.6 Decommissioning, storage and disposal

The FSW robot system must be decommissioned, stored and disposed of in accordance with the applicable national laws, regulations and standards.

1.4.7 Troubleshooting

The following safety measures must be implemented when troubleshooting on the FSW robot system:

- The tool and workpiece must be removed before troubleshooting.

⚠ WARNING Risk of serious injuries!

- The tool and workpiece can become very hot and cause burns on contact. If the tool is changed manually, suitable protective measures must be taken:

  Contact with the hands must be avoided.

  Personal protective equipment must be worn (e.g. protective gloves, safety footwear and long, closely fitting clothing)

⚠ WARNING Risk of serious injuries!

- The tool and workpiece have sharp edges that can cause injuries. Appropriate safety precautions must be taken:

  Hand contact must be avoided

  Personal protective equipment must be worn (e.g. protective gloves, safety footwear and long, closely fitting clothing)

- Work must generally be performed outside the danger zone. If work inside the danger zone is necessary, the user must define additional safety measures to ensure the safe protection of personnel.
- Switch off the robot controller and FSW controller and secure them (e.g. with a padlock) to prevent unauthorized persons from switching them on again. If it is necessary to carry out work with the robot controller and FSW controller switched on, the user must define additional safety measures to ensure the safe protection of personnel.

1.5 Standards and regulations

Name	Definition	Edition
2006/42/EC	Machinery Directive: Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)	2006
2014/30/EU	EMC Directive: Directive 2014/30/EU of the European Parliament and of the Council dated 26 February 2014 on the harmonization of the laws of the Member States relating to electromagnetic compatibility	2014
EN ISO 10218-1: 2011	Industrial robots: Safety Notice: Content equivalent to ANSI/RIA R.15.06-2012, Part 1	2011
EN ISO 12100: 2010	Safety of machinery: General principles of design, risk assessment and risk reduction	2010
EN ISO 13849-1: 2015	Safety of machinery: Safety-related parts of control systems; Part 1: General principles of design	2015
EN ISO 13849-2: 2012	Safety of machinery: Safety-related parts of control systems; Part 2: Validation	2012
EN ISO 13850: 2015	Safety of machinery: Emergency stop - Principles for design	2015
EN 60204-1:2006+A1:2009+AC:2010	Safety of machinery: Electrical equipment of machines; Part 1: General requirements	2009
EN ISO 14119:2013	Safety of machinery: Interlocking devices associated with guards; Principles for design and selection	2013

2 Application

2.1 Intended use

The FSW robot system is used for joining materials, such as aluminum, copper and their alloys, by means of friction stir welding. Other applications and materials must be approved by KUKA Deutschland GmbH in writing.

Permissible tools:

The welding tool must be designed in accordance with the process forces and temperatures as well as the performance data of the motor spindle. For correct connection of the welding tool to the motor spindle, see the operating instructions of the motor spindle.

Permissible clamping fixture:

The clamping fixture must be designed for the friction stir welding process.

⚠ WARNING Risk of death, serious injuries or damage to property

The partly completed machinery may only be used with a guard that is suitable for preventing expected hazards, such as death or injury.

When integrating the partly completed machinery, the system integrator must consider and comply with the standard for machine tools DIN EN 12417:2001+A1:2009/AC:2010.

⚠ WARNING Risk of serious injuries or damage to property

The standard tools must be adapted to the speed, temperature and feed rate.

The standard tools must have a dynamic balance of g = 2.5 (ISO 1940) at max. 5000 rpm as per the rating plate of the FSW spindle.

Tools that deviate from this must be calculated and approved in writing by KUKA. If non-approved tools or materials are used, this can result in material damage to the tool, FSW spindle or other components of the industrial robot.

Furthermore, the FSW tool must be checked regularly to ensure that it is fastened correctly, paying attention to any damage to the individual tool components.

⚠ CAUTION Fire hazard

Machining a non-approved material may result in ignition of the material. Only the material specified by KUKA may be processed.

2.2 Improper use (reasonably foreseeable misuse)

Any use or application deviating from the intended use is deemed to be misuse; examples of such misuse include:

- Machining of non-weldable substances or materials that exceed the maximum process parameters of the system
- Machining of non-approved materials, e.g. steel, titanium, wood, stone
- Use of non-approved tools
- Use outside the permissible operating parameters
- Use in potentially explosive environments
- Underground operation
- Outdoor use
- Use without suitable safeguards
- Transportation of persons and animals

3 Introduction

3.1 Documentation of the FSW robot system

The documentation of the FSW robot system consists of documents created by KUKA Deutschland GmbH and documentation from other manufacturers.

Documentation from KUKA Deutschland GmbH:

- Documentation for the manipulator
- Documentation for the robot controller
  - KR C4 operating instructions
  - Assembly and operating instructions of the optional interfaces for KR C4
- Documentation for the energy supply system
- KUKA System Software operating and programming instructions

Documentation from other manufacturers:

- Installation, operating and maintenance instructions for the recooling system
- Operating, installation and maintenance instructions for the FSW spindle

NOTICE

The FSW robot system may only be operated with the pre-installed FSW spindle.

NOTICE

The documentation from the component manufacturers must be read by the system integrator and the user. The safety instructions they contain must be taken into consideration in a risk assessment and must be observed.

3.2 Target group

This documentation is aimed at system integrators/system builders, system operators and users with the following knowledge and skills:

- Advanced KRL programming skills
- Advanced PLC programming skills
- Advanced knowledge of the robot controller system
- Advanced system knowledge of KUKA.PLC

NOTICE

The FSW robot system must be operated by trained personnel only.

NOTICE

For optimal use of our products, we recommend that our customers take part in a course of training at KUKA College. Information about the training program can be found at www.kuka.com or can be obtained directly from our subsidiaries.

3.3 Representation of warnings and notices

These warnings and notices are provided for safety purposes and **must** be observed.

DANGER Type of hazard

These warnings mean that death or severe physical injury **will** occur if no precautions are taken.

WARNING Type of hazard

These warnings mean that death or severe physical injury **may** occur if no precautions are taken.

CAUTION Type of hazard

These warnings mean that minor physical injury **may** occur, if no precautions are taken.

These warnings are preceded by a pictogram.
Examples:

Wear ear protectors

General warning sign

No smoking

***NOTICE* Type of hazard**

These warnings mean that damage to property **may** occur if no precautions are taken.

- **NOTICE**
  These notices may be:
  Tips to make work easier
  References to further information

3.4 Terms used

Term	Description
Axis range	Range of each axis, in degrees or millimeters, within which it may move. The axis range must be defined for each axis.
Stopping distance	Stopping distance = reaction distance + braking distance The stopping distance is part of the danger zone.
Workspace	The manipulator is allowed to move within its workspace. The workspace is derived from the individual axis ranges.
User	The user of the industrial robot can be the management, employer or delegated person responsible for use of the industrial robot.
HMI	Standard KUKA user interface for KRC robot controller.
CNC	Electronic control of machines.
CSP	Controller System Panel. Display element and connection point for USB and network
Ethernet	Bus system.
Power utility	Power supply company.
ES	Energy supply system
FSW	Friction stir welding
Risk assessment	The risk assessment includes the risk analysis, risk assessment, risk evaluation and implementation of the resulting measures.
Danger zone	The danger zone consists of the workspace and the stopping distances.
Main air, main air valve	The main air is the central air supply of the FSW controller. The main air valve can be used to shut off the air supply of the FSW robot system completely and centrally.
KRC	Robot controller (KUKA Robot Control)

Term	Description
KRL	KUKA Robot Language.
KSS	KUKA System Software.
Cooling air	Air flow for cooling the tool on the spindle head.
KUKA.PLC	Soft PLC integrated into the robot controller.
Manipulator	The robot arm and the associated electrical installations.
ProConOS	Runtime environment of KUKA.PLC
PPE	Personal protective equipment
Safeguarded zone	The safeguarded zone is situated outside the danger zone.
smartPAD	The smartPAD teach pendant has all the operator control and display functions required for operating and programming the industrial robot.
Sealing air	Counter-airflow which prevents swarf, particles, liquids and other materials from entering the cavities of the spindle.
PLC	Programmable logic controller.
Stop category 0	The drives are deactivated immediately and the brakes are applied. The manipulator and any external axes (optional) perform path-oriented braking. Notice: This stop category is called STOP 0 in this document.
Stop category 1	The manipulator and any external axes (optional) perform path-maintaining braking. The drives are deactivated after 1 s and the brakes are applied. **Notice:** This stop category is called STOP 1 in this document.
Stop category 2	The drives are not deactivated and the brakes are not applied. The manipulator and any external axes (optional) are braked with a normal braking ramp. **Notice:** This stop category is called STOP 2 in this document.
System integrator (Plant integrator)	System integrators are people who safely integrate the industrial robot into a complete system and commission it.
T1	Test mode, Manual Reduced Velocity (<= 250 mm/s).
T2	Test mode, Manual High Velocity (> 250 mm/s permissible).
External axis	Motion axis which is not part of the manipulator but which is controlled using the robot controller, e.g. FSW spindle, KUKA linear unit, turn-tilt table, Posiflex.

4 Product description

4.1 Overview of FSW robot system

The application module FSW Robot System for KR C4 includes components for installing a machine tool. The FSW controller contains the components for controlling the FSW spindle and the safety equipment. The components are pre-configured; connecting cables are supplied.

The FSW robot system consists of the following components:

- Industrial robot
  - Manipulator
  - Energy supply system A1-A6
  - Robot controller
  - smartPAD teach pendant
  - Connecting cables
  - Software
- Technology cabinet
  - FSW controller with hydraulic unit and pneumatic unit
  - Safety PLC with MGB gate switch (optional)
  - Recooling system
- FSW spindle (drive cabinet)
  - Force measuring sensors
  - Tool clamping system
  - Cooling
  - Force evaluation unit
- Seam position detection (optional)

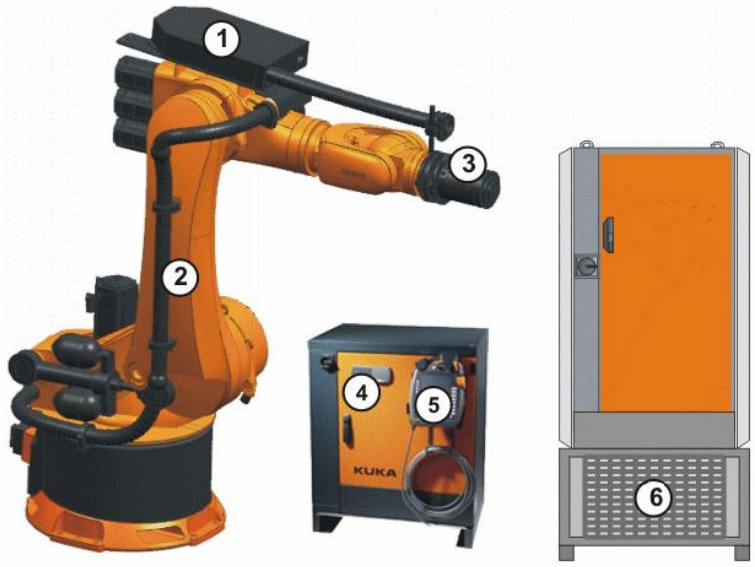

Fig. 4: Overview

1. Energy supply system
2. Manipulator
3. FSW spindle
4. KR C4 robot controller
5. KUKA smartPAD
6. Recooling system

4.2 Manipulator with energy supply system

Overview

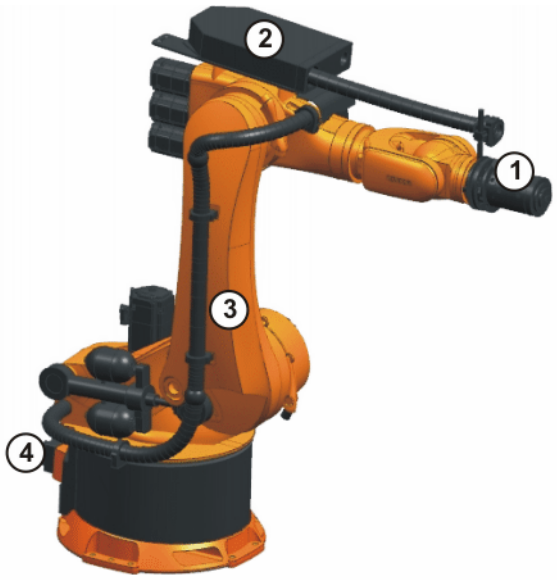

Fig. 5: Manipulator with energy supply system

1. FSW spindle
2. Energy supply system
3. Manipulator
4. Junction box and media panel on the base frame

- -

- **NOTICE**

  Further information about the robot (manipulator) KR 500 R2830 MT can be found in the KUKA assembly instructions for the KR 500 MT FORTEC; see Section 16.3.

Energy and fluids connections

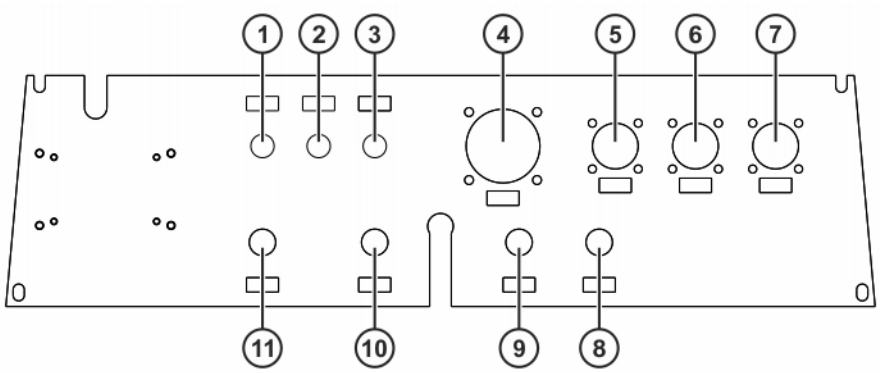

Fig. 6: Media connections on the base frame

1. Air: spindle head cooling
2. Air: spindle shaft clamping
3. Air: sealing air
4. Connections for motor and signal cables
5. Multibus connection X71
6. Control cable
7. Spare
8. Hydraulics: release tool
9. Hydraulics: clamp tool
10. Water: cooling, spindle motor, OUT
11. Water: cooling, spindle motor, IN

4.3 Description of energy supply system

Energy supply system

The following media are supplied to the FSW spindle via the energy supply system:

- Motor and signal cables for the FSW spindle
- Cooling water (supply and return) for the FSW spindle
- Air supply for spindle clamping
- Cooling air for the welding tool
- Air supply for sealing air
- 2x hydraulics for the tool clamping system
- Sensor cables for force evaluation

4.4 KR C4 robot controller

Overview

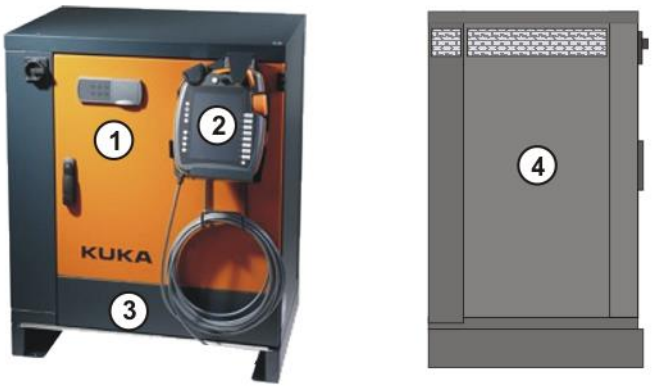

Fig. 7: Robot controller

1. KR C4 front view
2. smartPAD
3. Connection panel
4. Side view

- -

- **NOTICE**

  Information about the interfaces in the KR C4 connection panel can be found in the operating instructions “KR C4” and the assembly and operating instructions “Optional Interfaces for KR C4”.

Optional digital I/Os

Information about the digital I/O modules (16/16/4) can be found in the assembly and operating instructions “Optional Interfaces for KR C4”.

4.5 FSW spindle

Description

The FSW spindle is fastened to the flange of the manipulator by means of 6 Allen screws (M12).

With use of a 6D sensor, the FSW spindle is connected to the sensor via an adapter plate (8 M12 Allen screws). The 6D sensor is attached to the manipulator flange by means of an adapter.

The FSW spindle is controlled as a 7th robot axis by means of the KUKA Servo Pack (KSP) and cooled by means of water cooling.

The spindle motor has no brake winding; this is replaced by an inductance box. The inductance box must be connected to interface X7.1 on the robot controller.

The sensor and motor cables and the hydraulic and pneumatic hoses are routed through the energy supply system to the flange and connected to the spindle.

The FSW spindle has a mechanical clamping fixture and a hydraulic releasing fixture.

The FSW spindle is designed for tool location of type HSK.

WARNING **Risk of death, serious injuries or damage to property!**

- Use appropriate HSK tool holders and tighten clamping screws correctly to prevent ejection.

- -

NOTICE

Detailed information can be found in the operating, installation and maintenance instructions of the FSW spindle.

Overview

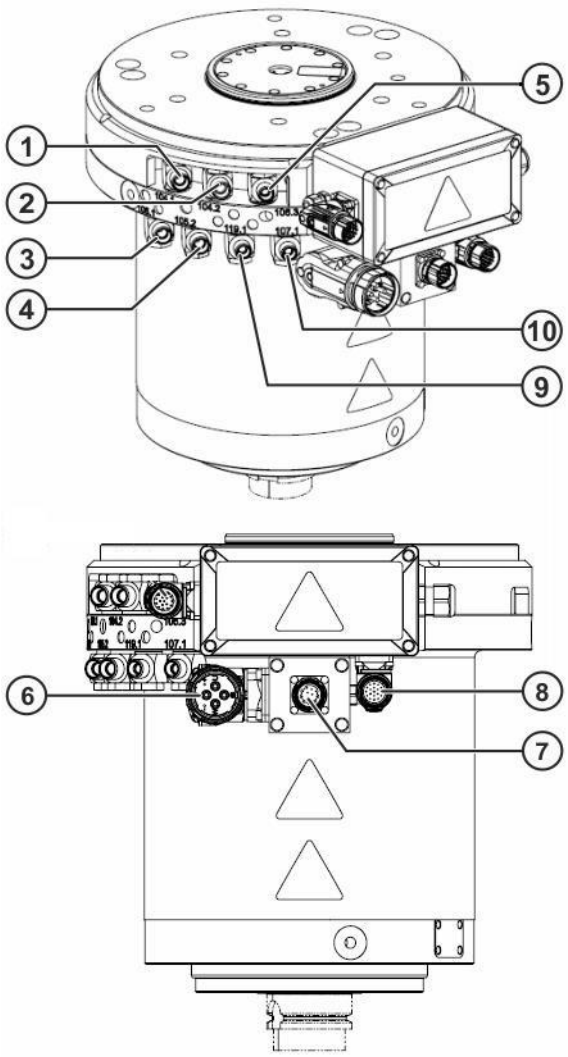

Fig. 8: FSW spindle

1. Hydraulic line for clamping the tool (104.1)
2. Hydraulic line for releasing the tool (104.2)
3. Motor cooling on (105.1)
4. Motor cooling off (105.2)
5. Power lead for spindle head cooling air (106.3)
6. Power connection for motor (101)
7. Motor temperature and encoder for spindle (102/103.1)
8. Tool clamping path monitoring and temperature switch (125.1)
9. Pneumatic line for spindle shaft clamping (119.1)
10. Pneumatic line for sealing air (107.1)

4.6 Technology cabinet

The technology cabinet consists of the following components:

- FSW controller
- Recooling system
- Hydraulic unit for the tool clamping system
- Pneumatic unit

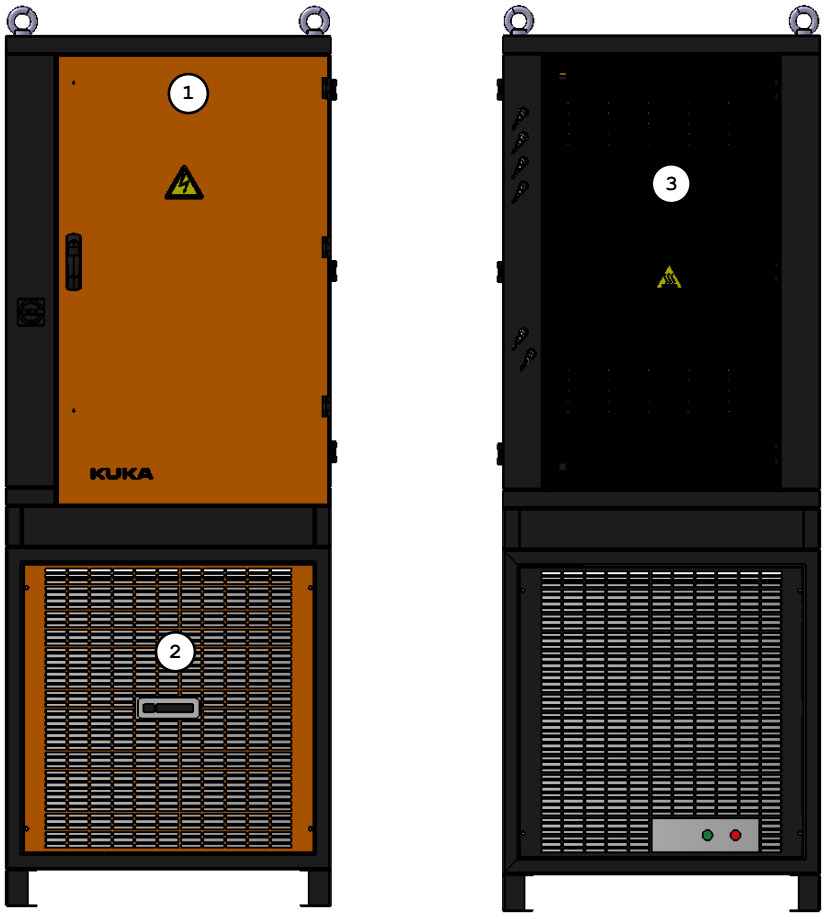

Fig. 9: Overview of technology cabinet

1. FSW controller, front view
2. Recooling system
3. FSW controller, rear view

4.6.1 FSW controller

Overview

- **NOTICE**
  See EPlan page “Mounting plate”

Connection panel

- **NOTICE**
  See EPlan page “Connector panel”

Hydraulic connections

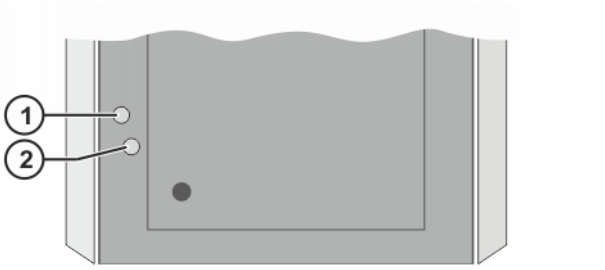

Fig. 10: FSW controller hydraulic connections

1. Hydraulic line for releasing the tool
2. Hydraulic line for clamping the tool

Pneumatic connections

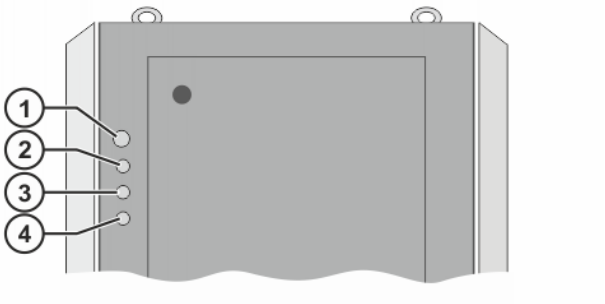

Fig. 11: FSW controller pneumatic connections

1. Air supply (IN), DN ½"
   Connection (KUKA side): WSV 15-L OMD CF (PARKER)
   Connection (customer side): 3C382-15-8 (PARKER)
2. Pneumatic line for spindle shaft clamping
3. Cooling air for spindle head
4. Sealing air

4.6.2 Hydraulic unit

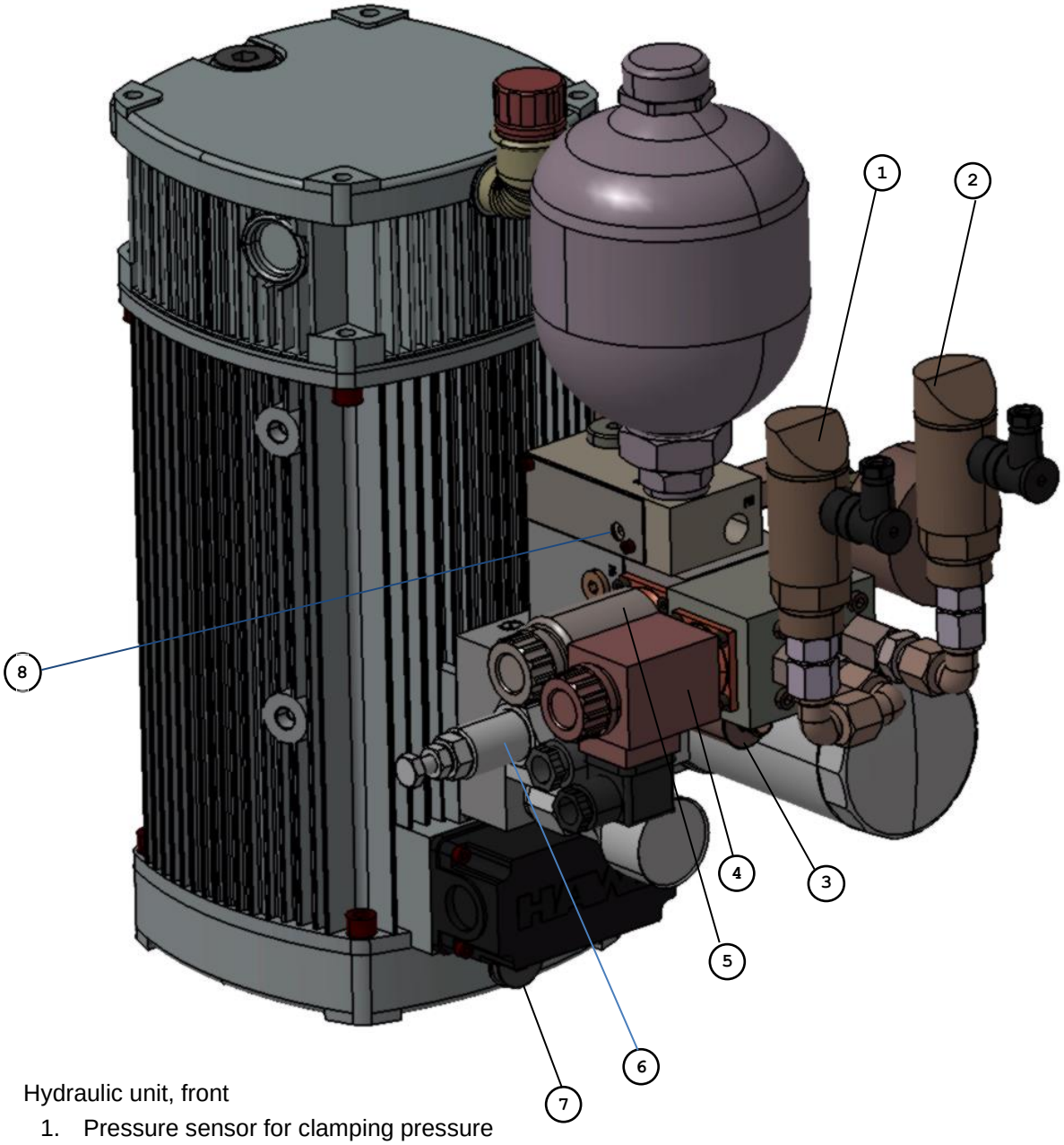

Fig. 12: Hydraulic unit, front

1. Pressure sensor for clamping pressure
2. Pressure sensor for release pressure
3. Pressure sensor for pump on/off
4. Valve: release tool
5. Valve: pressure enable, open
6. Pressure relief valve
7. Oil drain screw
8. Pressure relief valve with hexagon socket

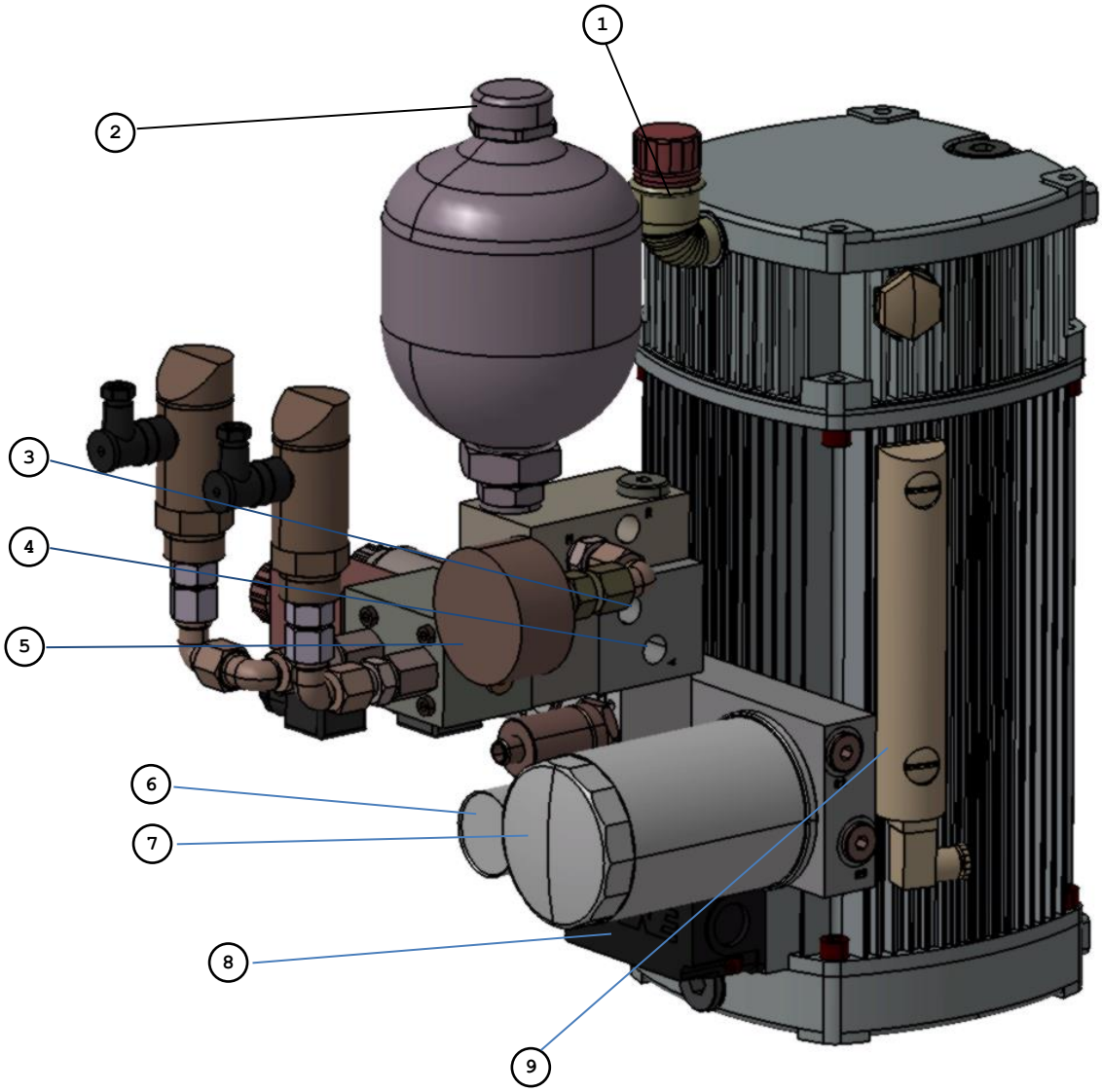

Fig. 13: Hydraulic unit, rear

1. Filling connection with ventilation filter
2. Accumulator with nitrogen connection
3. Connection for “Release” hose
4. Connection for “Clamp” hose
5. Manometer, system pressure
6. Filter clogging indicator
7. Return filter
8. Electrical connection for pump motor incl. temperature switch
9. Level indicator with float switch

-

NOTICE

Further information about the hydraulic unit is contained in the manufacturer documentation. The hydraulic unit documentation is part of the FSW spindle documentation.

NOTICE

For setting the hydraulic pressure values, see the hydraulic diagram.

4.6.3 Pneumatic unit

Overview of pneumatic connections

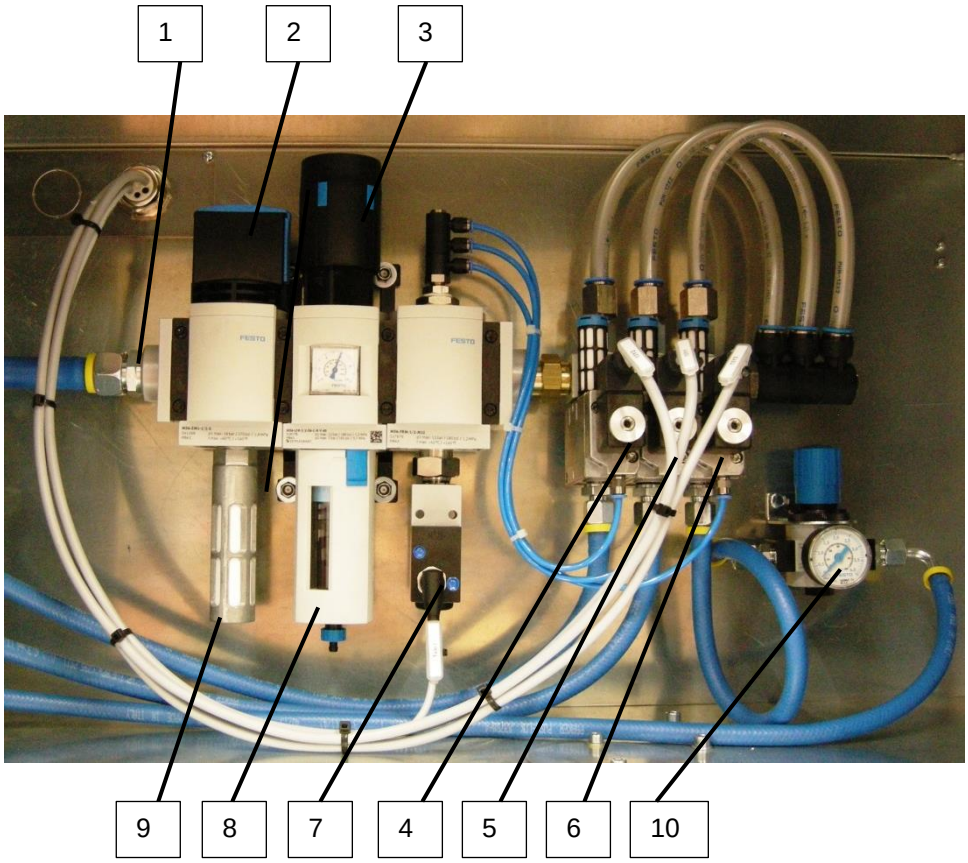

Fig. 14: Pneumatic unit in technology cabinet

1. Air IN
2. On-off valve, manual
3. Filter with pressure reducer and pressure gauge
4. Solenoid valve, clamping control, FSW spindle
5. Solenoid valve, overpressure/cooling, FSW spindle
6. Solenoid valve, sealing air
7. Pressure switch
8. Water drain & fine filter
9. Silencer

10. Sealing air pressure regulator

4.6.4 Recooling system

Description

The recooling system for water cooling of the FSW spindle is installed beneath the FSW controller. Regulation of the recooling system is performed by temperature sensors.

Overview

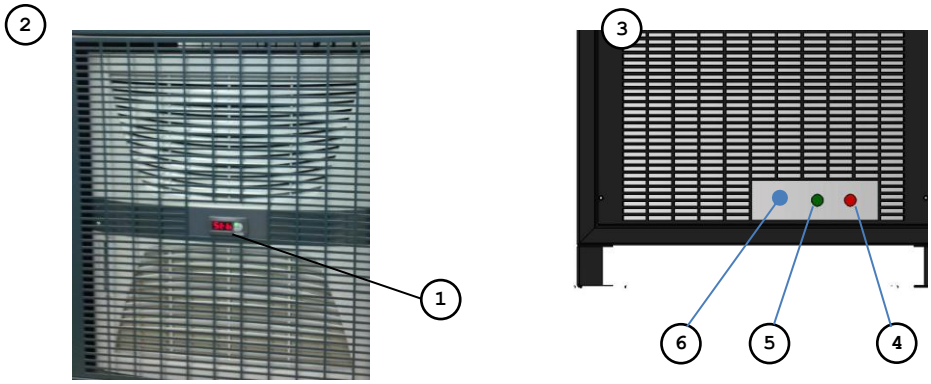

Fig. 15: Recooling system

1. Display
2. Front view
3. Rear
4. Coolant return
5. Coolant supply
6. Tank drain connection

- -

- **NOTICE**

  Further information can be found in the installation, operating and maintenance instructions of the recooling system.

4.7 Seam position detection (optional)

Description

Laser detection of the seam positions enables automatic compensation of component tolerances.

Overview

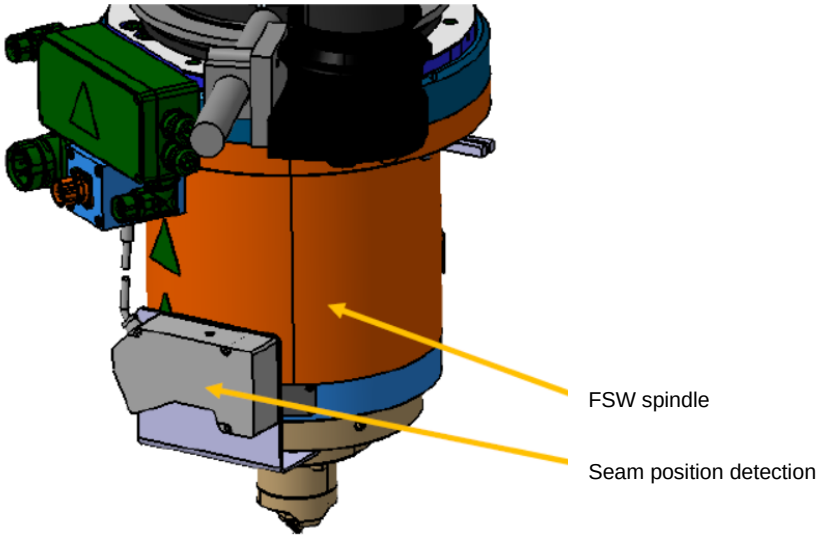

Fig. 16: Overview of seam position detection

5 Technical data

5.1 Principal data

FSW controller

Rated voltage	3 x 400 V AC / 3 x 460 V AC (±10%)
Control voltage	24 V DC
Rated frequency	50 Hz / 60 Hz
Mains-side fusing	min. 3 x 16 A, slow-blowing
Loop impedance (system impedance up to the connection point of the FSW controller)	≤ 200 mΩ
Weight	200 kg
Protection rating	IP 54

Ambient temperature in operation	+15 ... 35 °C (288 ... 308 K)
Rate of change of temperature	max. 1.1 K/min
Humidity class	3k3 to DIN EN 60721-3-3; 1995
Altitude	up to 1000 m above mean sea level without derating

-

Compressed air	min. 6 bar
Air filter	5 µm, oil-free

Manipulator

- **NOTICE**

  Further information is contained in the operating and assembly instructions for the manipulator.

Robot controller

The power supply ratings can be found in the robot controller operating instructions.

- **NOTICE**

  Further information is contained in the operating instructions for the robot controller.

FSW spindle

Spindle type	FSW3
Weight	115 kg
Max. speed	5000 rpm
Torque	51 Nm
Tightening torque (attachment to robot/adapter flange)	130 Nm

- **NOTICE**

  Detailed information can be found in the operating, installation and maintenance instructions of the FSW spindle.

Recooling system

- **NOTICE**

  Further information can be found in the installation, operating and maintenance instructions of the recooling system.

Hydraulic unit

Power	0.75 kW
Power	2.1 A
Operating voltage	400 V/460 V, 50/60 Hz
Control voltage	24 V DC
Operating pressure (clamp tool)	5 – 48 bar
Operating pressure (release tool)	38 – 48 bar
Safety valve pressure	85 bar

5.2 Technology cabinet

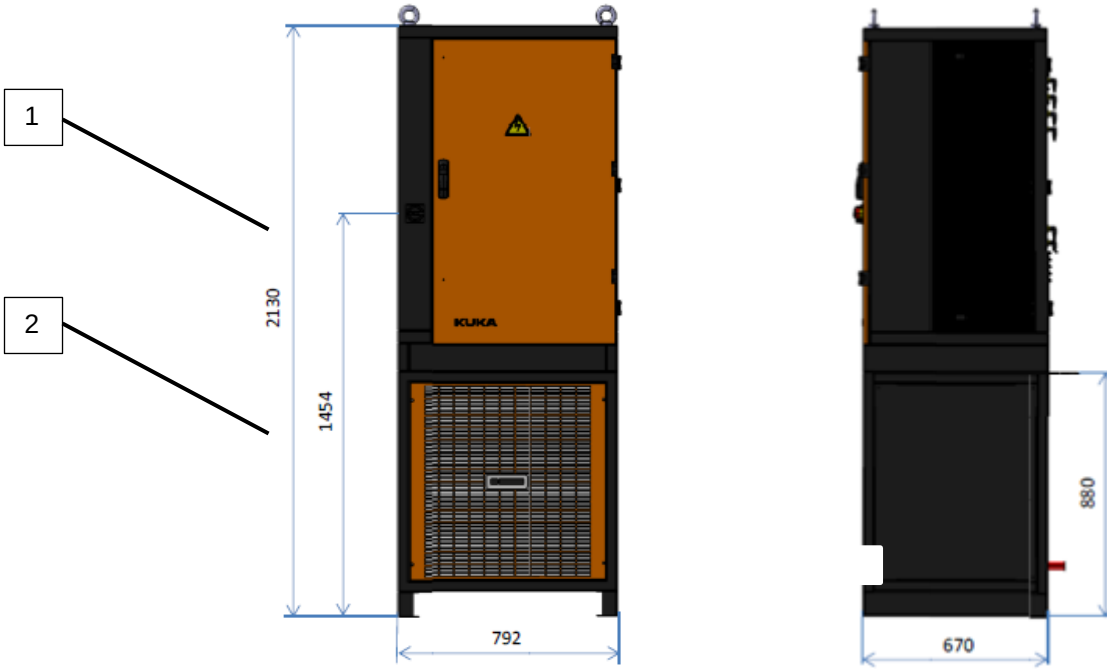

Fig. 17: Dimensions (in mm)

1. FSW controller
2. Recooling system

5.3 Technology cabinet minimum clearances

The minimum clearances that must be maintained for the technology cabinet are indicated in the diagram.

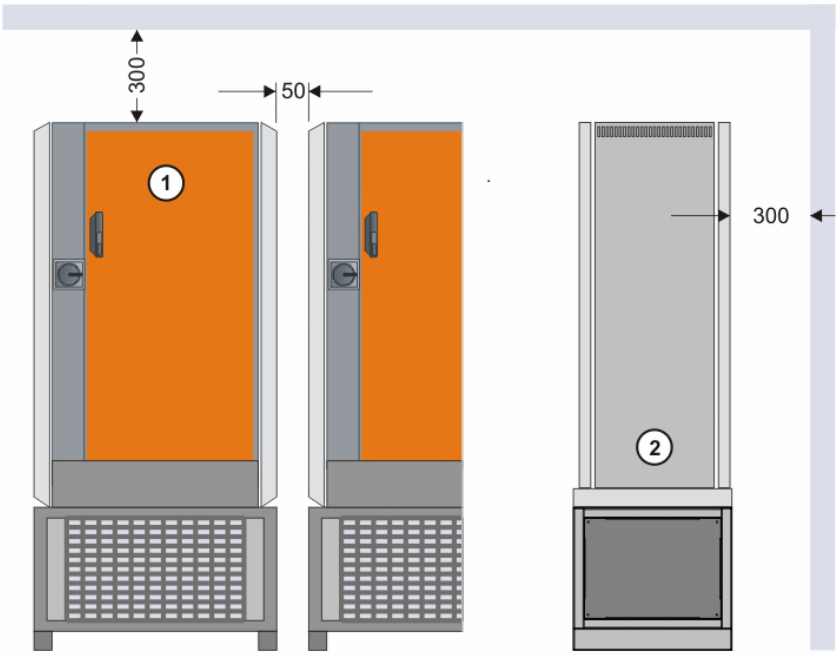

Fig. 18: Minimum clearances (in mm)

1. Front view
2. Side view

- **NOTICE** **Risk of damage!**

  If the minimum clearances are not maintained, this can result in damage to the FSW controller. The specified minimum clearances must always be observed.

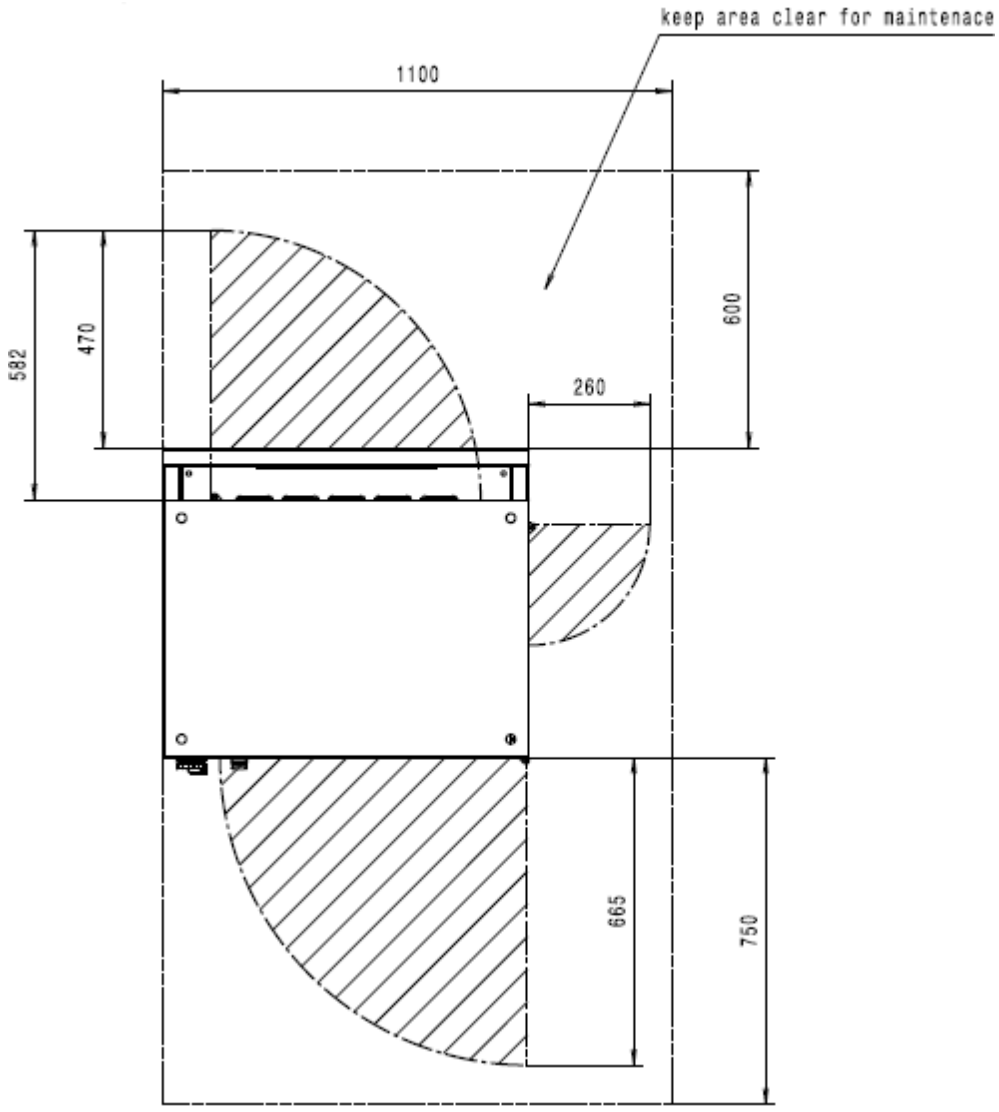

Fig. 19: Turning radii of technology cabinet doors (in mm)

5.4 Plates and labels

The following plates and labels are attached to the technology cabinet. They must not be removed or rendered illegible. Illegible plates and labels must be replaced.

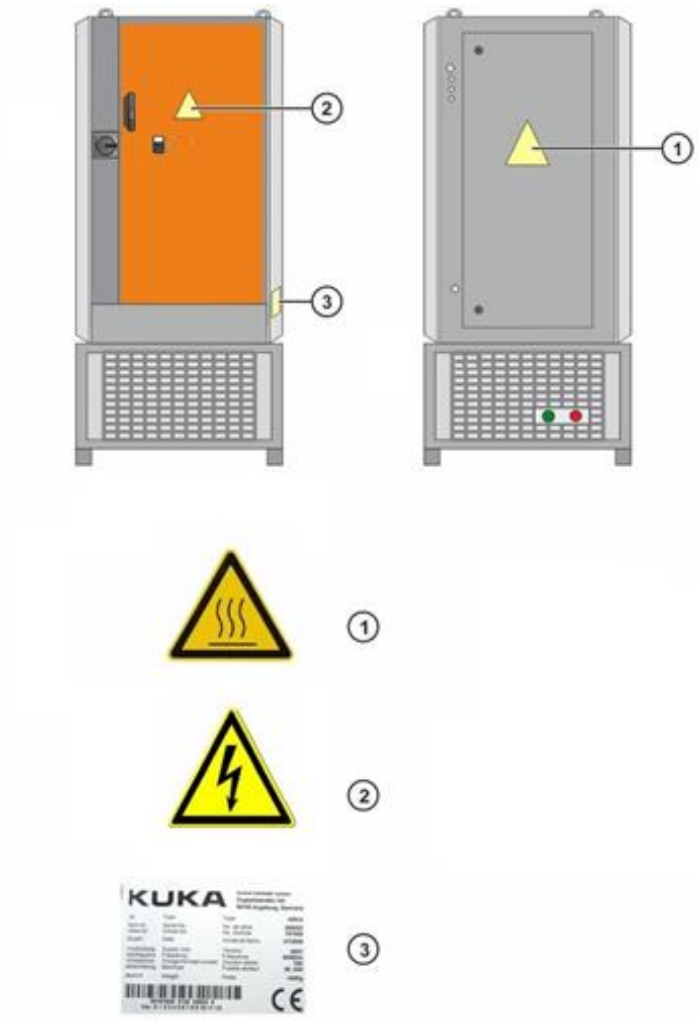

Fig. 20: Plates and labels on technology cabinet

- **NOTICE**

  The plates may vary slightly from the examples illustrated depending on the specific cabinet type or as a result of updates.

Plate no.	Designation
1	Hot surface warning sign
2	Hazardous voltage warning sign
3	FSW controller identification plate

FSW spindle

The following plates and labels are attached to the FSW spindle. They must not be removed or rendered illegible. Illegible plates and labels must be replaced.

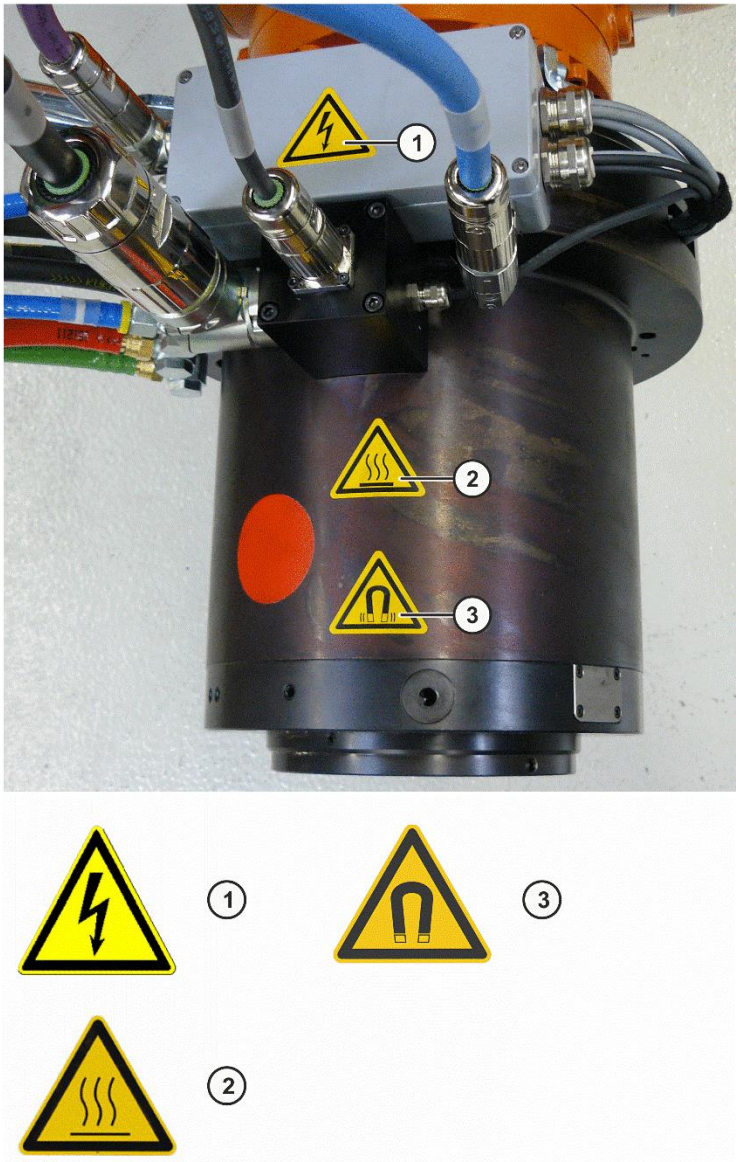

Fig. 21: Plates and labels on FSW spindle

Plate no.	Designation
1	Hazardous voltage warning sign
2	Hot surface warning sign
3	Magnetic field warning sign

Seam position detection (optional)

The following plate is attached to the seam position detection. It must not be removed or rendered illegible. Illegible plate must be replaced.

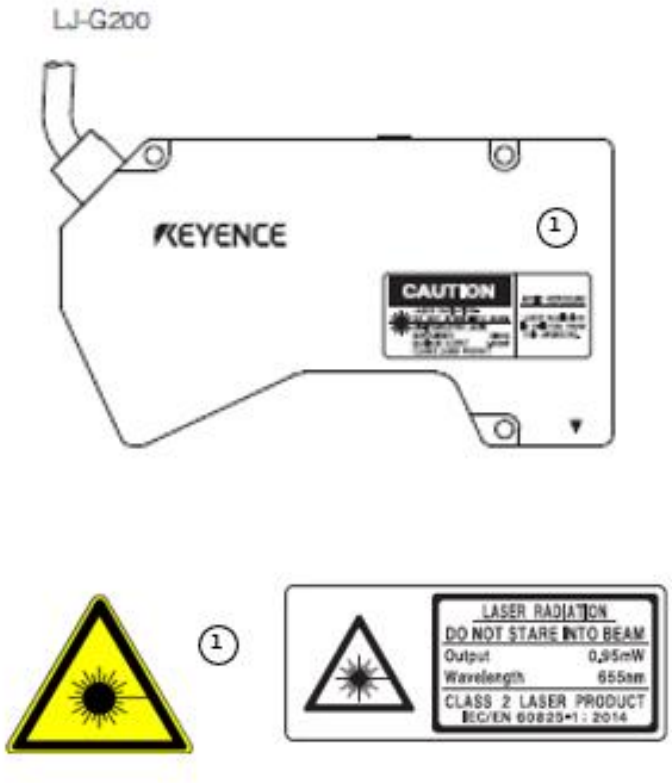

Fig. 22: Plate on the seam position detection

Plate no.	Designation
1	Laser radiation warning sign (Class 2 Laser)

- **NOTICE**

  For further information on warning signs and safety symbols, please refer to the safety layout, see Section 16.2.

5.5 Dimensions of holes for floor mounting of technology cabinet

The dimensions of the holes for floor mounting are indicated in the diagram.

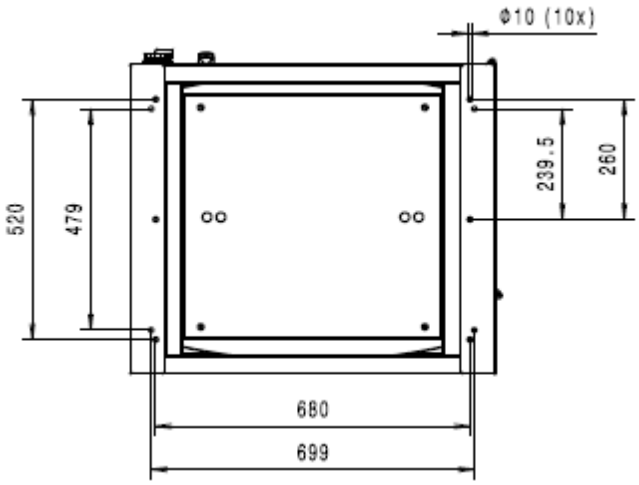

Fig. 23: Dimensions of holes for floor mounting, view from below

6 Planning

6.1 System integrator

The system integrator is responsible for integrating the following higher-level safety devices:

- External EMERGENCY STOP circuits
- Guard
- Safety gates
- The system integrator must ensure that the safety gates can only be opened if the motor spindle is no longer turning. Integrate a timer into the safety PLC in case of a de-energized robot/-controller fault.
- Cell controller, higher-level cell controller if applicable
- Safety light barriers, light curtains
- Connection of the individual components
- Creation of a grounding concept

6.2 System planning – FSW robot system

6.2.1 Installation site

Manipulator

When planning the system, it must be ensured that the installation site has the required grade and thickness of concrete and load-bearing capacity. The requirements on the mounting base are described in the manipulator specifications.

Robot controller

- It is imperative to comply with the minimum clearances of the robot controller from walls, cabinets and other system components in accordance with the technical data of the robot controller.
- The robot controller may only be installed outside the guard.

FSW controller

- It is imperative to comply with the minimum clearances of the FSW controller from walls, cabinets and other system components.
- The FSW controller may only be installed outside the guard.

6.2.2 Clamping fixture design

The user must design the clamping fixture in accordance with the friction stir welding process.

6.2.3 Operation in SME workshop

If the system is to be used in an SME workshop and connected to the public mains, approval must be received from the power utili

6.2.4 Noise protection

Assessment of the noise exposure depends on the materials to be machined.

The noise exposure must be considered by the user in a risk assessment.

⚠ CAUTION Health hazard due to noise!

- Depending on the materials used, the welding operation may cause considerable noise. This noise can cause damage to health.

  Take suitable measures to protect against noise.

6.2.5 Extraction system

The user must determine in a risk assessment what fume extraction, if any, is required.

⚠ CAUTION Health hazard due to dust and vapors!

- Depending on the materials used, the welding operation may generate large quantities of dust. If this dust comes into contact with hot surfaces, this can result in hazardous vapors. Inhalation of these vapors and dust can cause damage to health.

  Take suitable measures to protect against dust and vapors (fume extraction).

6.3 Installation conditions for robot and FSW controllers

The robot controller and the FSW technology cabinet may only be installed outside the safety fence or guard.

The connecting cables and hoses must be routed in such a way (e.g. cable ducts) as to prevent the risk of tripping. The system integrator and the operator must consider the hazard in a risk assessment. Where there is a risk of tripping, this must be marked accordingly.

6.4 Guard

The workspace of the manipulator must be protected by a guard.

The guard must meet the following requirements and be designed by the system integrator:

- It must not be possible for the tool to be ejected from the safeguarded area.
- It must not be possible for unauthorized persons to enter.

The following regulations must be observed and complied with.

- DIN EN ISO 12100 Safety of machinery – General principles for design – Risk assessment and risk reduction
- DIN EN 12417:2001+A1:2009/AC2010 Machine tools - Safety - Machining centers
- DIN EN ISO 13857:2008 Safety of machinery (Safety distances)
- DIN EN 14120:2015 Safety of machinery (Guards)

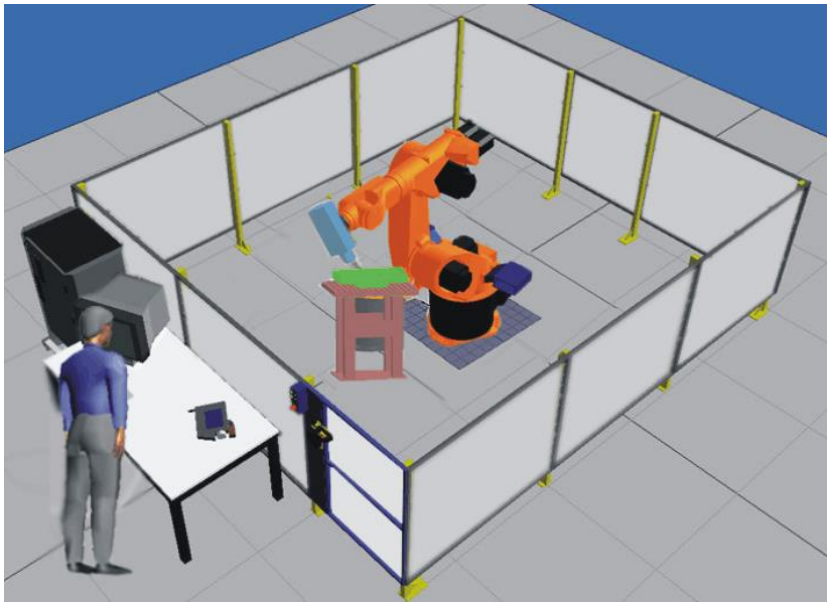

Fig. 24: Example: Guard

In accordance with the required occupational safety and risk assessment, the system integrator must attach warnings to the guard (e.g. “PPE must be worn”, “No entry for unauthorized persons”, etc.).

- **NOTICE**

  The guard is not part of the application module and must be erected by the user.

6.5 Grounding the tool

The tool is not included in the scope of supply. The FSW spindle chuck is not conductive. The tools are not grounded via the FSW spindle. If the user uses materials that can generate a static charge during machining, the tool must be grounded by attaching a slip ring or similar device.

A measurement on a connected mains power supply must be carried out in accordance with EN 60204-1, Section 18. Measurement using measuring equipment in accordance with EN 61557-3 (System impedance).

6.6 Connection example for grounding concept

The grounding concept must be taken into consideration and designed by the user.

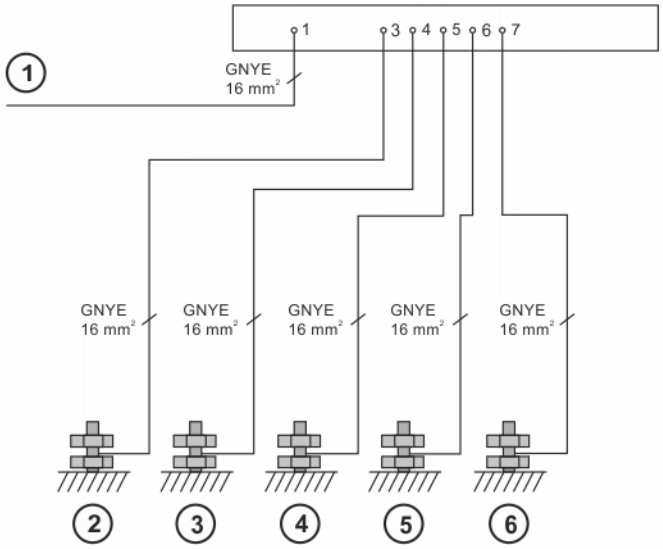

Fig. 25: Grounding concept (example)

1. Equipotential bonding rail, shop
2. Equipotential bonding connection, manipulator
3. Equipotential bonding connection, KR C4
4. Equipotential bonding connection, technology cabinet
5. Equipotential bonding connection, e.g. floor frame
6. Equipotential bonding connection, e.g. worktable, tool rack, tool changer

6.7 Performance Level

The safety functions of the safety gates and the EMERGENCY STOP circuit conform to category 3 and Performance Level (PL) d according to EN ISO 13849-1.

7 Transportation

7.1 Transporting the technology cabinet with lifting tackle

Precondition

- The FSW controller must be switched off.
- The cooling circuit of the recooling system is empty and the connections have been closed.
- The hydraulic circuit is empty and the connections have been closed.
- No cables may be connected to the FSW controller or technology cabinet.
- The door of the FSW controller must be closed.
- The technology cabinet must be upright.

Necessary equipment

- Lifting tackle with or without lifting frame

Procedure

1. Attach the lifting tackle with or without a lifting frame to all 4 transport eyebolts on the FSW controller.

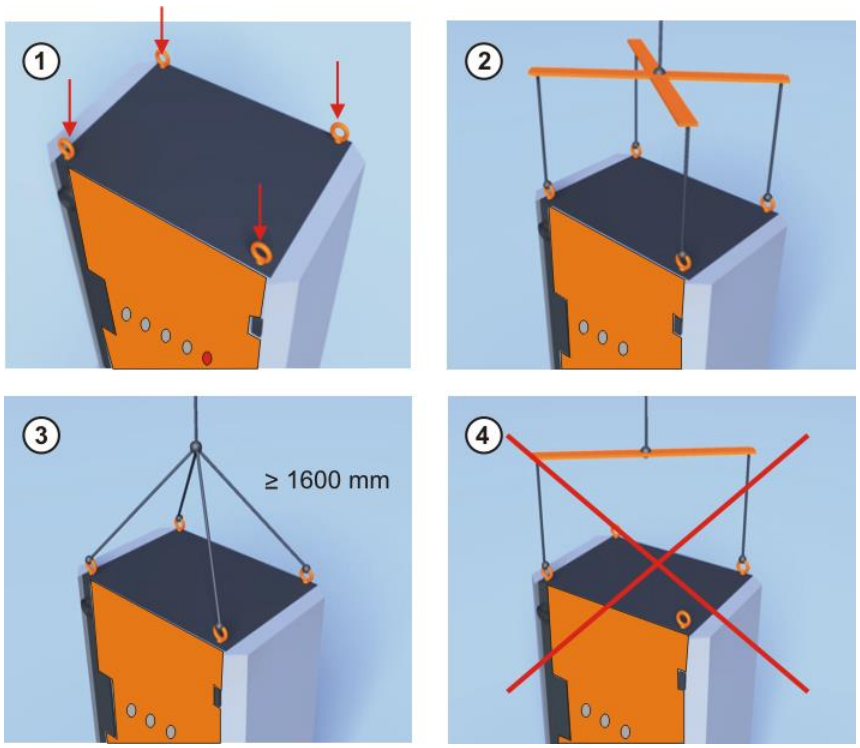

Fig. 26: Transportation using lifting tackle

1. Transport eyebolts on the technology cabinet
2. Correctly attached lifting tackle
3. Correctly attached lifting tackle
4. Incorrectly attached lifting tackle

2. Attach the lifting tackle to the crane.

⚠ CAUTION Risk of injuries or damage to property!

If the suspended technology cabinet is transported too quickly, it may swing and cause injury or damage.

Transport the technology cabinet slowly.

3. Slowly lift and transport the technology cabinet.
4. Slowly lower the technology cabinet at its destination.
5. Detach the lifting tackle from the technology cabinet.

7.2 Transporting the technology cabinet by fork lift truck / pallet truck

Precondition

- The FSW controller must be switched off.
- The cooling circuit of the recooling system is empty.
- No cables may be connected to the FSW controller or technology cabinet.
- The door of the FSW controller must be closed.
- The technology cabinet must be standing upright on a transport frame (e.g. pallet) that can be picked up using a fork lift truck or pallet truck.
-

Procedure

1. Pick up and transport the technology cabinet using a fork lift truck or pallet truck.

8 Operation

8.1 Operator control and display elements

Overview

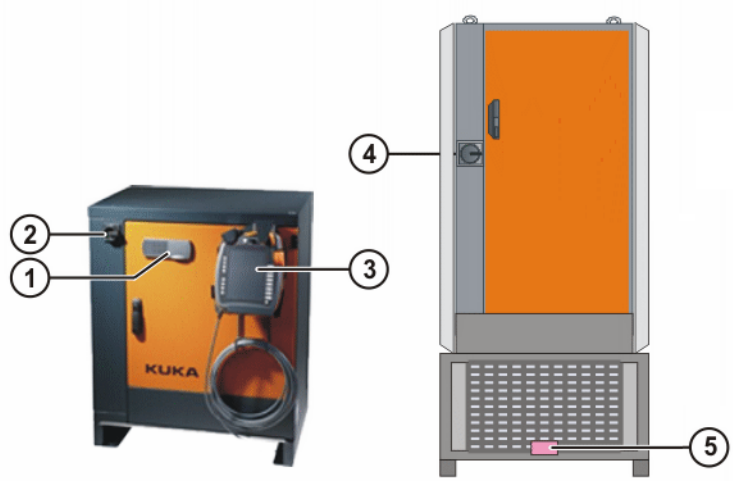

Fig. 27: Operator control and display elements

1. Controller System Panel (CSP)
2. Main power switch of robot controller
3. KUKA smartPAD
4. Main switch of FSW controller
5. Operator control and display elements for recooling system

8.2 Start-up after an EMERGENCY STOP

Description

The following EMERGENCY STOP devices can be found on the FSW robot system:

- EMERGENCY STOP device on the smartPAD.
- EMERGENCY STOP device on MGB gate switch (optional).

If an EMERGENCY STOP device is pressed, the FSW robot system is stopped under servo control.

Precondition

- The EMERGENCY STOP device has been pressed.

Procedure

1. Check and eliminate the situation that led to the EMERGENCY STOP.
2. Release the EMERGENCY STOP device on the smartPAD or on the MGB gate switch (optional).
3. Acknowledge the EMERGENCY STOP on the smartPAD.
4. The FSW robot system resumes the program.

8.3 Deactivating and activating operator safety (with the optional safety PLC)

Description

The inputs are used for monitoring and locking the safety equipment. Safety equipment, such as safety gates, can be connected to the dual-channel input. If nothing is connected to this input, operation in Automatic mode is not possible. Operator safety is not active for test modes T1 and T2. The spindle cannot be operated with the operator safety open.

Procedure

1. Press the illuminated pushbutton on the MGB switch and wait until the robot has enabled the cell.
2. Enter the system and rectify the fault.
3. Exit the system again and make sure no-one remains within the safeguarded zone.
4. Acknowledge the safety gate on the MGB switch and restart the robot via “Auto Start”.

8.4 HMI user interface main window

The application-specific visualization (HMI FSW) runs parallel to the standard KUKA visualization (KUKA.HMI) on the control panel of the robot controller (KUKA smartPAD).

Overview

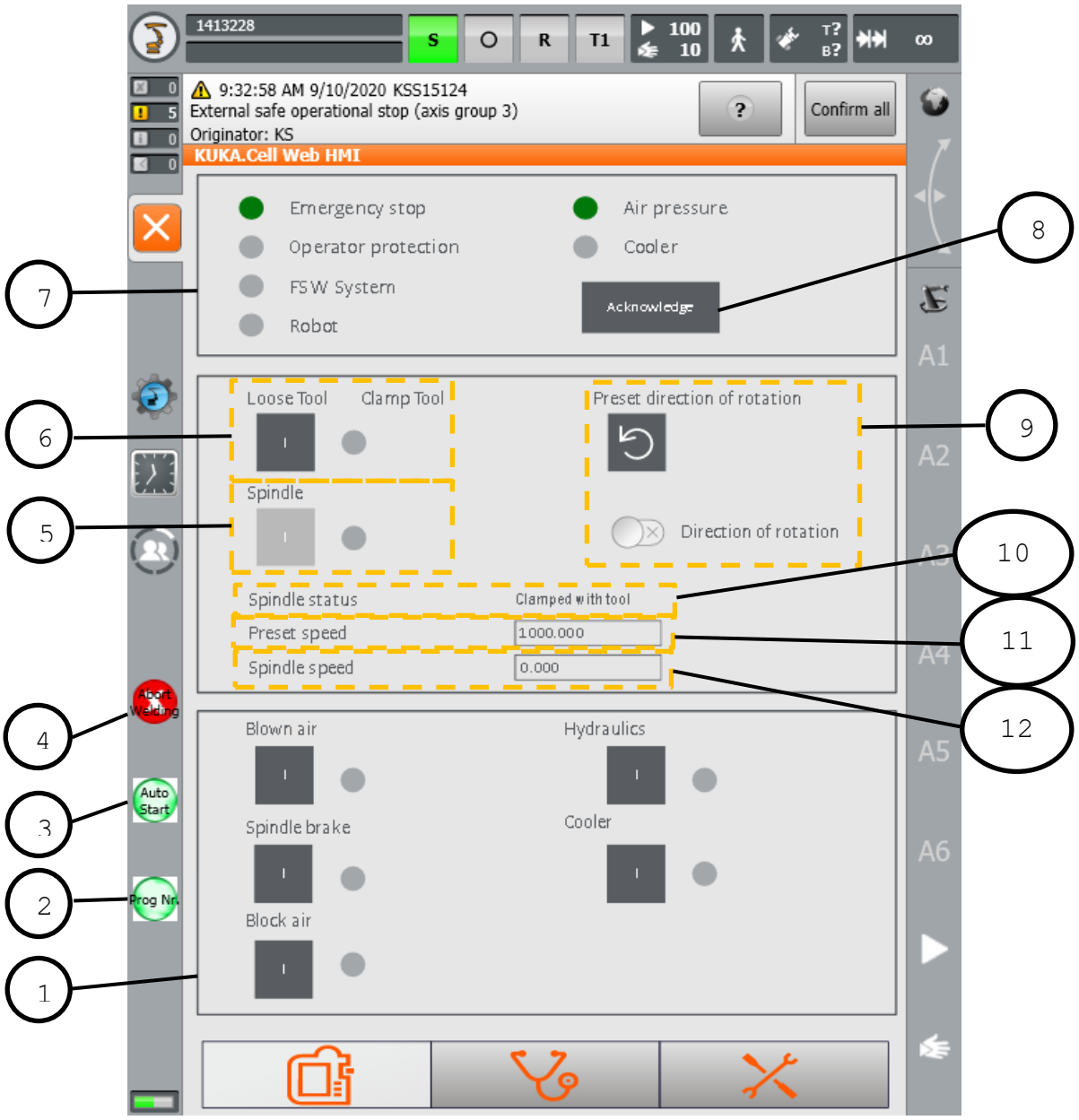

Fig. 28: Overview

Item	Button/LED	Description
1	Blown air I/O	Spindle head cooling on/off
	LED	■ green: blown air is switched on. ■ gray: blown air is switched off.
	Spindle brake I/O	Clamping on/off
	LED	■ green: clamping is switched on. ■ gray: clamping is switched off.
	Block air I/O	Sealing air on/off
	LED	■ green: blown air is switched on. ■ gray: blown air is switched off.
	Hydraulics I/O	Hydraulic system on/off
	LED	■ green: hydraulic system is switched on. ■ gray: hydraulic system is switched off.
	Cooler I/O	Switch cooler on/off
	LED	■ green: chiller is running. ■ gray: chiller is switched off.
2	Prog Nr.	Request program number from higher-level controller
3	Auto Start	Issue start command to higher-level controller
4	Abort Welding	Cancel the welding operation
5	Spindle I/O	Switch spindle on/off
	LED	■ green: spindle is running. ■ gray: spindle is not running.
6	Loose Tool / Clamp Tool I/O	Release the tool from the spindle or clamp the tool
	LED	■ green: tool is clamped. ■ gray: tool is released.
7	LED	■ EMERGENCY STOP red: EMERGENCY STOP is pressed. green: EMERGENCY STOP is not pressed. Operator protection red: operator protection is active. green: operator protection is not active. ■ FSW system green: FSW system is ready. gray: FSW system is not ready. ■ Robot

Item	Button/LED	Description
		green: robot is ready. gray: robot is not ready. ■ Air pressure green: air pressure present. gray: air pressure not present. ■ Cooler red: chiller fault. green: chiller is ready. gray: chiller is not ready.
8	Acknowledge	All FSW system error messages are acknowledged (no manipulator messages).
9	Direction of rotation	Direction of spindle rotation ■ Counterclockwise  ■ Clockwise 
10	Spindle status	State of spindle ■ Clamped with tool ■ Clamped without tool ■ Open
11	Preset speed Keypad opens	Entry of spindle speed
12	Spindle speed	Display of spindle speed rpm

- **NOTICE**

  The rotation and spindle speed parameters on this user interface apply to manual mode. For the welding program, these parameters must be set on the “Welding Parameters” user interface (see Section 8.4.2).

8.4.1 Spindle periphery

Overview

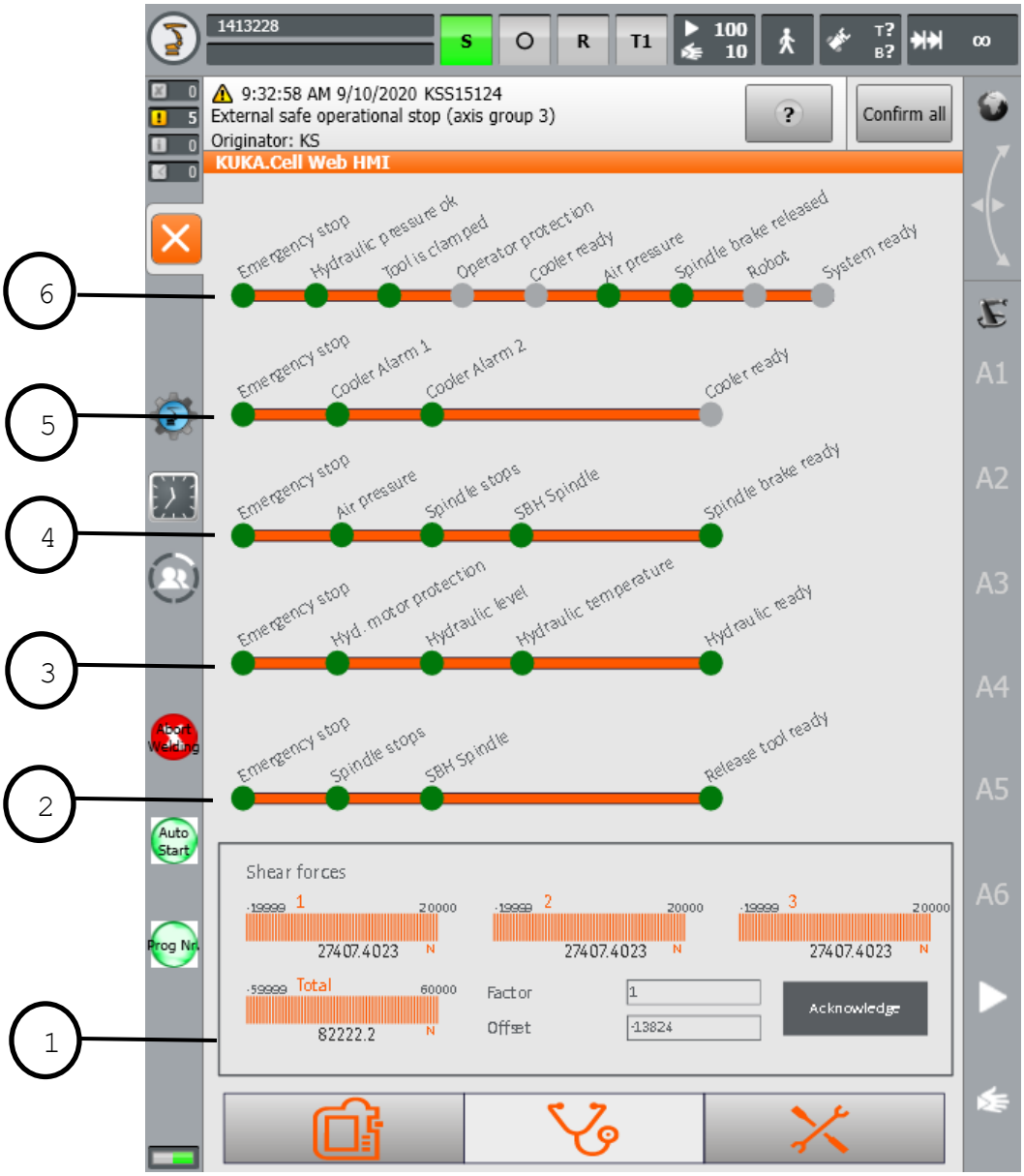

Fig. 29: Spindle

Item	Button/LED	Description
1	Shear forces	
	1,2,3	Display of pressure sensors 1 to 3 in N
	Indicator bar	■ red: pressure is too high. ■ green: pressure is OK.
	Total	Display of total sum of pressure sensors in N
	Indicator bar	■ red: total pressure is too high. ■ green: total pressure is OK.
	Factor	Conversion factor for adaptation of pressure level display on hardware
	Offset	Offset for adaptation of pressure level display on hardware (Raw pressure value from sensor x Factor + Offset = Value on HMI)
2	LED	Process sequence for tool change ■ **Emergency Stop** ▪ red: EMERGENCY STOP is pressed. ▪ green: EMERGENCY STOP is not pressed. ■ **Spindle stops** ▪ green: spindle is stationary. ▪ gray: spindle is rotating. ■ **SBH Spindle** ▪ red: SBH spindle fault ▪ green: no SBH spindle fault ■ **Release tool ready** ▪ green: tool enabling is ready. gray: tool enabling is not ready.
3	LED	Process sequence for hydraulic system ■ **Emergency Stop** ▪ red: EMERGENCY STOP is pressed. ▪ green: EMERGENCY STOP is not pressed. ■ **Hydraulic unit motor circuit-breaker** ▪ green: hydraulic unit motor circuit-breaker OK ▪ gray: hydraulic unit motor circuit-breaker has tripped ■ **Hydraulic level** ▪ green: hydraulic level is OK. ▪ gray: hydraulic level is too low.

Item	Button/LED	Description
		■ **Hydraulic temperature** ▪ green: hydraulic temperature is OK. ▪ gray: hydraulic temperature is too high. ■ **Hydraulic pressure** ▪ green: hydraulic pressure is present. ▪ gray: hydraulic pressure is not present. ■ **Hydraulic ready** ▪ green: hydraulic system is ready. ▪ gray: hydraulic system is not ready.
4	LED	Process sequence for main air ■ **Emergency Stop** ▪ red: EMERGENCY STOP is pressed. ▪ green: EMERGENCY STOP is not pressed. ■ **Air pressure** ▪ green: air pressure present. ▪ gray: air pressure not present. ■ **Spindle stops** ▪ green: spindle is stationary. ▪ gray: spindle is rotating. ■ **SBH Spindle** ▪ green: SBH spindle OK ▪ gray: SBH spindle not OK ■ **Spindle brake ready** ▪ green: clamping is ready. ▪ gray: clamping is not ready.
5	LED	Process sequence for cooler ■ **Emergency Stop** ▪ red: EMERGENCY STOP is pressed. ▪ green: EMERGENCY STOP is not pressed. ■ **Cooler Alarm 1** ▪ red: chiller has fault 1. ▪ green: no chiller fault 1. ■ **Cooler Alarm 2** ▪ red: chiller has fault 2. ▪ green: no chiller fault 2. ■ **Cooler ready** ▪ green: chiller is ready. ▪ gray: chiller is not ready.

Item	Button/LED	Description
6	LED	Process sequence for spindle ■ **Emergency Stop** ▫ red: EMERGENCY STOP is pressed. ▫ green: EMERGENCY STOP is not pressed. ■ **Hydraulic pressure OK** ▫ red: hydraulic system has fault. ▫ green: no hydraulic system fault. ▫ gray: hydraulic system switched off, therefore hydraulic system not active. ■ **Tool is clamped** ▫ green: tool is clamped correctly. ▫ gray: tool is not clamped. ■ **Operator protection** ▫ green: gates are locked. ▫ gray: gates are not locked. ■ **Cooler ready** ▫ green: chiller is ready. ▫ gray: chiller is not ready. ■ **Air pressure** ▫ green: air pressure present. ▫ gray: air pressure not present. ■ **Spindle brake released** ▫ green: spindle shaft is not braked. ▫ gray: spindle shaft is braked. ■ **Robot** ▫ green: robot is ready. ▫ gray: robot is not ready. ■ **System ready** ▫ green: spindle is ready. ▫ gray: spindle is not ready.

8.4.2 Welding parameters

Overview

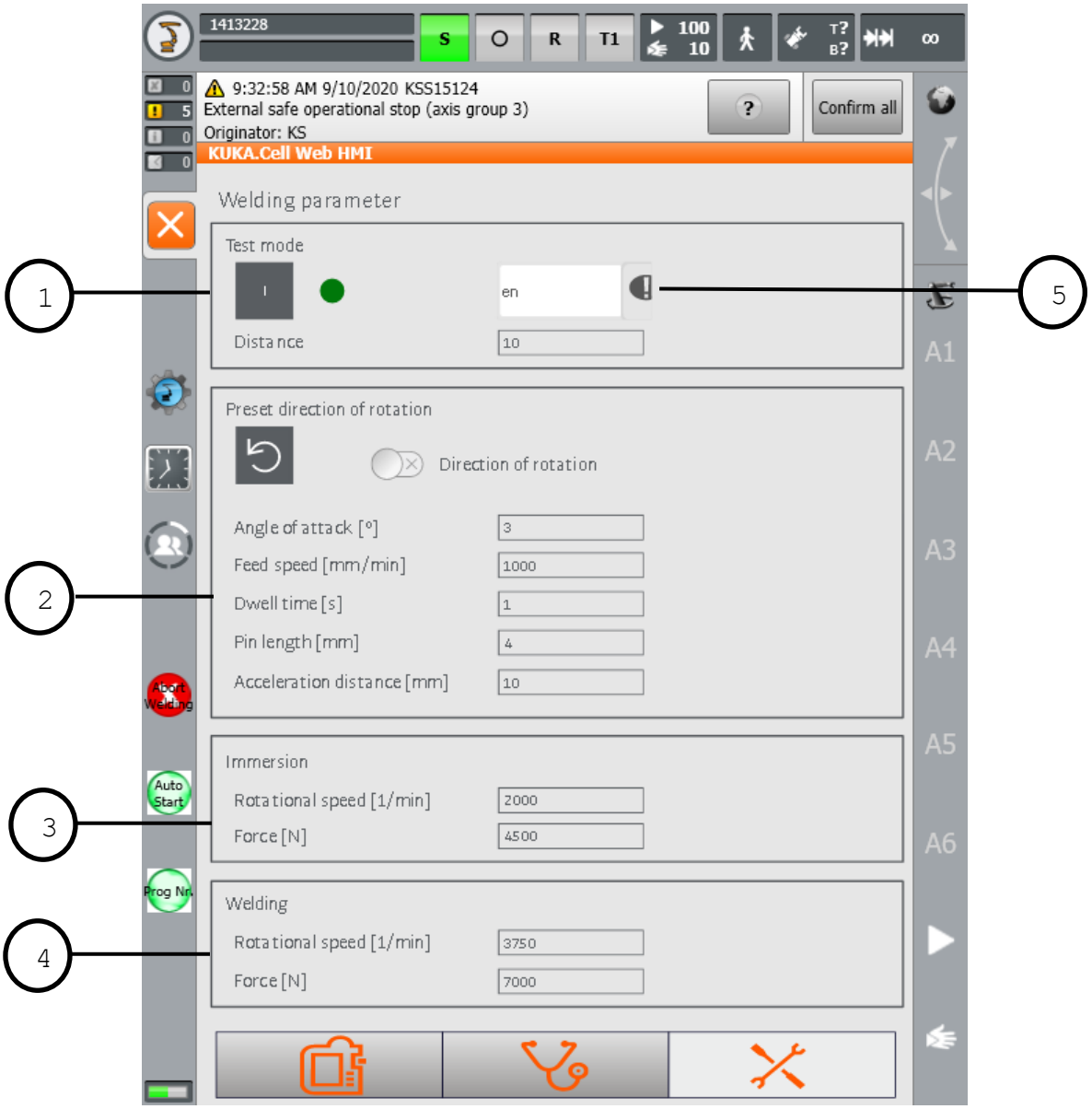

Fig. 30: Welding parameters

Item	Button/LED	Description
1	**Test mode I/O**	Switch test mode on/off
	LED	■ green: test mode is switched on. ■ gray: test mode is switched off.

Item	Button/LED	Description
	Distance [mm]	Entry for distance from the tool center point (TCP) to the processing surface in test mode
2	**Preset direction of rotation**	Set clockwise/counterclockwise motion
	Angle of attack [°]	Entry for angle of the spindle relative to the vertical position
	Feed speed [mm/min]	Entry for feed rate of the tool
	Dwell time [s]	Entry for dwell time of the tool at the plunge point before feeding starts
	Pin length [mm]	Entry for length of the tool clamped in the spindle
	Acceleration distance [mm]	Entry for path from the plunge point to the point at which the tool reaches the full feed rate.
3	**Immersion**	
	Rotational speed [1/min]	Entry for spindle speed during the plunge process
	Force [N]	Entry for pressing force with which the tool is moved towards the workpiece
4	**Welding**	
	Rotational speed [1/min]	Entry for spindle speed during the weld process
	Force [N]	Entry for pressing force which the tool exerts on the workpiece during the weld process
5	**Language**	Language selection Pressing the button opens a pop-up menu:

- ***NOTICE***

  The direction of rotation and spindle speed parameters on this user interface apply to the weld program. For manual mode, these parameters must be set on the “Overview” user interface.

8.5 Reaction to an error in the process

Description

An error in the process (torque, periphery monitoring) can result in the pin becoming welded to the material. To prevent this from happening, the pin must be pulled out of the material.

This is implemented by means of an interrupt on the robot controller (interrupt no. 10 with priority 4). As soon as an error occurs that still permits a robot motion (no open operator safety or EMERGENCY STOP), the pin is pulled out of the plasticized material.

The height of this retraction motion must be kept to a minimum and collisions with any system components present must be avoided.

- **NOTICE** **Risk of damage to property**

  Welding of the pin to the material during the process is to be avoided.

8.6 Operator control and indicator elements for the recooling system

Description

Operating states can be indicated in a display and parameters can be set using input keys.

Once the power supply has been switched on, the current software version is displayed for approx. 2 seconds. During operation, the supply temperature (to the device) of the coolant circuit is displayed and, alternately, any active messages in the form of error codes.

Overview

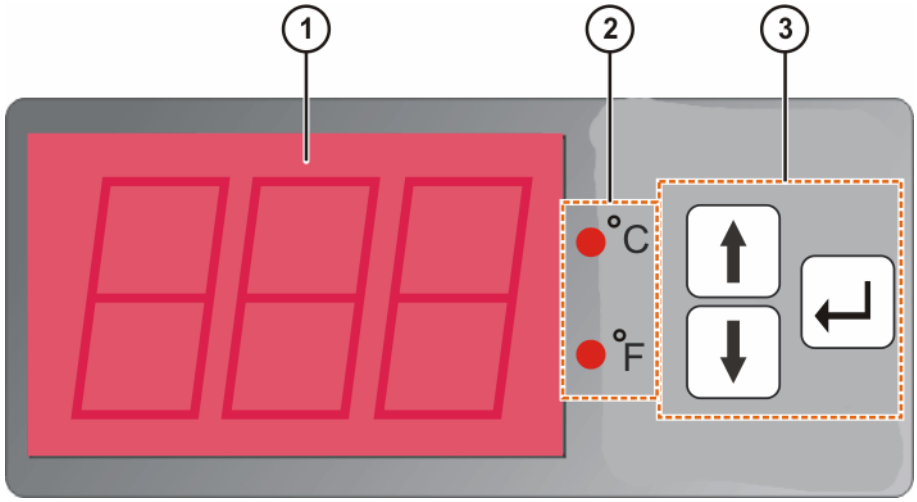

Fig. 31: Operator control and display elements for recooling system

1. 7-segment display
2. Temperature unit LEDs
3. Operator keys

For detailed information from Rittal, see Section 16.3.

9 Start-up and recommissioning

9.1 Overview

- **NOTICE** **Risk of damage to property**

  This is an overview of the most important steps during start-up. The precise sequence depends on the application, the manipulator type, the technology packages used and other customer-specific circumstances.

  For this reason, the overview does not claim to be comprehensive.

Steps	Description
1	Install and connect robot. Detailed information is contained in the robot assembly or operating instructions, in the chapter “Start-up”.
2	Install and connect the robot controller. Detailed information is contained in the robot controller assembly or operating instructions, in the chapter “Start-up”.
3	Install FSW controller. (See Section 9.2)
4	Perform visual inspection of FSW spindle. For further information, see Section 16.3, Operating Instructions, Corcom
5	Connect the electrical system of the FSW robot system. (See Section 9.3)
6	Connect the recooling system connections, check and fill cooling fluid. (See Section 9.4)
7	Check connections for leaks.
8	Connect compressed air to the FSW controller, activate compressed air, set to 6 bar and check for leaks.
9	Connect the pneumatic system in accordance with the pneumatic diagram supplied.
10	Check filter combination for leaks.
11	Connect hydraulic unit and fill with oil. (See Section 9.5)
12	Vent hydraulic hoses. (See Section 9.7)

13	Switch on the FSW robot system. (See Section 9.8)
14	Carry out a function test of the safety equipment.
15	Insert tool and ground it according to the type of material used for the workpiece. (See Section 6.5)
16	Carry out calibration and test programs in accordance with the operating instructions of the industrial robot.
17	Switch off FSW robot system. (See Section 9.9)

9.2 Installing the technology cabinet

Procedure

1. Install the technology cabinet outside the guard. The minimum clearances to walls, other cabinets, etc. must be observed.
2. Electrical compartments must only be opened using suitable and approved tools or a key.
3. Check the technology cabinet for any damage caused during transportation.
4. Check that fuses, contactors and boards are fitted securely.
5. Secure any modules that have come loose.
6. Check that all screwed and clamped connections are securely fastened.
7. Plug in the connecting cables.

9.3 Overview of electrical connections

The cables and hoses must be routed in such a way as to prevent the risk of tripping. The FSW robot system is supplied with the following components pre-installed:

- Manipulator with energy supply system and FSW spindle
- Robot controller
- Technology cabinet
- Connecting cable

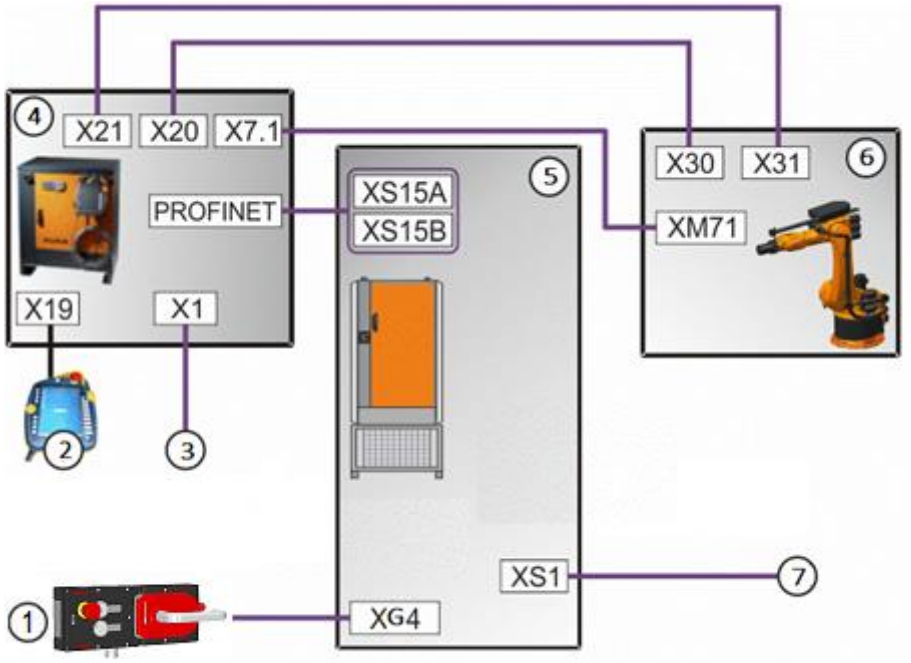

Fig. 32: Overview of electrical connections

1. Interface XG4. Gate switch on Emergency Stop and button (optional)
2. smartPAD
3. Power supply connection cable to robot controller
4. Connection to KR C4 robot controller
5. Connection to technology cabinet
6. Junction box and media panel on the manipulator
7. Mains connection cable is provided by the customer. The interface is XD1 of the appropriate technology cabinet. Connector bypack in scope of supply.

⚠ WARNING Risk of death or serious injuries!

Once the electric cables have been connected, the impedance must be checked. The impedance must be ≤ 200 mΩ. Failure to observe this safety precaution may result in death or severe injuries due to electric shock.

9.4 Connecting and filling the recooling system

Description

Information about the recooling system can be found in the installation, operating and maintenance instructions of the recooling system, see Section 16.3.

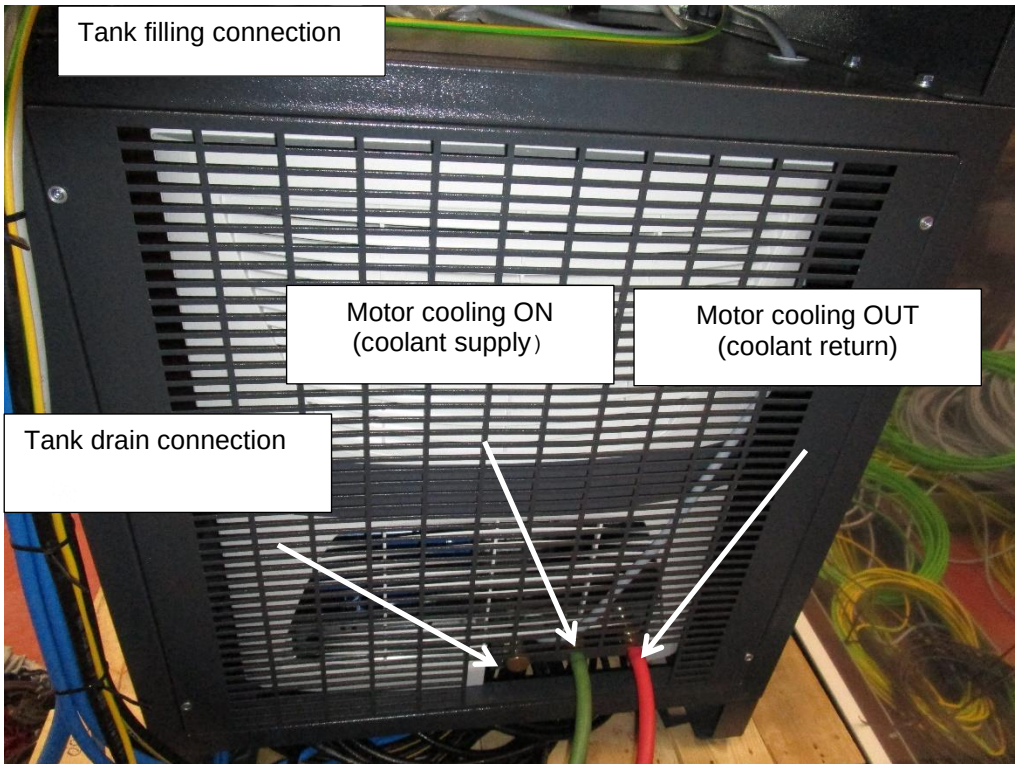

Fig. 33: Chiller

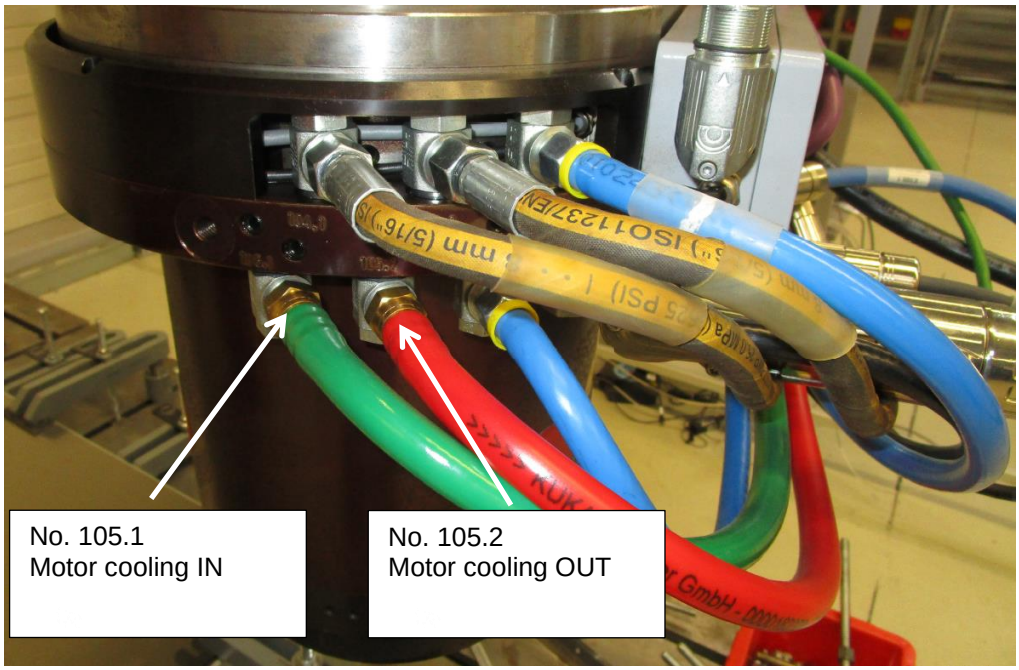

Fig. 34: FSW spindle motor cooling

NOTICE

When the machine is switched on, the cooling water pump is switched on too, thus establishing the cooling water circuit. It is recommendable to fill the cooling ducts with the spindle in a horizontal position.

Procedure

1. Connect the recooling system connections.
2. The cooling water reservoir is to be filled to the “MAX” mark on the level indicator with a mixture of water and 20% antifreeze based on ethylene glycol.
3. The cooling water circuit vents itself automatically. After a short runtime, check the fill level again and top up if required.
4. Check connections for leaks.

⚠ CAUTION Risk of injuries!

- Glycol is added to the cooling water to prevent build-up of bacteria and viruses. Contact with cooling water can cause injuries. If a person comes into contact with cooling water or cooling water spray during operation:

Immediately rinse the affected parts of the body with water (wash hands, rinse eyes).

9.5 Hydraulic system

The following procedures must be carried out in the sequence listed below before the hydraulic unit can be put into operation.

Precondition

- The filling connection and the filling equipment have been meticulously cleaned.
- The hydraulic supply to the tool clamping system has been connected correctly.
- During filling, the utmost care must be taken to ensure cleanliness.

Procedure

1. Check that the contents of the oil drum are free from all contamination, e.g. rust or condensation.
2. Unscrew the ventilation filter from the filling connection.
3. Fill the system with oil. If possible, fill the system using a mobile pumping unit with a fine filter.
4. Reseal the filling connection with the ventilation filter.
5. The hydraulic system must then be switched on briefly to fill the pipe/hose system. The fill level must be observed. Oil must be topped up if necessary.

Never put the pumps into operation without oil!
Prime the pumps and start them without pressure.
Before the machine starts, the pumps at the connections indicated with a sign must be filled with filtered hydraulic oil.

- The direction of rotation of the pump and the electric motor must be checked (check delivery rate; in the absence of a delivery rate, exchange two of the three main hoses).
- The hydraulic system must be fully vented.

The technical documentation and the operating instructions of the manufacturers of the components used in the machine must be observed (see Section 16.3).

6. Manufacturer used is HAWE, see document: D8010 “Compact hydraulic power pack type KA2 and KAW2”.

9.6 Flushing the hydraulic system

Following an oil change or an exchange of components, the hydraulic system must be flushed. For this, a flushing kit 550.010-89.010 with filter, hoses and installation materials is available. This must be installed in the system as illustrated (see Fig. 36:). The FSW head should be moved to a position in which the filter is well fitted and the hoses are not subjected to strain. Furthermore, an oil sump or similar should be placed underneath it.

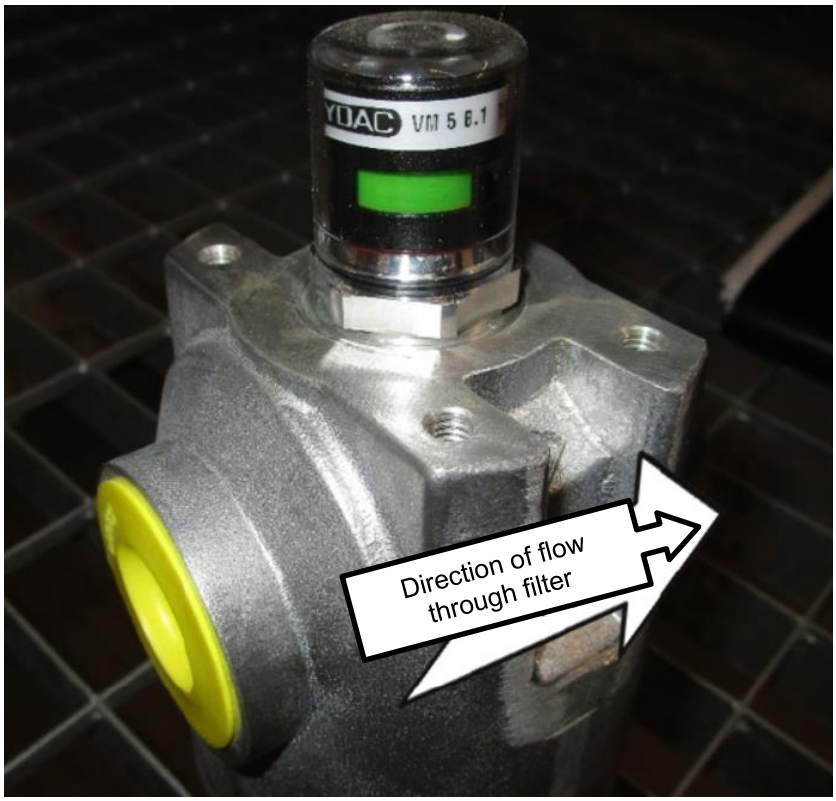

Fig. 35: Measuring connections

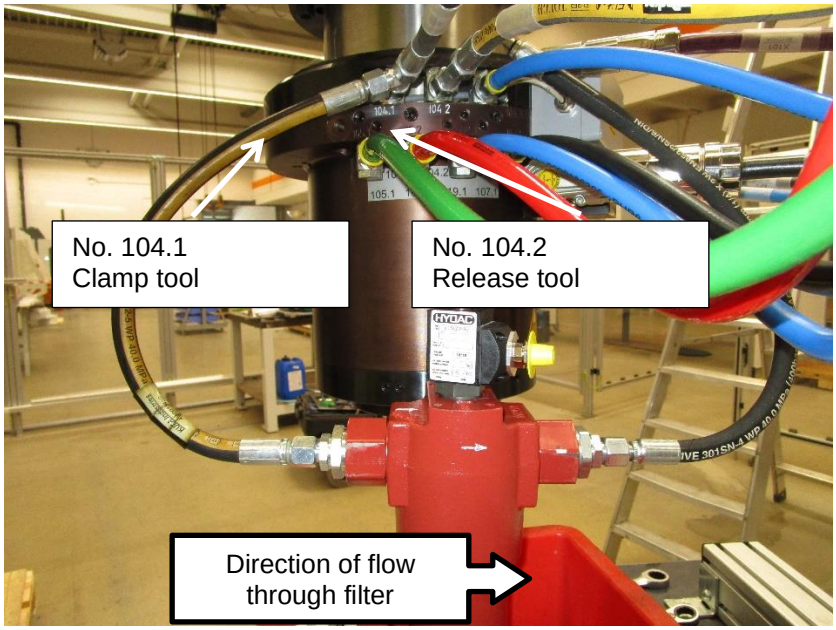

Fig. 36: Layout for flushing

Procedure

1. Remove measuring connections VKA 3-10L from connections 104.1 and 104.2 and replace them with hoses. Install the filter so that the direction of flow is from connection 104.1 to connection 104.2. The stamped mark indicating the direction of flow must be observed.
2. Now start the hydraulic unit. The valves must be in the clamping position. This is the home position.
3. The hydraulic system must now be switched on for 15 minutes. Check the temperature repeatedly. Should it be over 40 °C, the flushing operation must be paused.
4. Repeat step 3 three more times.
5. On completion of the flushing time, remove the filter and hoses. Then refit the measuring connections.
6. Once the measuring connections have been refitted, the system must be vented. See Section 9.7.
7. The filter element must be disposed of properly. The filter housing can be reused with a new filter element for subsequent flushing operations. It must be ensured that it does not become fouled during storage.

NOTICE

During flushing and venting, check the fill level in the hydraulic unit and top up if necessary.

9.7 Venting the hydraulic system

Vent the hydraulic system at the highest possible point of the consuming device lines or at the point furthest from the hydraulic unit.

Fig. 37: Venting the hydraulic hose

Precondition

- The hydraulic supply to the tool clamping system has been connected correctly.
- A measuring tube and a clean receptacle are required for venting. Prepare this equipment in advance.
- The hydraulic unit must be filled to the Max marking.

Procedure

1. Actuate the “Release tool” function.
2. At connection 104.2 of the tool clamping system, attach a measuring tube to the measuring point and screw it on by hand until a mixture of oil and air escapes. The measuring tube must be routed to and secured over a receptacle. Wait briefly, then unscrew the tube again.
3. Actuate the “Clamp tool” function.
4. At connection 104.1 of the tool clamping system, attach the measuring tube to the measuring point and screw it on by hand until a mixture of oil and air escapes. The measuring tube must be routed to and secured over a receptacle. Wait briefly, then unscrew the tube again.
5. Repeat steps 1 to 4 until only oil emerges.

⚠ CAUTION Risk of burn injuries!

- Venting should only be carried out after the FSW spindle has been stopped for a longer period, as the oil temperature and the surface temperature are otherwise liable to be high and could result in burn injuries.

9.8 Switching the FSW robot system on

Precondition

- The FSW robot system has been installed in accordance with the assembly and operating instructions.
- All electrical connections are correct and the energy levels are within the specified limits.
- The doors of the robot controller and FSW controller are closed.
- The peripheral devices are correctly connected.
- It must be ensured that no persons or objects are present within the danger zone of the manipulator.
- All safety devices and protective measures are complete and fully functional.
- The internal temperature of the robot controller and FSW controller must have adapted to the ambient temperature.

⚠ WARNING Risk of death or serious injuries!

- If the tool collides with the workpiece in test mode, splinters of material from the tool or workpiece can cause injuries.

  Personal protective equipment (e.g. safety goggles, protective clothing) must be worn during operation in test mode.

Procedure

1. Release the EMERGENCY STOP device on the smartPAD.
2. Switch on the main switch of the FSW controller.
3. Switch on the main switch of the robot controller.
4. Acknowledge the active messages on the smartPAD.

- ***NOTICE***

  When the FSW robot system is put back into operation following a power failure, the EMERGENCY STOP and operator safety functions must be reset.

- ***NOTICE***

  Further information is contained in the operating and programming instructions for the KUKA System Software (KSS).

-

9.9 Switching the FSW robot system off

Procedure

1. Perform safe retraction of the manipulator in manual mode T1.
2. Remove tool from the FSW spindle.
3. Turn the main switch on the robot controller to OFF.
4. Turn the main switch on the FSW controller to OFF.
5. Deactivate the compressed air.
6. Switch the mode selector switch to External and remove the key.

- **NOTICE** **Risk of damage to property!**
  If the FSW robot system is switched on by unauthorized persons, damage to property may occur. To prevent the FSW robot system from being switched on by unauthorized persons, the mode selector switch must be switched to External and the key must be removed.

-
-

9.10 Spindle clamp

- **NOTICE** **Risk of damage to property!**
  It is prohibited to rotate the spindle shaft during active clamping. KUKA Deutschland GmbH accepts no liability for damage or injury caused thereby. The risk lies entirely with the user.

- **NOTICE**
  Detailed information can be found in the operating, installation and maintenance instructions of the FSW spindle.

-

10 Programming for user group “User” (inline forms)

10.1 Programming commands – FSW

Overview

Command	Description
ModTech_FSW_Air	Spindle head cooling on/off
ModTech_FSW_Chiller	Chiller on/off (See Section 10.3)
ModTech_FSW_Spindle	Spindle operation (See Section 10.4)
FSWTech SpindleTool	Retract/advance spindle piston (See Section 10.5)

10.2 ModTech_FSW_Air

When welding materials which develop a high temperature during friction with the tool, the spindle head cooling must be switched on before the spindle is operated.

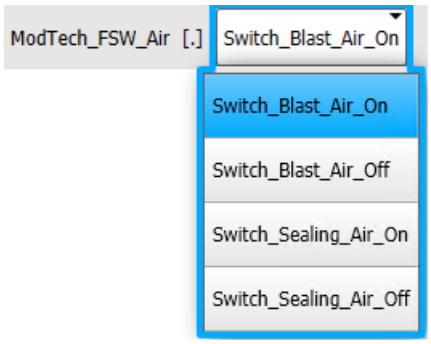

Fig. 38: Inline form “ModTech_FSW_Air”

Item	Description
1	**SWITCH BlastAIR_ON** Switch on spindle head cooling
2	**SWITCH BlastAIR_OFF** Switch off spindle head cooling
3	**SWITCH SealingAIR_ON** Switch on sealing air
4	**SWITCH SealingAIR_OFF** Switch off sealing air

10.3 ModTech_FSW_Chiller

The chiller is permanently supplied with power (SWITCH_ON and SWITCH_OFF control the standby mode). Before spindle operation, the chiller must be switched on. This must take place before “FSWTech_Spindle Function – SPINDLE_ENABLE”.

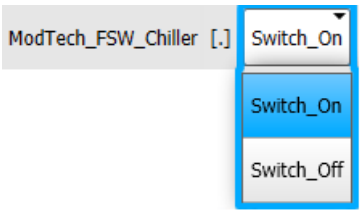

Fig. 39: Inline form “FSWTech Chiller”

Item	Description
1	**SWITCH ON** Switch chiller on. Deactivate standby mode.
2	**SWITCH OFF** Switch chiller off. Activate standby mode.

10.4 ModTech_FSW_Spindle

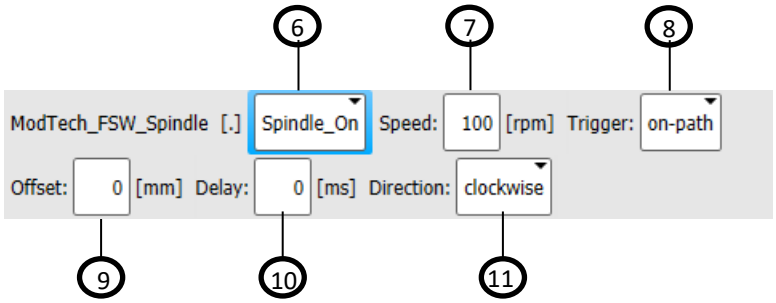

Fig. 40: Inline form “ModTech_FSW_Spindle Function on-path clockwise”

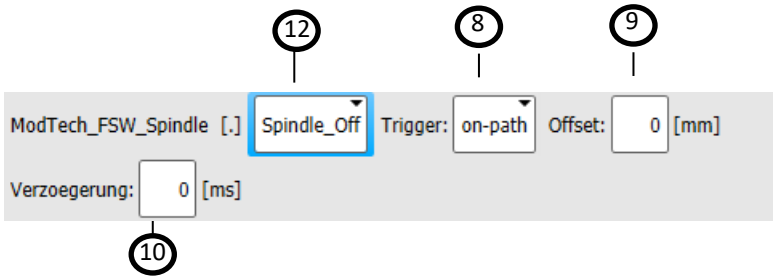

Fig. 41: Inline form “ModTech_FSW_Spindle Function OFF on-path clockwise”

Item	Description
6	**Spindle_ON** The spindle is switched on.
7	**Speed** Entry of the spindle speed in rpm.
8	**Trigger** ■ on-path: stop the spindle after “trigger when path” ■ on-distance: stop the spindle after “trigger when distance” without monitoring of “actual speed = setpoint speed” ■ none: stop the spindle at the current point (standing stop) with monitoring of “actual speed = setpoint speed” ■ Cont: immediate stop of the spindle
9	**Offset** Spatial offset of the activation or deactivation time relative to the start point or the end point of the motion
10	**Trigger** Time offset of the activation or deactivation time relative to the start point or the end point of the motion
11	**Direction** ■ ClockWise: clockwise motion (to the right) ■ Counter ClockWise: counterclockwise motion (to the left)
12	**Spindle_Off** The spindle is switched off.

10.5 ModTech_FSW_Tooling

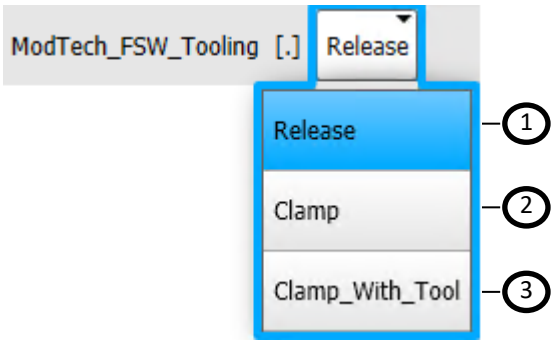

Fig. 42: Inline form “ModTech_FSW_Tooling”

Item	Description
1	**RELEASE** Advance the spindle piston and release the spindle
2	**CLAMP** Retract the spindle piston and clamp the spindle. No monitoring of whether the tool is present.
3	**CLAMP WITH TOOL** Retract the spindle piston and clamp the spindle. With monitoring of whether the tool is present and clamped.

10.6 Determining the load data

The tool to be used must be calibrated before start-up.
Use Load Detect to determine the load data with the tool. Also see KR C4 operating instructions, chapter “Start-up and recommissioning”.

11 Maintenance

11.1 Maintenance schedule

⚠ WARNING Risk of death, serious injuries or damage to property

Any damage that has occurred during the shift must be immediately rectified, in so far as safety facilities are involved; damaged parts or components of the system pose a danger to life and limb, and the consequences of damaged parts or components of the machine could lead directly or indirectly to a danger to life and limb.

Maintenance symbols

	Oil change
	Lubricate with grease gun
	Lubricate with brush
	Tighten screw/nut
	Check component, visual inspection
	Clean component
	Exchange battery

Description

Maintenance work must be performed at the specified maintenance intervals after commissioning at the customer's plant.

Precondition

- The robot controller must be switched off and secured to prevent unauthorized persons from switching it on again.
- The hydraulic unit is deenergized and depressurized.
- The pneumatic unit is depressurized.
- The power cable is deenergized.
- Work in accordance with the ESD guidelines.

⚠ WARNING Risk of death or serious injuries!

- Cables routed from power supply connection X1 to the main switch are energized even when the main switch is turned off! This mains voltage can cause injuries on contact.

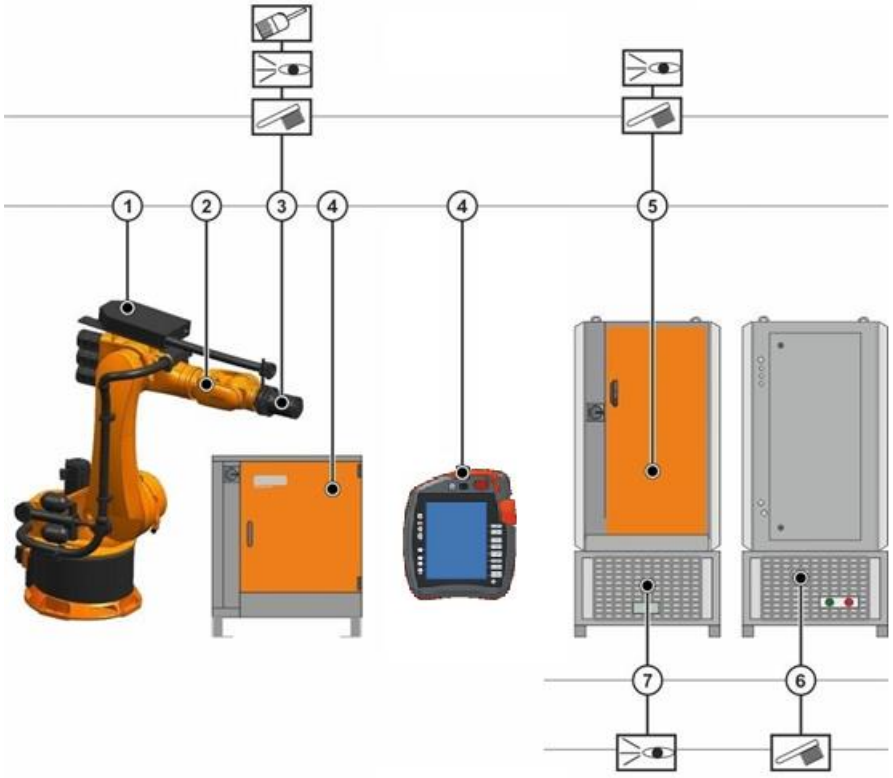

Fig. 43: Maintenance points

Interval	Item	Activity
1 day	1	Check the energy supply system. Detailed information about maintenance can be found in the energy supply system documentation.
1 day	2	Manipulator Detailed information about maintenance can be found in the manipulator documentation.
1 day	3	FSW spindle. Check the tool taper and the conical mount on the spindle shaft for dirt. Check the protection of the conical seat on the spindle shaft.

Interval	Item	Activity
		Detailed information can be found in the operating, installation and maintenance instructions of the FSW spindle.
1 day	4	Robot controller Detailed information about maintenance can be found in the robot controller documentation.
1 day		Visually inspect all electrical cabling and connections for damage. Also check whether the cables are kinked or pinched. In the case of damage, rectify the fault. If this is not possible, inform KUKA Service.
1 day		Check that all covers are in place. If not all covers are attached, attach those that are missing.
1 day / as indicated		Pneumatic system service unit: Check the condensate trap and empty it if necessary. Check the differential pressure indicator of the fine filter. Exchange the filter cartridge when red indicator >75%, but at least once each year. (See Section 11.3)
1 week		Pneumatic system, recooling system and hydraulic system: Check all hoses for leaks and damage. Also check whether the hoses are kinked or pinched. In the case of leaks or damage, rectify the fault. If this is not possible, inform KUKA Service.
1 week		Hydraulic unit: Check the optical clogging indicator of the return filter. Exchange if the indicator is red. (See Section 11.4)
1 week	7	Check the coolant level on the recooling system. Detailed information can be found in the installation, operating and maintenance instructions of the recooling system.
1 week		Visual inspection of the tool holder for fractures and cracks. In the case of damage, contact the manufacturer. Detailed information can be found in the operating, installation and maintenance instructions of the FSW spindle.
2 weeks	3	Clean the tool taper of the FSW spindle. Detailed information can be found in the operating, installation and maintenance instructions of the FSW spindle.
1 month	3	Lubricate HSK gripper on the FSW spindle. Detailed information can be found in the operating, installation and maintenance instructions of the FSW spindle.
1 month	7	Recooling system: Check the coolant for dirt and solid particles (swarf, etc.). Check the recooling system for leaks by means of a visual inspection. Measurement of the glycol content with a refractometer (see Section 11.5).

Interval	Item	Activity
2 months	6	Clean the fins of the condenser on the recooling system with compressed air or a brush.
6 months		Hydraulic unit: Check the gas pressure of the accumulator (see Section 11.4).
6 months		Check that all EMERGENCY STOP devices are functioning. If an EMERGENCY STOP device is not functioning, rectify the fault. If this is not possible, inform KUKA Service.
1 year	7	Recooling system: Exchange coolant (see Section 11.5). Detailed information can be found in the installation, operating and maintenance instructions of the recooling system.
1 year		Measure the loop impedance/system impedance (≤ 200 mΩ) in accordance with EN 60204.
1 year		Pneumatic system service unit: Exchange filter cartridges when the flow rate is reduced, but at least once each year (see Section 11.3).
1 year		Hydraulic unit: - Oil change or tribological investigation by a laboratory. - Exchange return filter when changing the oil, but at least once each year (see Section 11.4).
6 years		Hydraulic system: Hose lines must be exchanged after a service life of six years (see Section 11.4).
10 years		Pneumatic system: Hose lines must be exchanged after a service life of 10 years.

- **NOTICE**

  Information about maintenance work on all the components in this system is contained in the manufacturer documentation.

11.2 Maintenance intervals for the FSW spindle and FSW tool

- **NOTICE**

  Detailed information can be found in the operating, installation and maintenance instructions of the FSW spindle.

During resetting work and after every shift, the FSW tool must be checked to ensure that it is fastened correctly, paying attention to any damage to the individual tool components.

11.2.1 Preventive maintenance of the robot spindle

The FSW spindle is an external axis of the robot. In operation, it rotates continuously in one direction, which means the actual position of the axis increases all the time.

This value must not exceed approx. 2,000,000.

It is therefore necessary to remaster the spindle beforehand.

The operator is advised of this in due time by means of a notification message.

- Unmaster axis E1 via Start-up->Master->Unmaster in the main menu on the smartPAD.
- Master axis E1 via Start-up->Master->Dial in the main menu on the smartPAD.

11.3 Pneumatic system

11.3.1 Hose lines

Leakages and any obvious damage on all pipes, hoses and unions must be rectified before start-up.

For general applications, a service life of at least 10 years can be assumed. For safety-oriented applications, we recommend carrying out a regular inspection at least every 12 months. After exchange, the new lines must be expertly laid and fitted. Make sure that no connections are interchanged.

11.3.2 Valves/silencers

The correct functioning of the valves must be checked at regular intervals. The silencers serve to reduce noise and must not be removed. Heavily fouled silencers

must be exchanged as they can cause slow switching performance of the valves and machine malfunctions.

11.3.3 Filter-regulator

The system pressure of 5 bar is set at the filter-regulator and indicated on the manometer.

The air is filtered before entering the pneumatic system. The filter element must be exchanged in the case of a low flow rate despite unchanged pressure settings and after 12 months at the latest. The condensate from the air is trapped at the filter-regulator and must be checked at regular intervals (once every 8 hours) and drained. In the case of pressure regulating valves, the set pressures must be checked and adjusted if required.

Precondition

- Manipulator has been moved into its home position.
- The FSW controller must be switched off and secured to prevent unauthorized persons from switching it on again.
- The power cable is deenergized.
- Compressed air is shut off and vented.
- Pneumatic connections to customer equipment are disconnected and the system is depressurized.

11.3.4 Fine filter

The compressed air is further filtered by the fine filter. The filter must be checked at regular intervals.

The condensate is collected in the filter bowl. The fill level must be checked and drained if necessary.

The degree of clogging of the filter cartridge is shown by a differential pressure indicator. The red color zone rises as the degree of clogging increases. If it exceeds 75% at a normal flow rate, the filter cartridge must be exchanged.

11.4 Maintenance of the hydraulic system

11.4.1 Isolating the machine from hydraulic energy (depressurizing)

The machine must be depressurized before any work is carried out on the hydraulic system. The main switch must be switched off and locked!

Even after the electric power has been switched off, the machine still has energy stored in the hydraulic systems. This energy must be released from the machine by depressurizing the respective hydraulic system.

- Observe Section 16.3, see manufacturer HAWE.
- Observe specifications of manufacturer HAWE when entering and working in the machine, see Section 16.3.

11.4.2 Depressurizing the hydraulic system

Carry out the following steps in sequence:

- Switch off the machine.
- Open the pressure relief valve with hexagon socket (Fig. 44: item 8) using an Allen key in order to depressurize the hydraulic system.

For the hydraulic system to function, the pressure relief valve with hexagon socket must always be closed.

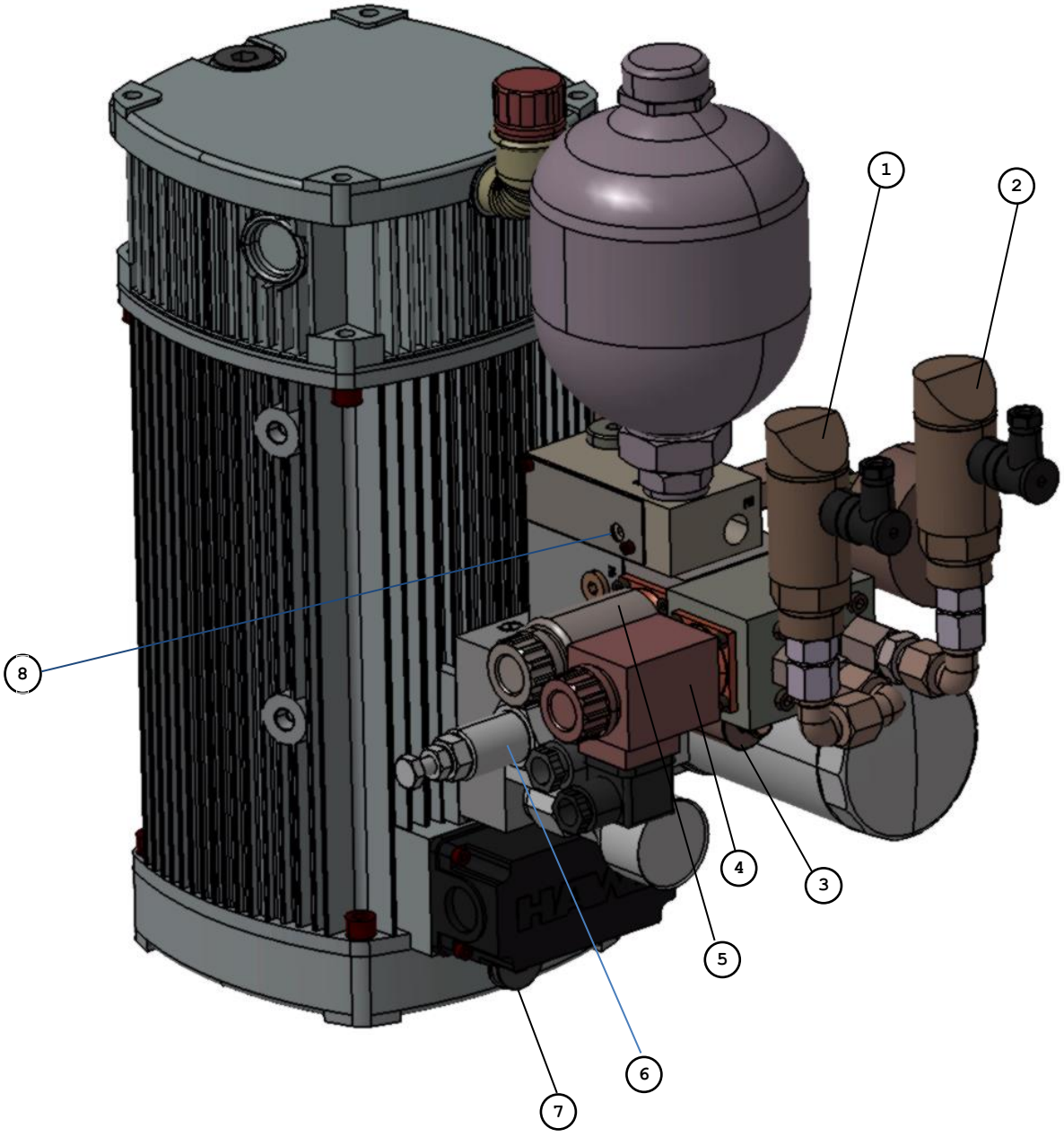

Fig. 44: Hydraulic unit, front

1. Pressure sensor for clamping pressure
2. Pressure sensor for release pressure
3. Pressure sensor for pump on/off
4. Valve: release tool
5. Valve: pressure enable, open
6. Pressure relief valve
7. Oil drain screw
8. Pressure relief valve with hexagon socket

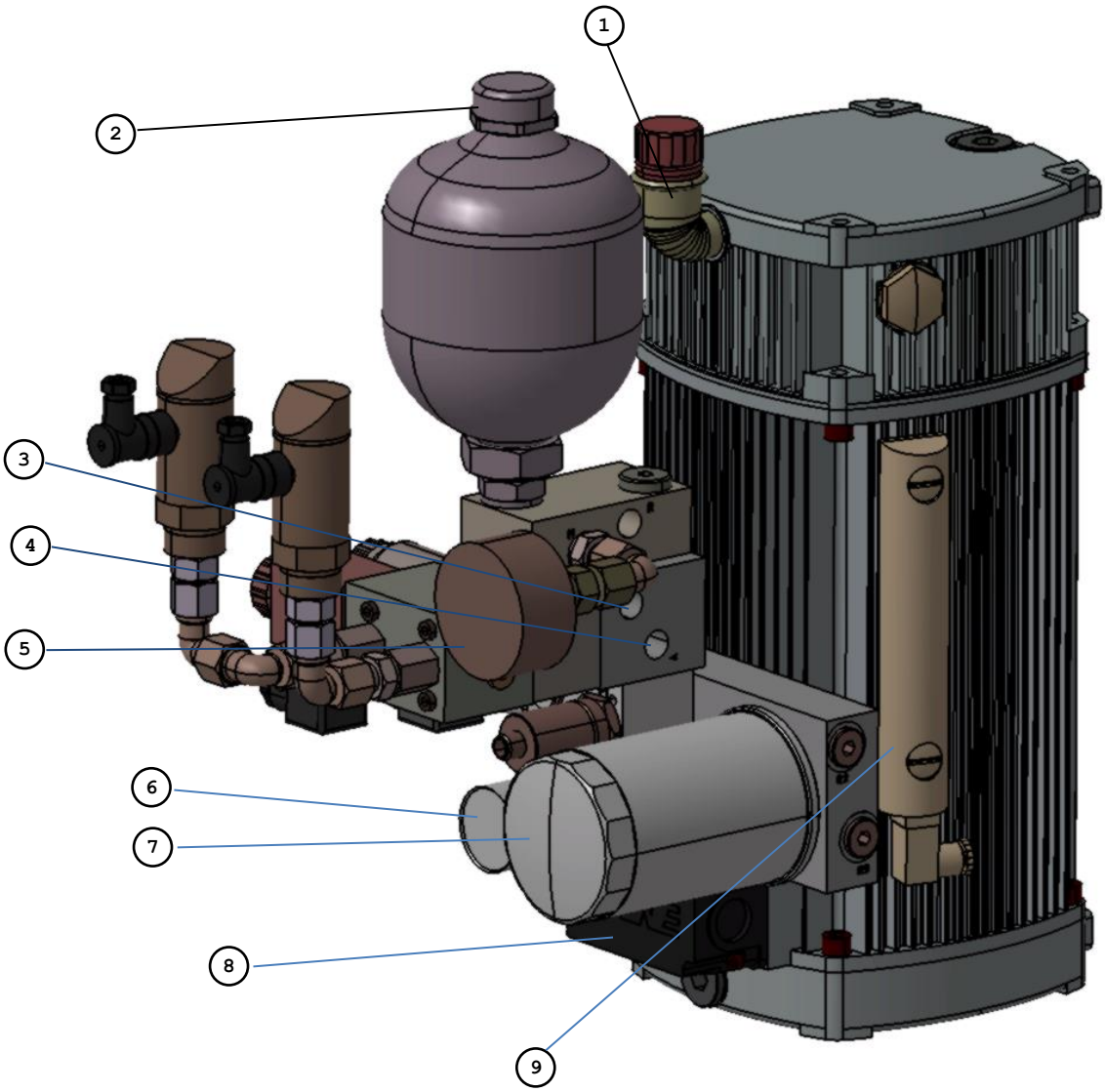

Fig. 45: Hydraulic unit, rear

1. Filling connection with ventilation filter
2. Accumulator with nitrogen connection
3. Connection for “Release” hose
4. Connection for “Clamp” hose
5. Manometer, system pressure
6. Filter clogging indicator
7. Return filter
8. Electrical connection for pump motor incl. temperature switch
9. Level indicator with float switch

- -

- **NOTICE**

  Further information about the hydraulic unit is contained in the manufacturer documentation. The hydraulic unit documentation is part of the FSW spindle documentation.

- **NOTICE**

  For setting the hydraulic pressure values, see the hydraulic diagram.

11.4.3 Checking the accumulators

General instructions

The accumulators are subject to the Pressure Equipment Directive 2014/68/EU.

In accordance with Article 3 of the Pressure Equipment Directive 2014/68/EU, the following accumulators require a declaration of conformity and a CE conformity mark:

- Accumulators with a volume > 1 liter and p • V > 50 bar • liter (Section 1.1 a, fluids of Group 2)
- Accumulators with p • V > 10,000 bar • liter (Section 1.1 b, fluids of Group 2)

Operation is only permitted within the specified parameters. Assembly, maintenance and servicing of the accumulator may only be carried out by authorized and instructed personnel and is governed by national regulations. In Germany by

- the Industrial Safety Regulations (BetrSichV). In the EU by EU Directive 2009/104/EC.
- Instructions for use.

This pressure equipment conforms to the provisions of Article 3, Paragraph 3 of the Pressure Equipment Directive (2014/68/EU) and therefore does not need to bear a CE mark.

The gas pressure of the hydraulic accumulators can be read from the hydraulic diagram.

The gas pressure must be checked every 6 months.

Precondition

- The hydraulic system is switched off and depressurized. See Section 11.4.2.
- Filling device for diaphragm accumulator type DFM for M28x1.5 gas filling valve and nitrogen cylinder

Checking gas pressure without filling and testing device

For this, the hydraulic accumulator charged to the system pressure is shut off. Using the manual relief valve (Fig. 44:), the hydraulic accumulator is then slowly depressurized. While doing this, the operator must observe the manometer (Fig. 45: , item 5). If the value of the currently displayed pressure p = xx bar suddenly drops to 0 bar, the pressure value p = xx bar is approximately the same as the gas pressure. If this value deviates from the setpoint gas pressure, connect a filling and testing device to the hydraulic accumulator and readjust the actual gas pressure value to the setpoint gas pressure. During the gas pressure test, the manual relief valve must be shut off.

Checking the hydraulic accumulator gas pressure with the filling device

- Switch off the hydraulic system and secure it against being switched on again.
- Depressurize the oil-containing section of the hydraulic accumulator.
- The manometer (Fig. 45: , item 5) must display a reading of 0 bar
- The accumulator filling and testing device must then be installed on the hydraulic accumulator (Fig. 45: , item 2). Compare the actual gas pressure value on the manometer with the prescribed setpoint gas pressure value at room temperature (RT = 25 °C). If there are deviations, top up with nitrogen gas until the setpoint value is reached.

Only nitrogen is to be used as the gas for filling the accumulator. (Nitrogen class 4.0 ultra-pure; N2 99.99 vol. %)

The product documentation D7969 issued by HAWE must be observed, see Section 16.3.

Maintenance of the return filter

The hydraulic unit is equipped with a return filter (Fig. 45: , item 7) with an optical clogging indicator (Fig. 45: , item 6). The clogging indicator should be checked weekly.

The filter should be exchanged

- - if the needle enters the red area when the hydraulic system is at operating temperature
- - when the oil is changed
- - once annually.

Pipes and screwed fittings

Pipes and screwed fittings must be checked weekly for leaks. Oil that has leaked out must not be used to refill the hydraulic system, but should instead be correctly disposed of in accordance with the pertinent regulations. When doing so, the measures set out in the relevant safety data sheet must be observed, see Section 16.3.

Inspecting / exchanging the hose lines

Because of ageing, wear and damage, it is essential that hose lines are inspected for operational safety and functional reliability.

1. Important inspection criteria include:

- Damage to the outer layer as far as the liner (chafe marks, cuts, cracks)
- Embrittlement of the outer layer (crack formation in the hose material)
- Deformation not compatible with the natural shape of the hose line, in the depressurized or pressurized state or during flexing, e.g. delamination, bubble formation, pinching, kinking
- Leaks in the hose, hose line or fitting
- Slipping of the hose out of the fitting
- Damage or deformation of the fitting resulting in impaired function and strength of the fitting or the connection between the hose and the fitting
- Corrosion of the fitting resulting in impaired function and strength
- Is free movement of the hose lines still possible, or has pinching, shearing or chafing occurred as a result of new system components or units which have been installed?
- Has it been ensured that the hose lines do not project into passageways, even when the units with which the hose lines are coupled are moved to their end positions?
- Have hose lines been painted over (explanation: not possible to recognize identification markings and cracks!)?
- Have storage periods and period of use been exceeded (see 3. below)?
- Have all covers been re-fitted after the inspection?
- Are any additional tear-out safeguards present or required?
- Please also refer to DGUV Rule 113-020 “Hydraulic hoses – Rules for safe use”; Appendix 1 “Scope of inspection; inspection criteria”

Employers' liability insurance association regulations require that hose lines must be inspected before first use and thereafter at least once a year by a competent person. Please also refer to German employers' liability insurance association regulation DGUV Rule 113-020: "Hydraulic hoses – Rules for safe use", available from:

- **Deutsche Gesetzliche Unfallversicherung e.V. (DGUV) Glinkastrasse 40, 10117 Berlin, Germany**
- **http://www.arbeitssicherheit.de**

«Firmenname» recommends having a visual inspection of all hose lines carried out every 200 hours by a competent person (previously: an expert) with regard to external defects and to verify that they are in a safe condition for use; this inspection should be documented in writing in dated inspection report together with documentation of the actual inspection intervals defined.

Hose lines must be checked at regular intervals to ensure that they are in a safe condition for use.

2. In the event of defective hose lines:

If defects are detected regarding the safe condition for use of a hose line, they must be rectified immediately or appropriate measures must be taken. It may be necessary to exchange these hose lines before it is permissible to continue operation of the machine. Hose lines may not be repaired, nor may new hoses be reassembled from old parts!

If a number of hose lines are exchanged at the same time, it must be ensured that all of the hose lines employed are adequately dimensioned for the loads anticipated in the combination concerned, and that it is not possible for the connections to be interchanged.

Defective hose lines must be exchanged immediately!

3. Exchanging hose lines:

Even if no safety-relevant defects have been detected in the hose line, it is the responsibility of «Kunde» to ensure that hose lines are replaced at appropriate intervals.

The period of use of hose lines (see DIN 20066) should not exceed six years, including a maximum storage period of two years (see also German Social Accident Insurance rule “DGUV Rule 113-020: Hydraulic hoses – Rules for safe use”).

11.4.4 Changing the hydraulic oil

The ageing and fouling of the hydraulic oil essentially depends on the operating conditions, e.g.:

- Temperature
- Operating pressure
- Filtering
- Penetration of contamination from the environment, ventilation systems and dynamic seals
- Air humidity

The oil should be changed after 12 months of operation.

Regular laboratory analyses of oil samples can lead to considerable lengthening of the oil change intervals.

Samples should be taken no later than after the first 12 months of operation and analyzed with regard to their tribological properties.

The laboratory result indicates whether the hydraulic oil needs to be changed due to ageing and/or deposit formation. In the case of fouling, the hydraulic oil can be cleaned to bring it up to the required cleanliness class by using a separate filter unit.

The laboratory result also provides information on the wear products in the hydraulic oil. These wear products can indicate that the components responsible are liable to fail soon.

Procedure

To change the oil:

1. Turn the main switch off and lock it.
2. The hydraulic system must be depressurized.
3. Remove the oil drain screw and drain the oil into a container. Dispose of the oil properly. When doing so, the measures set out in the relevant safety data sheet must be observed, see Section 16.3.

Use lint-free cleaning cloths.

Immediate removal of oil spills.

4. Screw in the oil drain screw together with a new seal and tighten it.
5. With the machine switched off, the hydraulic oil (see hydraulic diagram) must be refilled up to the MAX mark on the level indicator through a filter with a fineness of 10 µm.

HAWE instructions D 8010; B5488; 5488-1 must be observed!

11.4.5 Checking the miscibility and compatibility of oils

Work or troubleshooting on hydraulic equipment may be carried out only by persons having special knowledge and experience of hydraulic systems.

- **Miscibility** is a chemical property. Two liquids are truly miscible if they mutually dissolve to form a single “phase”.
- **Compatibility** means that while two oils can be mixed, they still retain their individual characteristics.

The mixing of oils of different type designations, from the same manufacturer or different ones, is a major cause of malfunctions, including complete failure of the hydraulic system.

While miscibility of oils is often confirmed by manufacturers, compatibility is rarely mentioned. In most cases the mixing of oils necessitates a change of the hydraulic oil, see also Section 11.4.4.

If oils are mixed, it is at the user’s own risk! «Firmenname» assumes no responsibility for failures that are caused as a result (e.g. of components).

«Kunde» must first clarify with the manufacturer of the oil whether mixing is possible and whether compatibility is assured!

If two incompatible oils are mixed, e.g. as the result of an incomplete oil change, the following problems can arise:

- Increased formation of surface scum
- Deteriorated air release property
- Increased risk of cavitation
- Wear to seals
- Different behavior in contact with water
- Influence on demulsification or emulsification characteristics
- Modified friction characteristics
- Modified wear protection characteristics
- Increased fouling of system due to loosened deposits
- Reduced filterability or reduced service life of filter

- Increased formation of deposits due to reactions between additives

Particularly critical is the mixing of hydraulic oil containing zinc with zinc-free hydraulic oil, which can lead to malfunctions resulting in the failure of the entire hydraulic system.

If the residual oil in the hydraulic system is mixed with the new hydraulic oil (different manufacturer and/or different type) a new oil mixture is produced. This new oil mixture may resinify, become lumpy, etc., and can also give rise to deposit formation or clogging.

For this reason, «Firmenname» cannot guarantee trouble-free operation of the hydraulic system if oil mixtures or non-approved hydraulic / lubricating oils are used.

If the hydraulic system is to be filled with a hydraulic oil other than that specified on the hydraulic diagram or lubrication system diagram, it is imperative for the following sequence of operations to be observed and carried out:

- Cleaning the machine:
  All components of the machine must be drained and cleaned. Pressure regulators, cylinders, filters, oil coolers, pumps, hydraulic accumulators, control blocks and various large or long sections of piping must be drained and flushed, dismantling them first if necessary. Particular attention must be paid to cleaning dead spaces, e.g. hydraulic blocks, etc.
- Filter elements must be exchanged for new ones.
- Drained residual oil must be disposed of in accordance with all pertinent regulations. When doing so, the measures set out in the relevant safety data sheet (see Section 16.3) must be observed.
- The residual oil must account for less than 2% of the total volume.
- The machine must then be reassembled properly. The hydraulic system must be flushed, see Section 9.6.

11.5 Maintenance of recooling system and cooling water

The following maintenance work is required on the recooling system:

- Check of the fill level of the coolant on the fill level indicator (weekly)
- Check of the quality of the coolant
- Measurement of the glycol content with a refractometer (monthly)
- To prevent the formation of fungus or algae, the coolant should be exchanged at least once annually. Even the use of clean water can result in the formation of fungus or algae.

Procedure

1. Unscrew the protective grille.
2. Remove the fastening screws from the underside of the recooling system.
3. Check water hoses for leaks and damage.
4. Screw the fastening screws back into the underside of the recooling system.
5. Attach the protective grille and screw it on.

- **NOTICE**

  Detailed information about maintenance can be found in the installation, operating and maintenance instructions of the recooling system.

- **⚠ CAUTION Risk of injury**

  Glycol is added to the cooling water to prevent build-up of bacteria and viruses. Contact with cooling water can cause injuries. If a person comes into contact with cooling water or cooling water mist during operation, the affected parts of the body must be rinsed with water (wash hands, rinse eyes).

- **⚠ CAUTION Risk of injury**

  Coolant may escape from the water hoses. Contact with cooling water can cause injuries. Tie the water hoses up out of the way during maintenance work.

- **NOTICE**

  After maintenance work to the recooling system, the supply and return hoses must be reconnected as before.

11.6 Cleaning the FSW robot system

Precondition

- Manipulator moved into its home position.
- The robot controller and technology cabinet must be switched off and secured to prevent unauthorized persons from switching them on again.
- The power cable is deenergized.

- **⚠ WARNING Risk of death or serious injuries!**

  Cables routed from power supply connection X1 to the main switch are energized even when the main switch is turned off! This mains voltage can cause injuries on contact.

- Tool and workpiece have been removed.
- Compressed air is shut off and vented.

- Pneumatic connections to customer equipment are disconnected and the system is depressurized.
- The hydraulic unit is switched off and the hydraulic system is depressurized.
- Work in accordance with the ESD guidelines.

Work regulations

- The manufacturer's instructions must be observed when using cleaning agents for cleaning work.
- It must be ensured that no cleaning agents enter electrical components.
- Do not use compressed air during cleaning work.
- Do not spray with water.

Procedure

1. Check that the tool and workpiece have been removed.
2. Check whether the hydraulic unit has been switched off and the hydraulic system is depressurized.
3. Pneumatic connections to customer equipment are disconnected and the system is depressurized.
4. Check that the robot controller and FSW controller have been switched off and secured against being switched on again.
5. Loosen and vacuum up any dust deposits.
6. Clean robot controller, manipulator and FSW controller with a cloth soaked with a mild cleaning agent.
7. Clean cables, plastic parts, and hoses with solvent-free cleaning agents.
8. Replace damaged, illegible or missing identifications, labels and plates.

12 Repair

12.1 Exchanging the FSW spindle

Precondition

- The robot controller and FSW controller are switched off and secured to prevent unauthorized persons from switching them on again.
- The hydraulic unit is deenergized and depressurized.
- The pneumatic unit is depressurized.
- The cooling unit is deenergized and depressurized.
- The power cable is deenergized.

⚠ WARNING Risk of death or serious injuries!

Cables routed from power supply connection X1 to the main switch are energized even when the main switch is turned off! This mains voltage can cause injuries on contact.

- Work in accordance with the ESD guidelines.

Procedure: see spindle operating instructions

1. Check the coding on the motor cable and the cable for the force sensors.
2. Open the vent plugs of the hydraulic hoses to release the remaining pressure.
3. Release the fittings on the hydraulic connections. First on the connection for the “Clamp” hose, then on the connection for the “Release” hose. Secure the sealing ring on the thread when doing so, e.g. using blanking plugs.
4. Carefully release the fittings on the connections for motor cooling. Minimize the escape of coolant, e.g. by using blanking plugs.
5. Remove the FSW spindle.
6. Install the new spindle and move it into position.
7. Connect the hoses for motor cooling.
8. Connect the hoses for the hydraulic system.

12.2 Exchanging the recooling system

Precondition

- The recooling system is switched off.
- The robot controller and FSW controller are switched off and secured to prevent unauthorized persons from switching them on again.
- The recooling system is depressurized.

Description

Information about the recooling system can be found in the installation, operating and maintenance instructions of the recooling system.

For detailed information from Rittal, see Section 16.3.

Procedure

1. Remove the electrical connection and the connections of the coolant circuit and seal them, e.g. using blanking plugs.
2. Empty the coolant tank into a container via the tank drainage nozzle either directly or using a hose.
3. Remove the recooling system.
4. Insert the new recooling system.
5. Fit the electrical connection and the connections of the coolant circuit.

Further information on this can be found in Section 9.4.

13 Troubleshooting

13.1 Event messages

Message	Cause	Remedy
The message “Operator safety open” is displayed in AUT EXT mode	■ Cable break ■ Gate limit switch or gate interlock defective.	Eliminate the error
Error: no tool in spindle	The tool in the FSW spindle is incorrectly clamped	Clamp tool again manually
EMERGENCY STOP	EMERGENCY STOP device triggered	■ Release the EMERGENCY STOP device ■ Acknowledge EMERGENCY STOP
Defective EMERGENCY STOP	■ EMERGENCY STOP device defective ■ Cable break	■ Exchange EMERGENCY STOP device ■ Rectify cable break
Conditions for the FSW spindle are not met	See FSW spindle documentation	See information from manufacturer
Chiller not ready	See operating instructions of recooling system.	Procedure: See information from the recooling system manufacturer.

14 Decommissioning, storage and disposal

14.1 Decommissioning

Precondition

- The system is deenergized.
- The system is depressurized.
- The system must be checked for depressurization.

Procedure

NOTICE

Information about decommissioning is contained in the documentation of the individual components.

14.2 Storage

Precondition

If the FSW robot system is to be put into long-term storage, the following points must be observed:

- The storage location must be dry and free from dust. Do not store product outside.
- Avoid temperature fluctuations.
- Avoid wind and drafts.
- Avoid condensation.
- Use appropriate coverings that cannot detach themselves and which can withstand the expected environmental conditions.
- Store loose parts and small parts in the workspace of the cell.
- Do not leave the FSW robot system exposed to direct sunlight while in storage.
- Observe and comply with temperature ranges for storage.
- Select a storage location in which the packaging materials cannot be damaged.

Procedure

1. Clean the FSW robot system. No dirt may remain on or in the FSW robot system.
2. Inspect the FSW robot system, both internally and externally.
3. Empty the coolant tank and hydraulic unit in accordance with the installation, operating and maintenance instructions for the recooling system.
4. Remove foreign bodies.
5. Remove any corrosion expertly.
6. Attach all covers to the FSW robot system and check that the seals are correctly in place.
7. Unplug electrical connections and seal them with suitable covers.
8. Seal hose connections by suitable means.

9. Cover the FSW robot system with plastic film and seal it at the base frame against dust.

Provide an additional desiccant inside the sheeting if necessary.

14.3 Disposal

When the robot system reaches the end of its useful life, it can be dismantled, and the materials can be disposed of properly by type.

The following table provides an overview of the materials used in the robot system. Some of the plastic components are marked with a material designation and must be disposed of accordingly.

NOTICE

As the end user, the customer is legally required to return depleted batteries. Used batteries can be returned to the vendor or brought to the designated collection points (e.g. in communal refuse collection facilities or commercial centers) free of charge. The batteries can also be sent to the vendor by post.

The following symbols can be found on the batteries:

Crossed-out garbage can: battery must not be disposed of with ordinary household refuse.

Pb: battery contains more than 0.004 lead by weight.

Cd: battery contains more than 0.002 cadmium by weight.

Hg: battery contains more than 0.0005 mercury by weight.

NOTICE

Lubricants, hydraulic oil, coolants and cleaning agents that are harmful to the environment must not be allowed to enter the ground or drainage system. These substances must be stored, transported and collected in suitable containers and disposed of in accordance with the applicable national laws, regulations and standards.

Material	Use	Disposal
Cast steel	Gear unit housing, hydraulic pump	
Steel	Frames, base frame, worktable, gear units, screws and washers	
Aluminum	Safety fence	
	Motors	Dispose of motors without dismantling.
PUR	Cable sheaths	
ETFE	Flexible tube	
Copper	Cables, wires	
PU	Hoses	
PA	Hinged clamps	
NBR	O-rings, shaft seals	
EPDM	Seals and covers	
PTFE	Sealing rings	
Makrolon	Windows	
Electrical components	Sensor, boards	Dispose of as electrical scrap without disassembling
Cooling water with glycol		

15 KUKA Service

15.1 Support requests

Introduction

This documentation provides information on operation and control and supports you during troubleshooting. For further support, please contact your local subsidiary.

Information

The following information is required for processing a support request:

- Model and serial number of the manipulator
- Model and serial number of the controller
- Model and serial number of the linear unit (if present)
- Model and serial number of the energy supply system (if present)
- Version of the System Software
- Optional software or modifications
- Diagnostic package **KrcDiag**
- Additionally for KUKA Sunrise: existing projects including applications
- For versions of KUKA System Software older than V8: archive of the software (**KrcDiag** is not yet available here.)
- Application used
- External axes used
- Description of the problem, duration and frequency of the fault

15.2 Service and spare parts

KUKA Deutschland GmbH has a worldwide reputation as a reliable and innovative partner for automatic production systems. A reputation we live up to every day.

Just as our manufacturing systems are flexible and custom-tailored, so is the range of services we offer.

Service

Service packages such as teleservice, maintenance and inspections guarantee the high availability of your KUKA system in the long term.

The KUKA Deutschland GmbH Training Center offers you customized training packages covering every aspect of the systems, machines, components and processes, ensuring that you derive maximum benefit from your investment.

Fast and efficient delivery of customized service is an important part of the KUKA Deutschland GmbH spectrum of products and services.

Spare parts

Spare parts from KUKA Deutschland are perfectly tailored to your machine or system. Only original spare parts are offered. If, in the event of a fault, or when stocking up on spare parts, you are not sure which parts you require, our team will help you quickly and systematically, even with the most difficult tasks.

How to contact us:

Address:	KUKA Deutschland GmbH Zugspitzstr. 140 86165 Augsburg Germany
Website:	www.kuka.com
e-mail:	hotline.DE@kuka.com
KUKA Service:	Phone+49 (0)821 797 2002 hotline.DE@kuka.com
KUKA Spare Parts:	Phone+49 (0)821 797 2002 hotline.DE@kuka.com

16 Appendix

16.1 Spare and wearing parts

NOTICE

The spare and wearing parts lists can be found in the folder “E_V_Parts”.

16.2 Drawings

Description	Designation/drawing number
Layout	401.002-03_Sheet01
Safety layout	401.002-03_Sheet02
Electrical circuit diagram	550.010-90.203
Pneumatic diagram	550.010-50,500.01
Hydraulic diagram	550.010-50,530.01
Cooling system	550.010-90.102
Integration of 6D sensor IP65 Omega191	550.010-11.005
FSW Safe Robot technology	550.010-11.020
Installation kit, pedestal/robot	867.009-81.501
Flushing kit (optional)	550.010-89.010

NOTICE

The drawings and diagrams can be found in the folder “Drawings_(Mechanical)” and “Diagrams_Drawings_(Electrical_Pneumatic)”.

16.3 Technical documents

Suppliers

Description / component	Manufacturer (incl. address)
Operating/Assembly Instructions KR 500 MT FORTEC robot, KSS 8.6 software KUKA.SafeOperation KR C4 controller KR C4 interfaces (optional)	KUKA Deutschland GmbH Zugspitzstrasse 140 D-86165 Augsburg www.kuka.com
Operating instructions for FSW motor spindle	Corcom
Operating instructions for chiller	Rittal
Operating instructions MSB	FESTO
Operating instructions for SPAU pressure switch	FESTO
Operating instructions for pressure regulator	FESTO
Assembly instructions for pump units	HAWE
Product documentation for pressure switching devices	HAWE
Product documentation for connection blocks	HAWE
Product documentation for diaphragm accumulators	HAWE
Description of valves	HAWE
Product documentation for compact hydraulic power pack, intermediate plate	HAWE
Product documentation, oil recommendation	HAWE
Product information for force-torque sensor (optional)	Schunk
Operating instructions for main switch and EMERGENCY OFF switch, CE	Siemens
Operating instructions for safety switching device, declaration of conformity	Siemens
PCD 507 (optional)	KUKA
Operating instructions seam position detection (optional)	Keyence

NOTICE

The documentation is located in the “Suppliers” folder.

Safety data sheets

Castrol safety data sheet Hyspin AWS 32
TYFO safety data sheet TYFOCOR

NOTICE

The data sheets are located in the “Documents_Certificates” folder.