

SAFETY

ROBOT SYSTEM KR ... WITH KR C...

General

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We have checked the content of this documentation for conformity with the hardware and software described. Nevertheless, discrepancies cannot be precluded, for which reason we are not able to guarantee total conformity. The information in this documentation is checked on a regular basis, however, and necessary corrections will be incorporated in subsequent editions.

Subject to technical alterations without an effect on the function.

PD Interleaf

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Valid for all robot types KR ...
robot controller KR C...

The primary purpose of this Documentation Module is the safety of the user and operating personnel when using the device described below.

1 Liability

The device described in these operating instructions is an industrial robot – called “robot system” in the following text –, consisting of robot, connecting cables and control cabinet.

The robot system – the subject matter of these operating instructions – has been built in accordance with state-of-the-art standards and the recognized safety rules. Nevertheless, improper use of the robot system or its employment for a purpose other than the intended one may constitute a risk to life and limb of operating personnel or of third parties or cause damage to the robot system and to other material property.

The robot system may only be used in technically perfect condition in accordance with its designated use and only by safety-conscious persons who are fully aware of the risks involved in its operation. Use of the robot system is subject to compliance with these operating instructions and with the manufacturer’s declaration* supplied together with the robot system. Any functional disorders affecting the safety of the robot system must be rectified immediately.

The design and rating of the mechanical and electrical equipment of the robot system was based on the EC machinery directives that came into force on 1 January 1993 (89/392 EEC dated 14 June 1989 with amendments 91/368 EEC dated 20 June 1991 and 93/44 EEC dated 14 June 1993) together with their annexes and associated standards.

The following harmonized standards in particular were taken into account with regard to the safety of the robot system:

EN 292	Parts 1 and 2 (November 1991)	EN 50081	Part 2
EN 60204	Part 1 (June 1993)	EN 50082	Part 1
EN 775		EN 55011	
EN 418		EN 6100–4	Parts 4 and 5
EN 614	Part 1	EN 61800	Part 3
prEN 954	Part 1	DIN 40040	

The electrical part of the robot system additionally conforms to the “EC low voltage directive” (73/23 EEC dated 19 February 1973 and EN 50082–1) and the directive on “Electromagnetic compatibility” (89/336 EEC dated 3 May 1989 with amendments 92/31 EEC dated 28 May 1992 and EN 55011).

* The manufacturer’s declaration is to be found in the control cabinet.



▪ **Designated use**

The robot system is designed exclusively for the applications specified in the robot Doc. Module “Technical Data” (Section 1).

Using the robot system for any other or additional purpose is considered contrary to its designated use. The manufacturer cannot be held liable for any damage resulting from such misuse. The risk of such misuse lies entirely with the user.

Operating the robot system within the limits of its designated use also involves continuous observance of these operating instructions with particular reference to the maintenance specifications.

The software employed is matched to the applications specified by the customer/user and has been thoroughly tested. In the event that the functions contained in the software are not executed without interruption, the Doc. Module “Error Messages/Troubleshooting” must be consulted to remedy this condition. This also applies to malfunctions occurring during service, set-up, programming and start-up activities.

The robot system may not be put into operation until it is ensured that the functional machine or plant into which the robot system has been integrated conforms to the specifications of the EC directives 89/392 EEC dated 14 June 1989 and 91/368 EEC dated 20 June 1991.

No liability can be accepted if these directions are disregarded.

If the user provides items of equipment and the like which do not constitute part of the KUKA contract and these parts are integrated into the periphery of the robot system on behalf of the user, KUKA cannot be held liable for any resulting damage. Any risk associated with these parts (mechanical, pneumatic and electrical) lies entirely with the user.

These operating instructions consist of the following parts:

- robot
- control cabinet
- software

They constitute an integral part of the robot system supplied by KUKA, whose serial numbers for robot and control cabinet can be noted from the manufacturer’s declaration.

2 Safety symbols

The following safety symbols are used in these operating instructions:



This symbol is used where failure to fully and accurately observe operating instructions, work instructions, prescribed sequences and the like could result in injury or a fatal accident.



This symbol is used where failure to fully and accurately observe operating instructions, work instructions, prescribed sequences and the like could result in damage to the robot system.



This symbol is used to draw attention to a particular feature. Observance of the note will generally result in facilitation of the work concerned.

3 Safety

3.1 Fundamental safety regulations


The mechanical and electrical equipment of the robot system for which these operating instructions, prescribed by the manufacturer, have been issued meets the requirements of the standard DIN EN 775 concerning the safety of industrial robots. The technical features and possible mounting positions of this robot system are presented in detail in these operating instructions and in the relevant specifications for the robot and control cabinet.



Improper use of the robot system or its employment for a purpose other than the intended one may cause

- **danger to life and limb**
- **danger to the robot system and other assets of the user and**
- **danger to the efficient working of the robot system or its operator.**

The associated operating instructions therefore contain numerous indications of danger, which also apply to applications and to the use of accessories and supplementary equipment supplied by KUKA.

Every person involved with installation or exchange, adjustment, operation, maintenance or repair of the robot system must have read and understood these operating instructions, particularly the Doc. Module “Safety, General”, paying special attention to the passages marked with the symbol , which are of paramount importance.

These passages contain switch-off procedures and other safety precautions serving to protect operating personnel. Particular attention must be devoted to them when any work concerning for example, transportation, installation, operation, conversion and adjustment, adaptation, maintenance or repair is carried out.

Installation, exchange, adjustment, operation, maintenance and repair must be performed only as specified in these operating instructions and only by personnel specially trained for this purpose. The user is recommended to have personnel assigned for this work complete an application-specific KUKA training course.

The user should check at specific intervals selected at his own discretion that the personnel attend to their work in a safety-conscious manner, are fully aware of the risks involved during operation and observe these operating instructions.

The responsibilities involved in operation of the robot system and in all other work performed on the robot system or in its immediate vicinity must be clearly defined and observed by the user in order to prevent any uncertainty regarding spheres of competence in matters of safety.

The danger zones of the robot system, i.e. areas in which the robot together with tools, accessories and additional equipment moves, must in all cases be safeguarded according to DIN EN 775 to prevent persons or objects from entering these zones or to ensure that the robot system is immediately shut down by an EMERGENCY STOP system if a person or object should nevertheless enter a danger zone. This safety facility is the responsibility of the user.

The switching times of the EMERGENCY STOP system must be taken into account when determining the size of the danger zones.

The paint markings on the floor and signs indicating the danger zones must differ clearly in form, color and style from other markings within the machine or plant in which the robot system is integrated.

3.2 Particular safety measures for users and operating personnel



The robot system must be switched off before exchange, adjustment, maintenance and repair in accordance with the regulations contained in these operating instructions, i.e. the main switch on the robot control cabinet must be turned to “OFF” and secured with a padlock to prevent unauthorized persons from switching it on again.



Voltages in excess of 50 V (up to 600 V) can be present in the KPS, the KSDs and the intermediate-circuit connecting cables up to 5 minutes after the control cabinet has been switched off!

Any method of working that impairs the functional and operating safety of the robot system must be avoided.

The user and operating personnel must ensure that only authorized personnel are permitted to work on the robot system. The user must clearly set out what the responsibilities of operating personnel actually entail and give them the authority to refuse to carry out instructions from third parties which are contrary to safety procedures.

Do not allow personnel to be trained or instructed or personnel taking part in a general training course to work on or with the robot system without being permanently supervised by an experienced person.

Work on the electrical system or equipment of the robot system may only be carried out by a skilled electrician himself or by specially instructed personnel under the control and supervision of such an electrician and in accordance with the applicable electrical engineering rules.

Work on the hydropneumatic counterbalancing system (if present) may only be carried out by persons having special knowledge and experience of hydraulic and pneumatic systems.




**The operating personnel are obliged to inform the user immediately of any changes to the robot system which impair its safety or give reason to suspect that this might be the case.
The user must ensure that the robot system is only ever operated in faultless condition.**

The user must ensure, by means of appropriate instructions and checks, that the work station and the environment of the robot system are kept in clean and orderly condition.



No functional safety equipment may be dismantled or taken out of operation if this would directly or indirectly affect the robot system and if exchange, adjustment, maintenance or repair is carried out on the robot system. This would cause danger to life and limb, such as contusions, eye injuries, fractures, serious internal and external injuries etc.

If it is necessary for such safety equipment nevertheless to be dismantled during the above-mentioned work on the robot system, the machine or plant in which the robot system is integrated must be shut down in the exact manner specified, with particular attention being paid to the text passages of the operating instructions concerned marked with the symbol , and measures must be taken to prevent unintentional or unauthorized start-up. Immediately after completion of the exchange, adjustment, maintenance or repair work, the safety equipment must be reinstalled and checked to ensure that it is functioning correctly.



If it is essential for personnel to enter the working range of the robot system for conversion, adjustment, maintenance or repair work on the machine or plant in which the robot system is integrated, the safety measures must always be designed in such a way (e.g. enabling switches) that the robot system is switched off immediately should an unintended situation arise.

Aspects requiring special consideration:

Only trained personnel familiar with the hazards may be entrusted with exchange, adjustment, maintenance and repair work on the robot system.



When work is carried out in the danger zone of the robot, the latter may only, if absolutely essential, be operated at manual traversing speed at the most, to allow the personnel enough time either to avoid dangerous movements or to stop the robot.

All persons situated in the environment of the robot must be informed in good time that the robot is about to move.

Wherever possible, only one person should work in the danger zone of the robot at any time, with a second person remaining in visual contact outside the danger zone within reach of an Emergency Stop pushbutton.

If two or more persons are working in the danger zone at the same time, they must also all remain in constant visual contact. Responsibilities for each type of work and for each person must be clearly and comprehensibly defined.



In sensor-assisted operation, the robot is liable to perform unexpected movements and path corrections if the main switch on the control cabinet has not been turned to "OFF".



If work is to be carried out within the working range of a switched-off robot, the robot must first be moved into a position in which it is unable to move on its own, whether the payload is mounted or not. If this is not possible, the robot must be secured by appropriate means.

Components, tooling and other objects must not become jammed as a result of the robot motion, nor must they lead to short-circuits or be liable to fall off.

Any motion of the robot that would cause indirect danger to persons or objects must be avoided.

Due regard must be paid to hazards posed by the peripheral system components of the robot such as grippers, conveyors, feed devices or other robots in a multi-robot system.

Any unauthorized conversion or modification of the robot system is not allowed.

No customer-specific equipment may be installed in or on the control cabinet without the approval of the sales representative of KUKA Roboter GmbH responsible for your system.

The robot system including accessories and additional equipment may not be equipped or operated with products of other manufacturers whose use is not expressly permitted in these operating instructions or the parts catalog of the robot system.

When using prescribed operating media which are specified as aggressive or toxic, appropriate protective clothing must be worn. Warning remarks must be observed.

The maintenance cycles prescribed in these operating instructions must be adhered to.

These operating instructions must always be kept ready to hand at the place of use of the robot system (e.g. in the tool compartment or in the receptacle provided for them) – whether as a manual or CD-ROM.

3.3 Safety functions

The safety functions include:

- Restricted envelope
- EMERGENCY STOP
- Enabling switches
- Guard interlock

The circuits for EMERGENCY STOP, enabling switches and interlock conform to control category 3 according to EN 954-1

3.3.1 Restricted envelope – working space limitation

The robot is designed as standard to allow the attachment of adjustable mechanical stops in the three main axes for the limitation of the working space. In addition, the range of motion of all axes can be restricted using software limit switches.

3.3.2 EMERGENCY STOP

The EMERGENCY STOP button of the robot system is located on the KCP, which is also used as the programming and operator control device.

When triggered in the test modes, the EMERGENCY STOP function causes a safety stop with immediate disconnection of power to the drives, dynamic braking and application of the holding brakes.

In the automatic modes, an EMERGENCY STOP causes a controlled stop, with power to the drives being maintained in order to ensure this controlled stop. The power is only disconnected once the robot has come to a standstill.

3.3.2.1 External EMERGENCY STOP

If, due to the risk situation, it is necessary to install additional EMERGENCY STOP devices or if several EMERGENCY STOP systems need to be linked together, this can be done via a special interface provided for the purpose. See “Peripheral Interface” chapter.

3.3.3 Enabling switches

The KCP is equipped with three three-position enabling switches, which can be used to switch on the drives in the operating modes Test 1 and Test 2. Each of these enabling switches has three positions, of which only the middle position allows the robot to move. In either of the other positions, hazardous motions are safely stopped and the drives are safely disconnected.

3.3.3.1 External enabling switch

The “external enabling switch” function allows the connection of an additional enabling device. If it is necessary for a second person to be in the safeguarded space, then this is only permitted if this person also uses an enabling device.

3.3.4 Guard interlock (operator safety)

The robot controller features a two-channel safety input, to which the guard interlock can be connected. In the automatic modes, the opening of the guard connected to this input causes a controlled stop, with power to the drives being maintained in order to ensure this controlled stop. The power is only disconnected once the robot has come to a standstill. Motion in Automatic mode is prevented until the guard connected to this input is closed. This input has no effect in Test mode.

The guard must be designed in such a way that it is only possible to acknowledge the stop from outside the safeguarded space.

3.4 Emergency axis override device

The emergency axis override device can be used to move the robot mechanically after a malfunction via the main axis drive motors and, depending on the type of robot, also via the wrist axis drive motors in some instances. It is only for use in exceptional circumstances and emergencies (e.g. for freeing people).



The emergency axis override device may only be used if the main switch on the control cabinet has been turned to “OFF” and secured with a padlock to prevent unauthorized persons from switching it on again.



If a robot axis has been moved using the emergency axis override device, all robot axes must be remastered.

The robot may only be moved manually using the override device supplied by KUKA. The override device is pushed onto the axle of the motor (remove protective cap), which can then be turned. It is necessary to overcome the resistance of the mechanical motor brake and any other loads acting on the axis. The protective cap must be put back on after the operation.



The motors reach temperatures during operation which can cause burns to the skin. Appropriate safety precautions must be taken.

4 Planning and construction

The following safety measures must be implemented during the planning and construction of a robotic installation.

4.1 Foundations and substructures

It must be ensured that the dimensions and qualities specified by KUKA for the foundations, substructure or the ceiling construction have been adhered to. Deviations from these dimensions or quality requirements are not permitted.

4.2 Load ratings of the robot

It must be checked that the torques, acceleration, weights and other mechanical and environmental conditions to be expected in operation of the robot system lie within the permissible range for the robot.

4.3 Safety zones and working zones

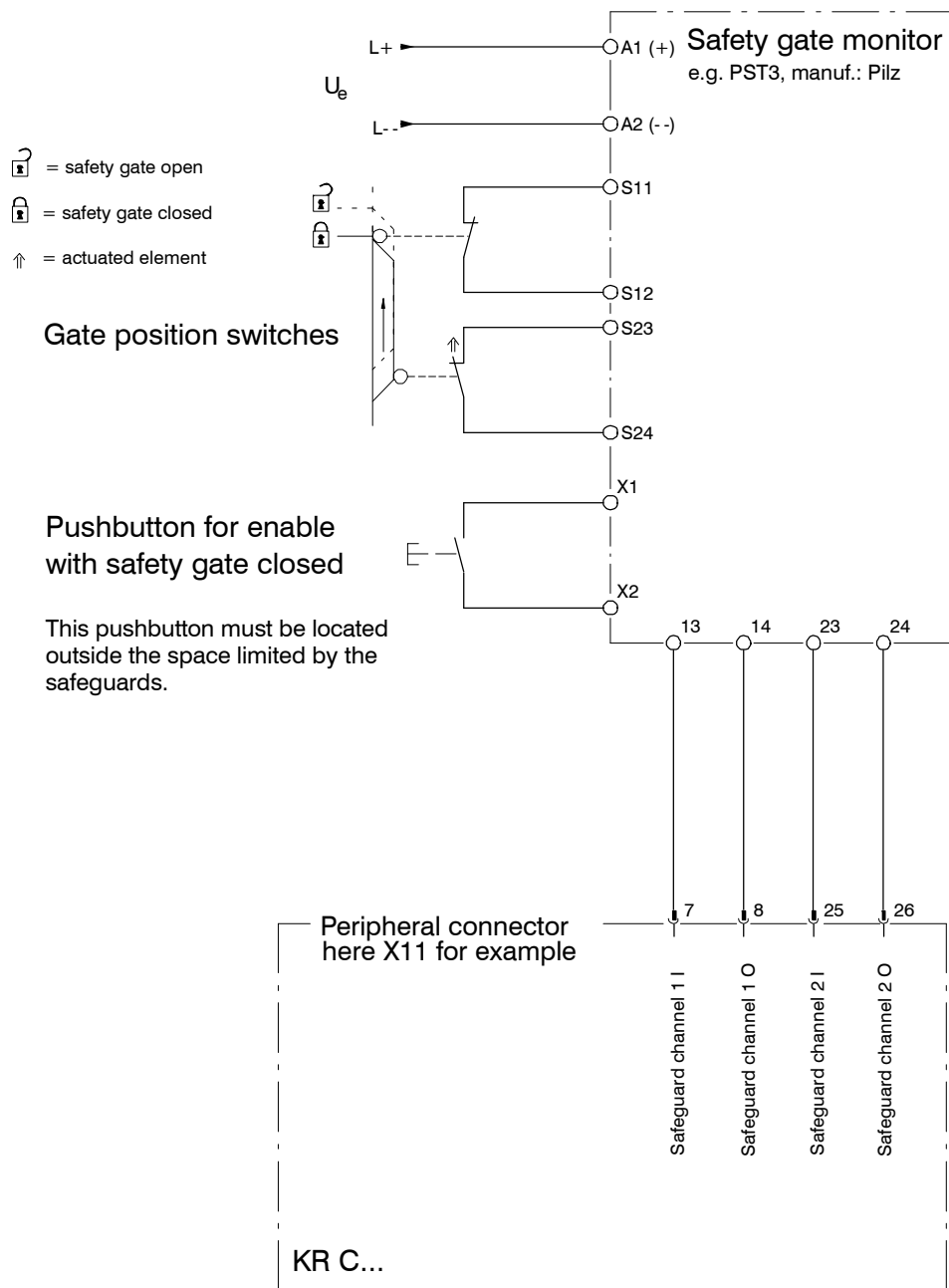
Working zones are to be restricted to the necessary minimum size. In addition to software limitation, they can also be safeguarded with adjustable mechanical stops (“working range limitation” accessory). The working zones must meet the safety requirements, i.e. on no account may persons or equipment be exposed to any danger.

Danger zones, i.e. areas in which robots move, must be safeguarded by means of protective barriers. These can take the form of safety fences, light barriers, light curtains or zone scanners, for example.

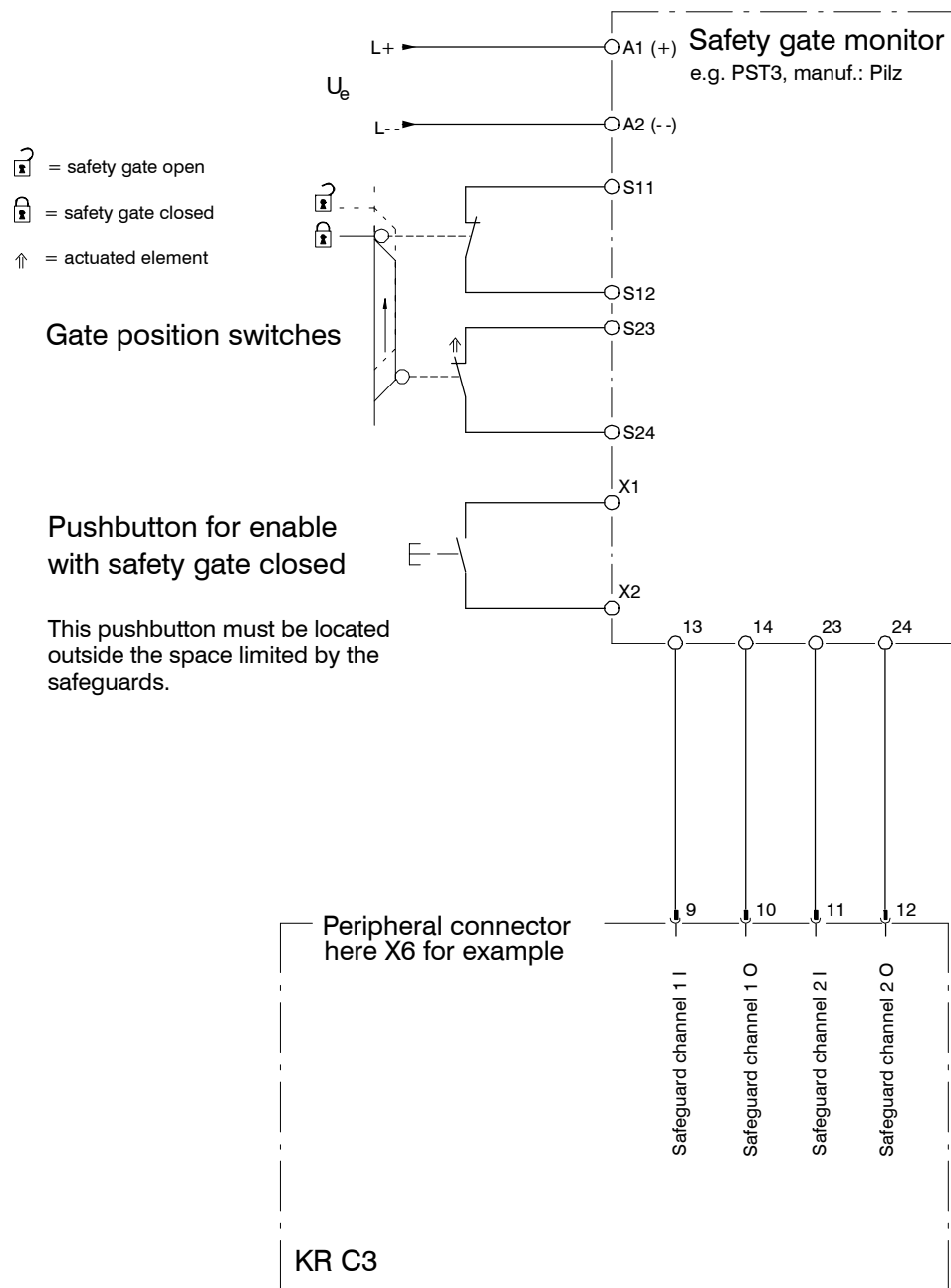
Fixed safety devices (safety fencing) must be designed to withstand all forces that are likely to occur in the course of operation, whether from inside or outside the enclosure.

If **safety fences** are used, they must have a mesh size as specified in DIN EN 294, DIN EN 349 and DIN EN 811. They must also be high enough to prevent anybody from reaching over them. The size of the fence sections must be selected in accordance with the strength of the fencing; design measures must be taken to prevent them from bending. The number of entrances (gates) in the fencing must be kept to a minimum. There should preferably be only **one** gate. All entrances must be connected to the safety devices incorporated in the robot and to the overall EMERGENCY STOP system.

Shown below is an example illustrating the connection of gate position switches in combination with a pushbutton for enabling operation when the safety gate is closed.



Irrespective of these safeguarding measures, the danger zone is to be indicated by means of paint markings on the floor. These markings must differ distinctly in form, color and style from other markings within the machine or plant in which the robot system is integrated.



Irrespective of these safeguarding measures, the danger zone is to be indicated by means of paint markings on the floor. These markings must differ distinctly in form, color and style from other markings within the machine or plant in which the robot system is integrated.

4.4 Operation in potentially explosive areas of explosion protection zone 2

(in compliance with EN 60079–10)

When operating an “explosion protection zone 2”-class KUKA industrial robot in potentially explosive areas of protection zone 2, the following preconditions must be met.



Protection zone 2 covers areas in which there is only an occasional and short-term risk of dangerous, potentially explosive atmospheres forming.



Operation is not permitted in areas at risk from flammable dust.

4.4.1 Industrial robot requirements

The industrial robot, connecting cables and accessories must be explicitly released by KUKA Roboter GmbH for operation in explosion protection zone 2 in accordance with the directives and regulations in force.



The operation of robots of normal design is not permitted in potentially explosive areas.

4.4.2 Operating environment of the industrial robot

The operating environment of the industrial robot must be defined and set up by the user as an explosion protection zone 2, in accordance with DIN VDE 0165 / DIN EN 60079–14 (Part 1).

The following requirements apply here:

- Equipment which, during normal operation, does not produce sparks, arcs or impermissible temperatures, may be used. (“Normal operation” here means the uninterrupted operation of a piece of equipment within defined limit values, e.g. temperature.)
- A temperature equal to or greater than the ignition temperature of the flammable material in question is not permissible.
- Only substances which comply with temperature class T3 are permissible in explosion protection zone 2.



Temperature class T3 is defined as follows:

- maximum permissible surface temperature of the equipment 200° C
- ignition temperature of flammable materials > 200° C

The safety characteristics of the potentially explosive atmospheres which could arise must be checked by the person responsible for the system. The following characteristics are laid down in EN 1127–1 / VDE 0165:

- Ignition temperature
- Flash point
- Explosion class
- Lower explosive limit (LEL)
- Upper explosive limit (UEL)
- Temperature class

4.4.3 Tools and additional equipment

Tools and additional equipment used in the protection zone must be released by the supplier and/or system builder for operation in protection zone 2 in compliance with the regulations in force.



The following standards, among others, must be observed:

- VDE 165 / EN 50021
- VDE 0100 (Part 540)



Responsibility for the fitting, adaptation and operation of tools lies entirely with the suppliers and/or system builders concerned.

4.4.4 KR C... control cabinet installation site

The KR C... control cabinet must be installed and operated **outside** the potentially explosive area.

4.4.5 Operation of the KUKA Control Panel (KCP)

The KUKA Control Panel (KCP) may only be used **outside** the protection zone. Exceptions are only permissible during programming.

4.4.6 Robot power supply

The customer must fuse-protect the robot power supply using a ground-fault circuit interrupter with a 300 mA tripping current. Type F374, ABB Stotz GmbH.

4.4.7 Electrical connecting cables

The electrical connecting cables between the KR C... control cabinet and the robot consist of motor and control cables.

The system user is responsible for the proper laying of the cables, cable inlets and the necessary safety measures (e.g. cable ducts) in compliance with the relevant regulations and standards.



Cable requirements:

Standard Cable with PVC sheath, flame-retardant in accordance with VDE 0472 (Part 804 B)

Special version, only if required:

Cable with PUR sheath, flame-retardant according to VDE 0472 (Part 804 B)

Temperature range for fixed installation: 80° C.

Cable diameter: motor cable approx. 25 mm

Data cable: data cable approx. 11 mm

4.4.8 Working range monitoring

Working range monitoring must be carried out with proximity switches using a redundant (dual-channel) design.



If mechanical limit switches are used, verification of the restricted breathing enclosure is required.

All equipment in the working range monitoring system must be suitable for the protection zone concerned.

4.5 Collision protection

The robot can be equipped with a collision protection device (additional equipment). This must in all cases be connected to the EMERGENCY STOP circuit of the robot system and higher-level controller.

In the case of conveyor operation, additional precautions are required to ensure that the conveyor cannot collide with the robot when the EMERGENCY STOP function is triggered. Appropriate measures must be taken to prevent the conveyor from continuing to move in areas where a collision is possible after an EMERGENCY STOP, e.g. by means of short systems with transfer stations.

4.6 Tool change

Removal and installation stations must be provided to allow tools to be changed. These stations must be accessible to the operator outside the danger zone and the robot must be able to move to them by means of a special program step.

4.7 Safety mats

If the presence of operating personnel in the work envelope of the robot is unavoidable (e.g. for loading components), the danger zone is to be isolated by means of a safety mat or light curtain. This can be accomplished by connecting the safety mat or light curtain to range limit switches ("working range monitoring" accessory) or a limit switch for the robot's home position and to the EMERGENCY STOP circuit.

4.8 Interface characteristics

The voltage and output load capacity values of all signals corresponding with the robot controller must lie within the permissible limits for the controller.

4.9 EMERGENCY STOP circuit (EN 418)

If the robot system is operated in conjunction with a higher-level controller, the two EMERGENCY STOP circuits must be interconnected. Both these circuits must be of failsafe design (dual EMERGENCY STOP contactors with reciprocal monitoring). In addition, every operator station must be provided with an EMERGENCY STOP device. This may take the form of a pull cord or a mushroom-head pushbutton with a locking mechanism. It is particularly important that a regular check is made to ensure that the EMERGENCY STOP devices are functioning correctly.

4.10 Presetting of outputs

Outputs are to be preset in accordance with the main project file, i.e. signals for hold functions must not be reset when the robot controller is switched off if personnel or equipment would be endangered as a result.

4.11 Tooling and additional equipment

If they have not been supplied by KUKA, tooling and additional equipment for the robot must be designed to the same standard of safety as the robot system. The specifications valid for the machine or plant into which the robot system is integrated must be applied analogously to the tooling and equipment (e.g. fuses for the primary circuit of welding transformers).

4.12 Safety regulations

The machine or plant into which the robot system is integrated must be checked before the robot system is installed to ensure that the user's safety regulations, general accident prevention rules and trade association regulations have been observed. Please observe Section 5.9.

5 Installation, operation and other work



Personal protection:

All persons working within the danger zone of the robot system must wear protective clothing. Of particular importance are safety helmets, safety footwear and closely fitting clothing. In addition, the safety regulations of the relevant trade associations are to be observed.



The motor units, the hydropneumatic counterbalancing system and the robot wrist are liable to reach operating temperatures which may result in burns. Work must not be carried out on these components until they have cooled down sufficiently.

5.1 Mains connection conditions

The mains connection conditions specified by KUKA in respect of conductor cross-sections, fuses, voltage and frequency must be adhered to. The pertinent regulations of the power utilities concerned must be observed.

5.2 Transportation

The prescribed transport positions for the robot must be observed. All angle specifications are referred to the mechanical zero of the robot axis concerned.



If fork slots are installed on the robot's base frame, the forks of the fork lift truck must be placed in these slots. In this case, it is forbidden to pick up the robot in any other way using a fork lift truck!

When being exchanged, individual parts and larger assemblies are to be fastened with care to the lifting gear and secured so that they do not constitute a hazard. Only suitable and technically faultless lifting gear and load-bearing equipment with an adequate carrying capacity may be used.



Do not work or stand under suspended loads!

The fastening of loads and the instructing of crane operators should be entrusted to experienced persons only. The marshaller giving the instructions must be within sight or sound of the operator.

5.3 Protection from dirt and UV radiation



No welding may be carried out in the immediate vicinity of the open control cabinet due to, amongst other factors, the risk of EPROMs being erased by UV radiation. Foreign matter (e.g. swarf, water, dust) must be prevented from entering the control cabinet. If a particularly large amount of dirt or dust is created during the installation phase, the control cabinet and robot must be covered.

5.4 Start-up

It must be ensured that all safety devices, limit switches and other protective measures are installed completely and functioning correctly before the robot system is started up. The system elements of the robot and the control cabinet must be checked for foreign bodies. No persons or objects may be in the danger zone (work envelope of the robot) during the start-up procedure. It must be ensured that the correct machine data have been loaded before the system is put into operation for the first time.



In order to comply with protection classification IP54, the control cabinet must only be operated with all of the provided cover plates for devices and options which are not present (e.g. connectors, converters, disk drives).

5.5 Software



Special software has been developed for the control computer. The software detects most incorrect entries and operator errors. For further information refer to the relevant parts of these operating instructions.

The hardware and software supplied have been checked for viruses. It is the user's responsibility to make sure that the latest virus scanner is always used. Relevant details can be found in the Chapter "Running Up / Shutting Down the Controller".

5.6 Operation

All safety regulations must be adhered to while the robot system is in operation. No changes may be made to safety measures or equipment. In the event of a malfunction, the robot must be switched off immediately. Until the fault has been eliminated, measures must be taken to prevent unauthorized start-up and to preclude any danger to persons or objects. Appropriate records are to be kept of malfunctions, their causes and the remedial action taken.

Check the robot system at least once per working shift for obvious damage and defects. Report any changes, including changes in the robot system's working behavior to the competent department or person immediately. If necessary, stop the robot immediately and lock it!

5.7 Shut-down

Before any exchange, adjustment, maintenance or repair work is carried out, the robot system must be shut down as specified in these operating instructions and precautions must be taken to prevent unauthorized start-up (e.g. padlock, keyswitch). If it is absolutely essential for the robot to be moved during certain activities, special attention must be paid to the relevant remarks in Section 3.2.

It is important to be prepared for possible movements of the robot even after the controller has been switched off and locked.

5.8 Additional remarks

Always tighten any screwed connections that have been loosened during maintenance and repair as specified.

When carrying out overhead work always use safety-oriented ladders and working platforms. Never use the robot or the control cabinet as a climbing aid.

Ensure that all consumables, auxiliary substances and replaced parts are disposed of safely and with minimum environmental impact!

5.9 Safety instruction

The personnel responsible for installation, exchange, adjustment, operation, maintenance and repair must be instructed before any work is commenced in the type of work involved and what exactly it entails as well as any hazards which may exist. Records are to be kept of the content and extent of the instruction.

The above-mentioned personnel must be instructed orally every six months and in writing every two years with regard to the observance of safety regulations and precautions. The instruction may be carried out by safety officers of the user and/or within the framework of the KUKA training program. Instruction is also required after particular incidents or technical modifications.

6 Safety labelling

6.1 General

Identification plates, warning labels and safety symbols are attached to the robot and to the inside and outside of the control cabinet. The connecting cables between the robot and the control cabinet as well as electric cables and other lines both in and on the robot and control cabinet are provided with designation labels, many also with position marks.

All of these plates, labels, symbols and marks constitute safety-relevant parts of the robot system. They must remain attached to the robot or control cabinet concerned for the whole of their service lives in their specified, clearly visible positions.



It is forbidden to remove, cover, obliterate, paint over or alter in any other way detracting from their clear visibility

- identification plates,
- warning labels,
- safety symbols,
- designation labels and
- cable marks.

6.2 Robot

See robot Doc. Module “Technical Data”.

6.3 Control cabinet

See control cabinet Doc. Module “Maintenance / Repair”.

7 ESD directives

7.1 General

The ESD regulations (ESD: electrostatic sensitive devices) must be observed at all times when handling modules for use in the KR C.... These modules are fitted with high-quality components and are very sensitive to electrostatic discharges (e.s.d.).

Partly through friction (triboelectricity) and partly through electrostatic induction, it is not rare for objects, or even people under certain environmental conditions, to become charged to very high voltages, up to several thousand volts.

The most common kind of electrostatic charging is caused by friction. This effect is particularly encouraged by the combination of synthetic fibers and dry air and occurs as a result of two fabrics with different dielectric constants rubbing together. This charges the materials, i.e. one material gives electrons to the other, resulting in an accumulation of charge carriers of one particular polarity. The same effect can also occur in people. Moving in a dry atmosphere with well-insulated shoes on a synthetic carpet, you can build up a charge of up to approximately 15 kV.

Even a fraction of this voltage (although imperceptible to a person) is enough to destroy ESDs. It is possible to see from the following table that the voltage endurance of modern semiconductor components, compared with the voltages which arise through electrostatic charging, is alarmingly low.

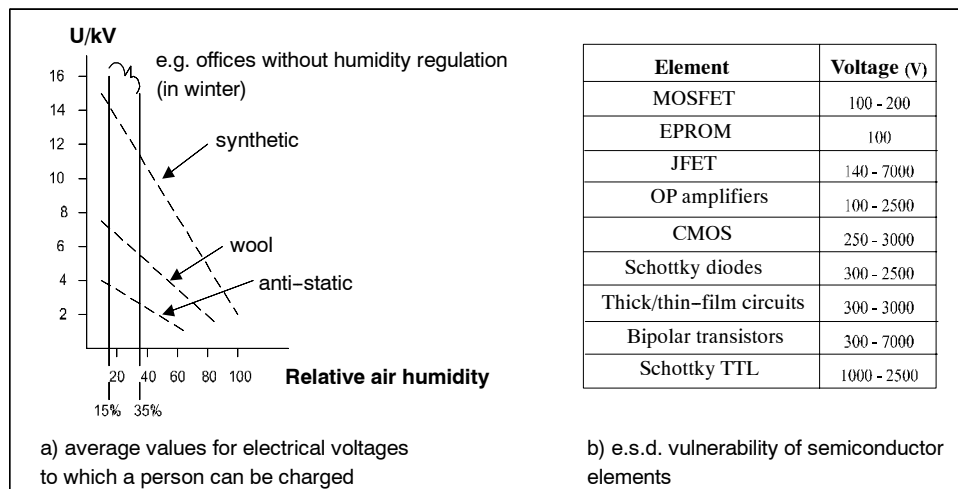


Fig. 1 Electrostatic charges in people and e.s.d. vulnerability of semiconductors

Furthermore, as well as causing complete failure of components, e.s.d. can also be responsible for partial damage to an IC or component, which in turn reduces service life or leads to sporadic faults of parts which are still, for the time being, able to function.



For these reasons, not only new modules, but also defective modules, must be handled very carefully in a way suitable for ESDs.

7.1.1 Handling ESD modules

- Components should only be unpacked and touched if
 - you are wearing ESD shoes or ESD shoe grounding strips, or
 - you are constantly grounded by means of an ESD armband through a 1 M Ω protective resistor
- Before touching an electronic module you should discharge the voltage from your own body (by touching a grounded, electroconductive object)
- Surroundings: antistatic table surfaces, conductive floor coverings, high relative air humidity, grounded tables and chairs (through 1 M Ω protective resistor)
- Electronic modules must not be brought near VDUs, monitors or television sets
- Modules may only be measured if
 - the measuring instrument is grounded (e.g. by means of a protective conductor) or
 - before measuring with a potential-free measuring instrument, the measuring head is briefly discharged (e.g. touched against an uncoated metallic section of the controller casing).
- Only unpack and touch electronic components if it is absolutely necessary.

The best protection against the effects of electrostatic discharges is not letting these charges build up in the first place. For this reason, the grounding of all possible electric potential carriers is absolutely vital for the optimal handling of ESDs (see diagram).

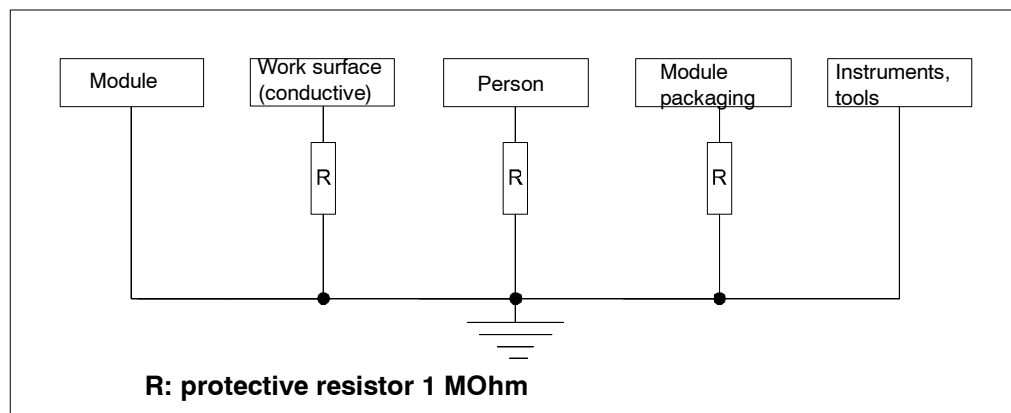


Fig. 2 Handling ESD modules

7.1.2 Packaging suitable for ESDs

When packaging ESD modules and components, care should always be taken to use only conductive and antistatic packaging materials, e.g. metallized or graphite-containing packaging, antistatic plastic bags, etc.

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