CR QA Meeting
Risk assessment for Kicker magnet

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on behalf of BINP team

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CDR review process
Questions in EDMS

h.schwarz@gsi.de (Other)

1. Do we have no water or oil cooling with a pressure than more 0.5 bar?
   If yes than we need also the Pressure Directive!

2. If you use this Directive you have to use the EN ISO 12100 for the risk assesment.
   See the Example from a E-Septum. Please ask Oleksiy Dolinskyy for futher information.

i.petzenhauser@gsi.de (Other)
I am no expert in risk assessment, but I don't understand some points of the list.

As an example: RL-05: Probability of occurence is very low and the impact is very low.
And then it is written that a lot of steps for mitigation are done (De-energize, only specialists, protective equipment, etc.) If it is not dangerous before, why bother? I think the Pre-Mitigation risk is higher?

Title:	**Risk assessment**
Description:	Hazard analysis and risk assessment of the Kicker Magnet System for the Collector Ring (CR) of the FAIR Accelerator Project
Organization:	Budker Institute of Nuclear Physics SB RAS
Valid for:	FAIR Contract No. CC 2.5.2.2.1.
	PSP: 2.5.5.1., 2.5.5.2.
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V1.3	27.07.2020	CDR Reviewing/Correction	Aleksey Kasaev	
V1.4	10.11.2020	CDR Reviewing/Correction	Aleksey Kasaev	

Table of Contents

Preamble

This document describes the processes used by BINP to identify and analyze hazards and assess risks associated with the life cycle of Injection/Extraction Kicker magnets for the FAIR Collector Ring (CR) System.

A hazard is defined as a condition or activity that, if left uncontrolled, can result in an equipment failure and/or personnel injury or illness.

A hazard analysis is used to identify and control hazards while performing work, both scientific and operations. Also hazard analysis evaluates hazards in the workplace and contains descriptions of the location, task, hazard and controls.

A risk assessment evaluates the potential consequence of exposure to a hazard.

Standards of Performance

Managers shall analyze work for hazards, authorize work to proceed and ensure that work is performed within established controls.

All staff and users shall identify, evaluate and control hazards in order to ensure that work is conducted safely and in a manner that protects the environment and the public.

1. Specification

The Risk analysis is oriented to the hazards during the life cycle of Injection/Extraction Kicker magnets for the FAIR Collector Ring (CR) System.

Comprises items related to the Work Packages: PSP 2.5.5.1., 2.5.5.2. CR Injection/Extraction Kicker magnets.

The specifications of Injection/Extraction Kickers for the Collector Ring (CR) are described in the Detailed Specifications *F-DS-CR-2.5.5-Inj_Extr_Kicker_v1.4_2016_09*.
The Risk analysis is applied to production and testing; shipment, transportation and storage; installation and commissioning; operation; adjustment; testing; maintenance and repair; decommissioning and dismantling of Injection/Extraction Kicker magnets.

2. Functional Description

The product limits

- Use limits (intended use/not intended use)
  Injection/Extraction Kicker magnets are used to create a pulse magnetic field of high quality for research purposes. Warranties are invalid if you do not use the product for its intended purpose.

- Spatial boundaries
  Total dimensions: 2552mm×595mm×1380mm (length×width×height)
  Required space: 2552mm×745mm×2700mm (length×width×height)

- Work and storage area
  Be sure you keep the product in a dry place that cannot span high humidity.
  Storage temperature is from 5°C to 40°C, storage humidity is from 30% to 70%.
  The magnet is intended for use in a closed electrical installations and in vacuum conditions.

Brief description of the product

The CR will use Injection/Extraction Kicker magnets. The six ferrite dipole magnets install into two vacuum tanks and uses for deflection of injection or extraction ion beam. There will be magnets with a deflection angle of ±15 mrad with a maximum field value of 54 mT. The usable magnet gap is 130 mm, while the horizontal good field region amounts to 180 mm. The integrated field quality as a function of radius over the length of the magnet is $\Delta B \cdot l / B \cdot l = \pm 1 \times 10^{-2}$.

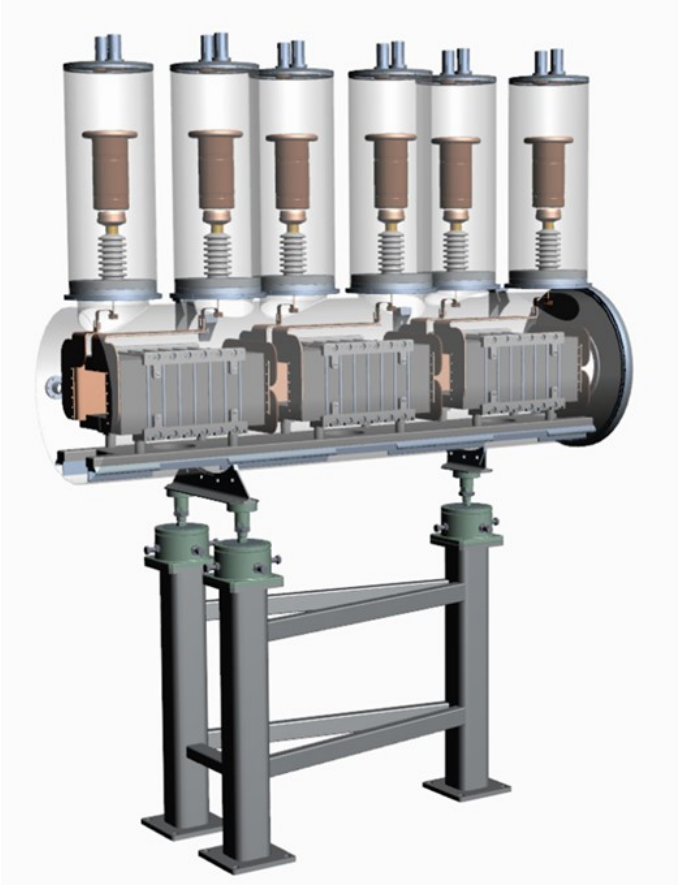
All CR Injection/Extraction Kickers are equipped in addition high voltage power supplies for provide short action magnetic field.

Vacuum tank serve for high conditions of vacuum quality and give the possibility to minimize aperture of kicker magnet.

All 6 Injection/Extraction Kickers of the Collector Ring will be connected with high voltage power supplies.

All Injection/Extraction Kicker magnets are equipped with cable connectors, alignment feet, references for alignment, stands and with additional handling and transportation units.

The 3D-Model of the Injection/Extraction Kicker magnet is presented on Fig. 1.



3. Applicable Documents

Applicable Specification, Laws and Regulations

All Injection/Extraction Kicker magnets for the FAIR Collector Ring (CR) System will be designed and manufactured in compliance with the FAIR Specifications (Annex 1), according to the best BINP engineering practice and applying the following laws and regulations:

Federal Law 184-FZ On Technical Regulation, dated 27.12.2002
GOST R ISO 31000-2010 Risk management. Principles and guidelines.
GOST R ISO/IEC 31010:2011 Risk management. Risk assessment techniques.
GOST R 51901.1-2002 Risk management. Risk analysis of technological systems.
GOST R 51901.11-2005/ IEC 61882:2001 Hazard and operability studies (HAZOP studies) – Application guide.
GOST 27.301-95 Dependability in technics. Dependability prediction. Basic principles.
GOST 27.310-95 Dependability in technics. Failure mode, effects and criticality analisys. Basic principles.

GOST R 54125-2010 (ISO 12100:2010) Safety of machinery and equipment. Principles for safety ensuring while designing.

BINP declares as a manufacturer that the Injection/Extraction Kicker magnets can be safely operated, if handled and used in the specified way in the accelerator tunnel/at the test bench according to the BINP Installation and Operation Manual, *FCRM_MK_Installation_Operation_manual_A*.

Applicable EU Directives

Directive	**Description**	**True**		**Justification for the decision, measures**
		Yes	**No**	
2006/42/EG	Machine Directive	+		Transportation and installation process
2006/95/EG	Low Voltage Directive	+		The magnet is electrical equipment designed to operate at a nominal voltage of 220 V.
2004/108/EG	Electromagnetic Compatibility	+		The magnet contains a large stored energy and requires a big power.
2014/68/EU	Pressure Equipment Directive	+		The power supply cooling

4. Hazard Analysis and Risk Assessment

A risk assessment is carried out in a few steps in accordance with the following documents:
GOST R ISO 31000-2010 Risk management. Principles and guidelines.
GOST R ISO/IEC 31010:2011 Risk management. Risk assessment techniques.

- Set the limits of the product
- Identify hazards
- Assess the risk
- Define safety objective and take protective measures
- Check the effectiveness of the measure
- Carry out further risk mitigation measures

A risk assessment evaluates the potential consequence of exposure to a hazard. The risk assessment process builds on the hazard analysis and determines risk based on severity of the undesired consequence and likelihood of the consequence occurring.

The risk assessment process identifies the hazards, analyzes those hazards against risk and assigns a risk level. Using the risk level, controls are established to reduce the risk to an acceptable level.

Impact (I)/ Severity Evaluation Criteria

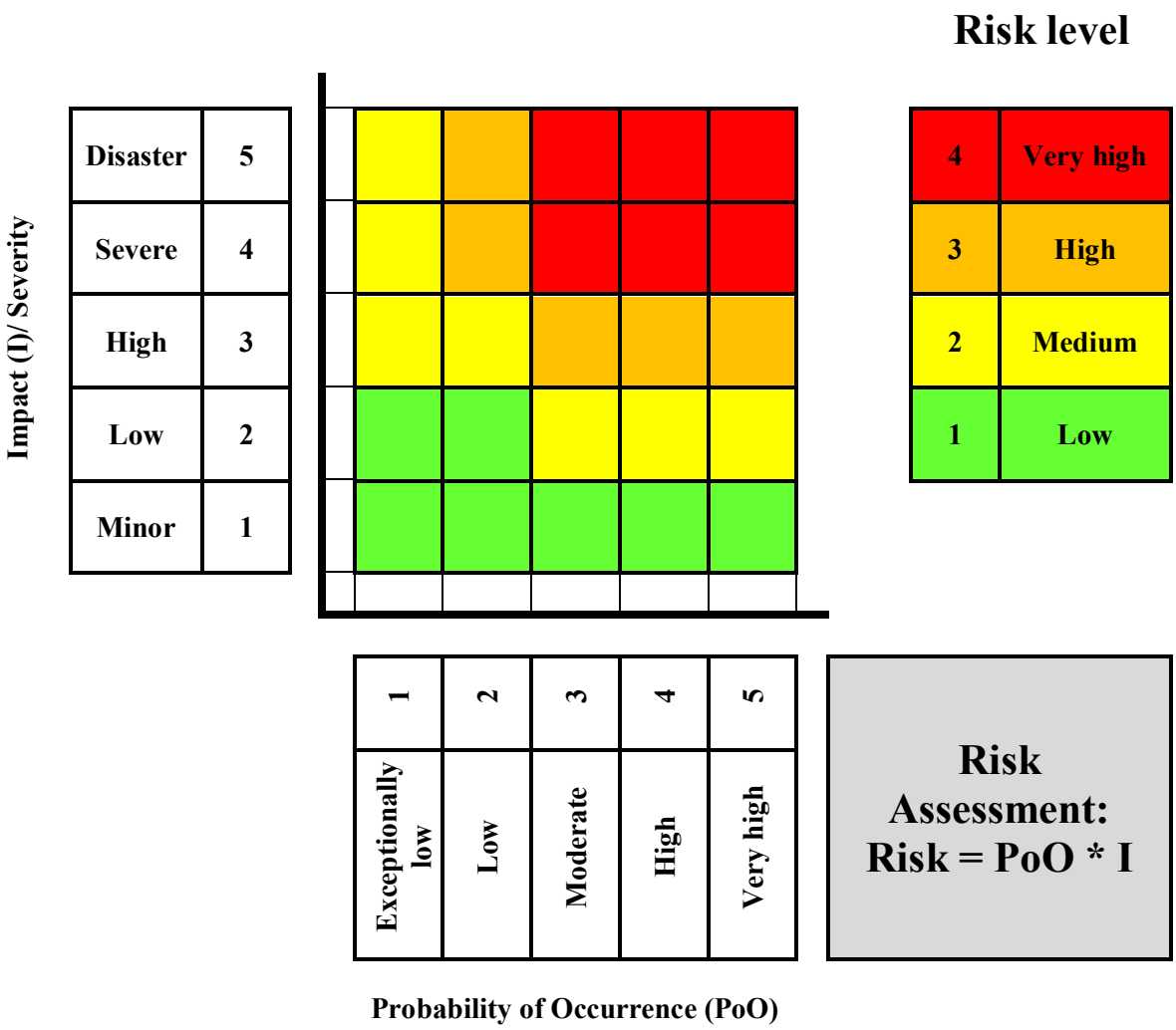
Effect	**Criteria: Severity of Effect**	**Rank**
Disaster	Complete loss of system or major sub-system and potential for hazard to life.	5
Severe	Complete loss of primary function. Critical component and/or assembly destroyed or put out of action.	4
High	Part loss or limitation of primary function and/or secondary function.	3
Low	Inconvenience or difficulty in achieving certain functions and/or very delayed project finish.	2
Minor	Inconveniences observed in certain operation.	1

Probability of Occurrence (PoO)

Rates	**Criteria: Occurrence Rates**	**Rank**
Very high	Very high number of failures likely.	5
High	Frequent failure likely.	4
Moderate	Moderate number of failures.	3
Low	Few failures ever expected.	2
Exceptionally low	Very remote possibility of failure.	1

Risk Rating

Risk level	**Risk potential**	**Measures**
4	Very high	The measures taken are not sufficient to mitigate the risk sufficiently.
3	High	Measures with increased protection are urgently needed.
2	Medium	Measures with normal protective effects necessary.
1	Low	Organizational and personal measures possible.


Risk level
Impact (I)/ Severity
Disaster 5
Severe 4
High 3
Low 2
Minor 1
4 Very high
3 High
2 Medium
1 Low
1 Exceptionally low
2 Low
3 Moderate
4 High
5 Very high
Probability of Occurrence (PoO)
Risk Assessment: Risk = PoO * I

5. Risk Assessment Table

BINP conduct hazard analysis and risk assessment to identify the hazards and appropriate controls.

The hazard-check list of the product is presented in the table below.

The risk assessment is oriented to hazards. The life phases of the product are identified with symbols (A, B, C, etc.) that mean:

Symbol	**Life cycle of the product**
A	Production & testing
B	Shipment & transportation & storage
C	Installation & commissioning
D	Operations
E	Adjustment
F	Testing
G	Elimination of faults in normal operation
H	Fault tracing & reparation
I	Maintenance & repair
J	Decommissioning & dismantling
ALL	All life phases of the product

The life phases are listed taking into account the potential hazards, endangered personnel, required level of electrical authorization in Annex 2.

Risk Log		Risk Identification			Risk Rating Pre-Mitigation			Risk Mitigration	Post-Mitigation Risk Rating		
Risk-ID	**№**	**Description of Risk (orientating to the hazard)**	**Life cycle**	**Possible consequences**	**Probability of Occurrence**	**Impact**	**Risk Level**	**Mitigration Strategy**	**Probability of Occurrence**	**Impact**	**Risk Level**
		TECHNICAL RISKS									
		Mechanical hazards									
RL-001	1	Damage of the magnet	BCI	Damage of parts of the magnet; Performance below specification; Failed to reach the required field quality	2	3	**2**	• Check that fastening bolts between the yoke plates and blocks are correctly tightened; • Magnet must be properly fastened to a suitable stand to prevent any fall during installation, operation, maintenance and storage. • Obey warning signs and boundaries. Follow handling and installation instructions according to the BINP Installation and Operation Manual, *FCRM_MK_Installation_Operation_manual_v1.3*	1	3	**2**
RL-002	2	Failure of welding joints	ABCI	Damage of parts of the magnet	2	3	**2**	Carry out inspection of welding lines on a regular basis. Follow handling and installation instructions according to the BINP Installation and Operation Manual, *FCRM_MK_Installation_Operation_manual_v1.3*	1	3	**2**
RL-003	3	Failure of brazing joints	ABCI	Damage of parts of the magnet; Water leakage from cooling system	2	3	**2**	Carry out inspection of brazing joints on a regular basis. Follow handling and installation instructions according to the BINP Installation and Operation Manual, *FCRM_MK_Installation_Operation_manual_v1.3*	1	3	**2**
RL-004	4	Magnet falling during handling	BCJ	Damage of parts of the magnet up to complete loss of the magnet; Personnel injury	2	4	**3**	• Check that fastening bolts between the yoke plates and blocks are correctly tightened; • Check that lifting eye bolts are correctly tightened; • Check that used chains, straps and hooks have the weight rating adapted to the magnet weight, corresponding number of attachment points and corresponding lifting angles. • Magnet must be properly fastened to a suitable stand to prevent any fall during installation, operation, maintenance and storage. • Obey warning signs and boundaries. Follow handling and installation instructions according to the BINP Installation and Operation Manual, *FCRM_MK_Installation_Operation_manual_v1.3*	1	4	**2**
		Electrical hazards									
RL-005	5	Contact with live parts (hydraulic fittings, etc.)	ACDF GHI	Electrical shock; Personnel injury	3	4	**4**	• Electrical equipment must be de-energized before work is conducted unless special exceptions exist. • Only qualified and authorized personnel may work on or near live parts, and only with a valid Electrical Work Permit. • Rule out accidental touching of live parts while an employee works on or near them. • Use proper Personal Protective Equipment. • Obey warning signs and boundaries.	2	3	**2**
RL-006	6	Cracks or breaks in the insulation (transmission cable insulation, layer-to-layer insulation in HV transformer, bus bars-to-case insulation, capacity destruction)	CI	Loss of equipment functionality; High voltage breakdown; Short circuits and fire	2	3	**2**	Carry out inspection of insulation (including thermal imaging) on a regular basis. Follow handling and installation instructions according to the BINP Installation and Operation Manual, *FCRM_MK_Installation_Operation_manual_v1.3*	1	3	**2**
RL-007	7	Cable breaks (power, diagnostic, etc.) including cracks or breaks in the insulation, failure of cable connections	CI	Loss of equipment functionality; Electrical shock; Fire; Personnel injury	2	3	**2**	• Cables must be labelled. • Cables must be traceable, viewable and accessible. • Cables must be protected from mechanical damage. • Avoid creating stumbling hazards with cables. • Regular inspection of insulation and connections. • Braked cables must be marked, apply a do-not-use tag. • Braked cables must be replaced.	1	3	**2**

RL-008	8	Thermoswitch internal interlock failure (temperature of coil)	D	Coils overheating	1	3	**2**	Check visually/electrically the continuity of thermoswitches. De-energize magnet in case of coils overheating.	1	3	**2**
RL-009	9	Power/ power supply failure (supply interrupted due to external reason)	D	Loss of equipment functionality	2	1	**1**	Does not require any action (supply interrupted due to external reason).	2	1	**1**
RL-010	10	Power supply and magnet still energized	ALL excluding BEJ	Would be no consequences	1	1	**1**	Does not require any action (would be no consequences).	1	1	**1**
RL-011	11	Work with power tools	ALL excluding BD	Electrical shock; Personnel injury	1	1	**1**	• Maintain tools so they are in good condition. • Inspect tools before each use. • Use the right tool for the job. • Use tools in accordance with manufacturers' instructions. • Obey all labels and instructions. • Worn-out tools must be marked, apply a do-not-use tag. • Worn-out tools must be replaced.	1	1	**1**
		Oil hazards									
RL-012	12	Oil leakage	ALL excluding BJ	Risk of pollution and fair	3	3	**3**	• Visual inspection of oil vessel. Satisfactory condition is absence of patches on the surfaces/tunnel floor. • Measure and compare the oil flow rate to the design value Follow installation instructions according to the BINP Installation and Operation Manual, *FCRM_MK_Installation_Operation_manual_v1.3*	1	2	**1**
		Thermal hazards									
RL-013	13	Fire/high temperature also origin of noxious gases	ALL excluding BEJ	Equipment failure up to complete loss of the magnet; Personnel injury	1	5	**2**	Use fire supervision system in the tunnel. Carry out preventive diagnostic measures in the tunnel on a regular basis. Use automatic fire suppression system in the tunnel. Use fire-proof and non-toxic materials. Verify that the area is free from unnecessary inflammables. Follow the GSI Safety Regulations. Complete the required GSI Safety Trainings.	1	5	**2**
		Radiation hazards									
RL-014	14	Accidental release of radiation to the tunnel environment (initiator fire and/or mechanical damage to the equipment)	D	Tunnel environment radioactive contamination; Workers exposure to radiation; Difficulties to repair and maintenance of equipment	1	5	**2**	Use radioactivity supervision system in the tunnel. Carry out preventive diagnostic measures in the tunnel on a regular basis. Follow the GSI Safety Regulations. Complete the required GSI Safety Trainings.	1	5	**2**

RL-015	15	X-ray radiation during thyratron operation	ACDF	Don't switch thyratron without protective shield. Workers exposure to radiation.	1	5	**2**	Do not open pulser case during operation. Follow the GSI Safety Regulations. Complete the required GSI Safety Trainings	1	5	**2**
		Magnetic field hazards									
RL-016	16	Magnetic field	ALL excluding BEJ	Personnel injury	1	1	**1**	The area surrounding the kicker magnet testing is not recommended to the people carrying a pacemaker. Obey warning signs and boundaries.	1	1	**1**
RL-017	17	Electromagnetic interference	D	Equipment failure	4	4	**4**	Do not use electronic device nearly equipment when the kicker magnet power supply cabinet is open and ready.	2	3	**2**
		Ergonomic hazards									
RL-018	18	Accidents of the sharp edges	ALL	Personnel injury	3	1	**1**	Use the rubber corner bumpers. Use the basic Personal Protective Equipment (hard hats, safety glasses, steel tip shoes).	2	1	**1**
		Combination of hazards									
RL-019	19	Design alteration and/or performance below specification	A	Delays to the schedule; Failed to reach the required field quality	3	3	**3**	The Parties shall monitor the scientific and technical progress of the Collaboration Contract activities. The Parties shall clarify the Technical Specifications during the project development. (Risk originated mainly from unpredictable deviation of the magnetic susceptibility of the stainless steel material of Injection/Extraction Kickers vacuum chambers from the specified low value. Proposed the following mitigation measures: special multi-pole correctors, which will compensate the negative influence of all field distortions produced in Injection/Extraction Kickers by slightly magnetic material of their vacuum chambers.)	2	3	**2**
RL-020	20	Lack of knowledge about GSI site, GSI safety regulations and procedures	ALL excluding AB	Damage to the personnel health due to hazards created by others	2	1	**1**	The Parties shall coordinate efforts to create and maintain a clean and organized work environment. Follow the GSI Safety Regulations. Complete the required GSI Safety Trainings.	1	1	**1**

6. Warning Signs and Boundaries

Warning signs and boundaries are used to safeguard personnel against exposure to the hazards. The Section provides a brief overview of proposed signs and postings, barricades and barriers.

Installation of warning signs and boundaries is the FAIR/GSI responsibility. Appearance, size and place of installation of warning signs and boundaries are carried out to comply with the FAIR/GSI standards.

A table of proposed Warning Signs and Boundaries:

Description	Appearance
WARNING SIGNS	
Caution Heavy	
Danger High voltage	
Danger Strong magnetic field	
Danger men working on equipment **Do not** **switch on** **or touch**	
WARNING BOUNDARIES	
Caution tape or ribbon	
Stanchions	

Annex

Life cycle of the product

The life phases are listed taking into account the potential hazards, endangered personnel, required level of electrical authorization.

Electrotechnical Personnel
Electrotechnical personnel are divided into the following groups: administrative & technical, operational, operational & repair and repair personnel who organize and carry out installation, adjustment, maintenance, repair and control of operation of electrical installations.
Administrative & technical personnel are supervisors who responsible for organization of technical and operational activities, including installation, commissioning and repair of electrical installations.
Operational personnel are specialists responsible for operational control and maintenance of electrical installations (inspections, maintenance of the workplaces, issuance of work permits, supervision of workers, performance of activities during the nominal operation).
Operational & repair personnel are specially trained specialists who qualified and authorized for operational servicing of the assigned electrical installations.
Repair personnel are specialists who carry out maintenance and repair, also assembly, adjustment and testing of electrical equipment.
Electrical & engineering personnel are specialists who use equipment that utilizes electric energy for electronic, electromechanical, chemical, heating, lighting or similar purposes (for example, welding, electric arc furnaces, etc.); also workers who carry out activities that require an Electrical Safety Level II or higher level of Electrical Authorization.
Non-electrotechnical personnel are specialists not meeting the definition of “electrotechnical” and “electrical & engineering" personnel.

Levels of Electrical Authorization

Electrical Safety Level I assigned to non-electrotechnical personnel using power tools at the workplace, do not require special electrical training (office personnel, etc).

Electrical Safety Level II assigned to electrotechnical personnel serving installations and powered equipment (without the right to connect/disconnect of electrical installations), such as welders, operators of high-frequency current installations, engineers of lifting equipment, etc.

Electrical Safety Level III assigned to electrotechnical personnel only; gives the independent right for inspection, maintenance, connection/disconnection of electrical installations up to 1000V.

Electrical Safety Level IV assigned to electrotechnical personnel only; gives the right to maintenance of electrical installations over 1000V. At least Level IV is required for personnel who are responsible for the electric facilities in the organization. Also assigned to operational personnel who conduct & assess Electrical Safety Trainings in the organization.

Electrical Safety Level V assigned to personnel responsible for electric/electric-power facilities in the organizations; also assigned to engineering personnel who operate electrical installations over 1000V.

Symbol	Life cycle of the product	Potential Hazards	Endangered Personnel, Required Level of Electrical Authorization
A	Production & testing	Mechanical hazards Electrical hazards Humidity hazards Thermal hazards Magnetic field hazards Ergonomic hazards	*Electrical & engineering personnel* *Electrical Safety Level II and higher level for workers; Electrical Safety Level III and higher level for supervisors*
B	Shipment & transportation & storage	Mechanical hazards Humidity hazards Ergonomic hazards	*Non-electrotechnical personnel*
C	Installation & commissioning	Mechanical hazards Electrical hazards Humidity hazards Thermal hazards Magnetic field hazards Laser hazards Ergonomic hazards	*Electrical & engineering personnel, Operational personnel* *Electrical Safety Level II and higher level for workers; Electrical Safety Level IV and higher level for supervisors*
D	Operations	Electrical hazards Humidity hazards Thermal hazards Radiation hazards Magnetic field hazards Ergonomic hazards	*Operational personnel* *Electrical Safety Level II and higher level for workers; Electrical Safety Level IV and higher level for supervisors*
E	Adjustment	Electrical hazards Humidity hazards Ergonomic hazards	*Electrical & engineering personnel* *Electrical Safety Level II and higher level for workers; Electrical Safety Level IV and higher level for supervisors*
F	Testing	Electrical hazards Humidity hazards Thermal hazards Magnetic field hazards Ergonomic hazards	*Operational personnel* *Electrical Safety Level II and higher level for workers; Electrical Safety Level III and higher level for supervisors*

G	Elimination of faults in normal operation	Electrical hazards Humidity hazards Thermal hazards Magnetic field hazards Ergonomic hazards	*Operational & repair personnel* *Electrical Safety Level II and higher level for workers; Electrical Safety Level IV and higher level for supervisors*
H	Fault tracing & reparation	Electrical hazards Humidity hazards Thermal hazards Magnetic field hazards Ergonomic hazards	*Operational & repair personnel* *Electrical Safety Level II and higher level for workers; Electrical Safety Level IV and higher level for supervisors*
I	Maintenance & repair	Mechanical hazards Electrical hazards Humidity hazards Thermal hazards Magnetic field hazards Ergonomic hazards	*Repair personnel* *Electrical Safety Level II and higher level for workers; Electrical Safety Level IV and higher level for supervisors*
J	Decommissioning & dismantling	Mechanical hazards Electrical hazards Ergonomic hazards	*Electrical & engineering personnel, Non-electrotechnical personnel* *Electrical Safety Level III and higher level for supervisors*
ALL	All life phases of the product	Combination of any of the above hazards, also Commercial Risks, Management Risks, External Risks	*Any of the above personnel, also Administrative & technical personnel*