

Technical Requirements for Electrical Equipment <small>Title</small> Environmental Specification for Normal Operation	Document TBE 101
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Contents

1	Introduction	2
2	Definitions	2
3	Environmental Conditions	2
3.1	General	2
3.2	Specific Environments	3
3.3	Electrical Environmental Conditions	3
3.4	Standardisation	4
4	Tables	5
4.1	Table 1 - Severity A - Environmental conditions for normal operation	5
4.2	Table 2 - Severity B - Environmental conditions for normal operation	6
4.3	Table 3 - Severity C - Environmental conditions for normal operation	7
4.4	Table 4 - Severity D - Stationary use at non-weather protected locations	8
4.5	Table 5 - Severity E - Stationary use at underground location	9
4.6	Table 6 - Electrical Environment – Immunity	10
4.7	Table 7 - Electrical Environment – Emission	12

Document	Issue	Date	Supersedes
TBE 101	11	2022-11-17	10

1 Introduction

This document defines the environmental conditions applicable for electrical equipment during normal plant operation considering the following environmental parameters. (Environmental specifications applicable for accident conditions are described in TBE 102:1).

- Industrial environmental conditions as classified by IEC 60721-3-3 and IEC 60721-3-4
- Ionising radiation
- Temperature transients
- Electrical environmental conditions according to IEC 61000-6-2 (Immunity) and IEC 61000-6-4 (Emission)¹

2 Definitions

The typical environments in a nuclear power plant have been divided in five basic severity categories, depending on the location:

- | | |
|-------------------|--|
| Severity A | Applicable to equipment installed in electrical rooms or similar mild environments.
Ionising radiation level is insignificant. |
| Severity B | Applicable to equipment installed in process locations outside the reactor containment.
Equipment may be subjected to ionising radiation. |
| Severity C | Applicable to equipment installed inside the reactor containment.
Equipment is subject to ionising radiation. |
| Severity D | Applicable to equipment installed at non-weather protected locations. |
| Severity E | Applicable for equipment installed underground. |

3 Environmental Conditions

3.1 General

Each electrical equipment is assigned one of the above listed severities. If the equipment cannot be assigned to one of the above listed severities, the necessary additional requirements shall be specified in the Technical Specification.

The different severities are specified in Tables 1-5. The applicable severity and additional requirements are stated in the Technical Specification.

¹ IEC 61000-6-2 and IEC 61000-6-4 are test specifications, here used as a reference for description of the electrical environment. For relay protection IEC 60255-26 applies.

3.2 Specific Environments

The following environmental conditions are applicable in addition to the conditions specified according to IEC 60721-3-3 and IEC 60721-3-4.

Severity C

Temperature Transient Exposure to +90°C and 100% RH during 8 hours per year

Severity B and C

For locations according to severity B or C ionising radiation shall be taken in consideration. Radiation levels are specified in the Technical Specification.

Severity D

For equipment in non-weather protected locations special attention shall be taken to moving parts that can be affected by ice and frost formations.

Wetwell

The Environmental Conditions for BWR Wetwell are described in Technical Specification.

3.3 Electrical Environmental Conditions

In addition to IEC 61000-6-2, as specified in table 6, the following conditions are applicable.

IEC 61000-6-2

Table Reference

- | | |
|-----|--|
| 1.1 | Power-frequency magnetic field, 50 Hz.
3 A/m (rms) for CRT Displays.
30 A/m (rms) for control room and similar environments without high levels of magnetic fields.
300 A/m (rms) for switchgear and other areas with high levels of magnetic fields. |
| 1.4 | Electrostatic discharge
Performance criteria “A” for operator panels and all parts accessible during normal operation
No degradation of function or performance allowed. |
| 4.3 | Interruptions in supply voltage, applicable to both AC and DC supply.
Interruption (reduction >95 % of nominal voltage) of any duration typically shorter than 5 000 ms. The electrical equipment has to recover to the required operating state without external intervention after the supply voltage interruption. |

Voltage and frequency fluctuations

The product shall conform to specified requirements on function and accuracy within variations in voltage and frequency at the point of connection of the object/product as stated below:

DC supply	85 ... 110 %	Continuously
AC supply, 220 V *	187 ... 242 V	Continuously
AC supply, 380 V *	323 ... 418 V	Continuously
AC supply, other	85 ... 110 %	Continuously
Mains frequency	47,5 ... 53 Hz	Continuously
Mains frequency	45 ... 55 Hz	Duration in the range of 10 s

* Nominal voltage from the auxiliary supply system of the plant to objects with rated voltage 220/230 VAC and 380/400 VAC respectively.

Additional electrical environmental conditions for relay protection systems

Environmental class 4 according to IEC 61000-4-5 defines the electrical environment for relay protection systems that are interfacing switchgears that are part of the outside plant external system.

3.4 Standardisation

The environmental conditions are to the extent possible specified according to the following standards:

IEC 60721-3-3 Classification of environmental conditions

- Part 3: Classification of groups of environmental parameters and their severities.
- Section 3: Stationary use in weather protected locations

Applicable environmental parameters are listed in Tables 1-3.

IEC 60721-3-4 Classification of environmental conditions

- Part 3: Classification of groups of environmental parameters and their severities.
- Section 4: Stationary use in non-weather protected locations

Applicable environmental parameters are listed in Table 4 & 5.

IEC 61000-6-2 Electromagnetic Compatibility (EMC)

- Part 6-2 Generic standards - Immunity for Industrial environments

Applicable parameters are listed in Table 6. Deviations from the standard are stated as remarks and also listed in section 3.3 above.

IEC 61000-4-5 Electromagnetic Compatibility (EMC)

- Part 4-5: Testing and Measurement Techniques - Surges Immunity Test

Applicable parameters are listed in Table 6.

IEC 61000-6-4 Electromagnetic Compability (EMC)

- Part 6-4 Generic standards – Emmision standard for industrial environments

Applicable parameters are listed in Table 7.

4 Tables

4.1 Table 1 - Severity A - Environmental conditions for normal operation

SEVERITY A - Environmental conditions for normal operation				
Environmental Classes according to IEC 60721-3-3				
Environment	Class	Description	Level	Remarks
Temperature air	3K22	Low	+5°C	Normal ambient temperature is 25°C unless other is given in the Technical Specification
	3K22	High	+40°C	
Temperature change	3K22	Ramp	0.5°C / min	Average over a period of time of 5 min
Humidity	3K22	RH	5-85 %	Non-condensing
Water from sources other than rain	3K23	Dripping water		
Chemically active substances	3CX	Salt and sulphur pollutions	Specified in Technical specification	Applies only to Ringhals
Mechanically active substances	3S6	Setting (sedimentary) dust	6 mg/(m ² *d)	d=days
Mechanical conditions	3M12	Stationary vibration, random: Acceleration spectral density Frequency range	Specified in technical specification	Location specific
		Shock	20 m/s ²	
Ionising radiation			None	

4.2 Table 2 - Severity B - Environmental conditions for normal operation

SEVERITY B - Environmental conditions for normal operation				
Environmental Classes according to IEC 60721-3-3				
Environment	Class	Description	Level	Remarks
Temperature air	3K22	Low	+5°C	Normal ambient temperature is 25°C unless other is given in the Technical Specification
	3K23	High	+55°C	
Temperature change	3K22	Ramp	0.5°C / min	Average over a period of time of 5 min
Humidity	3K22	RH	5-85 %	Non-condensing
Water from sources other than rain		Splashing	Specified in Technical Specification	Nuclear requirement
Chemically active substances	3CX	Salt and sulphur pollutions	Specified in Technical Specification	Applies only to Ringhals
Mechanically active substances	3S6	Setting (sedimentary) dust	6 mg/(m ² *d)	d=days
Stationary & non-stationary vibration including shock		Displacement Acceleration Frequency Shock	1.5 mm 5 m/s ² 2-9 / 9-200 Hz $\hat{a} = 70 \text{ m/s}^2$	Nuclear requirement. Only applicable to floor standing equipment or equipment mounted to the building structure
Stationary & non-stationary vibration including shock		Displacement Acceleration Frequency Shock	3.0 mm, 10 m/s ² 2-9 / 9-200 Hz $\hat{a} = 250 \text{ m/s}^2$	Nuclear requirement. Applicable to equipment mounted to process systems
Ionising radiation			Specified in the Technical Specification	Location specific

4.3 Table 3 - Severity C - Environmental conditions for normal operation

SEVERITY C - Environmental conditions for normal operation				
Environmental Classes according to IEC 60721-3-3				
Environment	Class	Description	Level	Remarks
Temperature air	3K22	Low	+5°C	Temperature transient +90°C, 8 hours / year. Normal ambient temperature is specified in the Technical Specification. The Conditions for BWR Wet well are described in Technical Specification.
	3K23	High	+55°C	
Temperature change	3K23	Ramp	0.5°C / min	Average over a period of time of 5 min
Humidity	3K23	RH	10-100 %	100% RH, 8 hours per year. The Conditions for BWR Wet well are described in Technical Specification.
Water from sources other than rain		Water jets		Nuclear requirement
Chemically active substances	3CX	Salt and sulphur pollutions	Specified in the Technical Specification	Applies only to Ringhals
Mechanically active substances	3S6	Setting (sedimentary) dust	6 mg/(m ² *d)	d=days
Stationary & non-stationary vibration including shock		Displacement Acceleration Frequency Shock	1.5 mm 5 m/s ² 2-9 / 9-200 Hz $\hat{a} = 70 \text{ m/s}^2$	Nuclear requirement. Only applicable to floor standing equipment or equipment mounted to the building structure
Stationary & non-stationary vibration including shock		Displacement Acceleration Frequency Shock	3.0 mm, 10 m/s ² 2-9 / 9-200 Hz $\hat{a} = 250 \text{ m/s}^2$	Nuclear requirement. Applicable to equipment mounted to process systems
Ionising radiation			Specified in the Technical Specification	Location specific
Pressure			500 kPa (abs)	
Pressure change			0 - 50 kPa/h	

4.4 Table 4 - Severity D - Stationary use at non-weather protected locations

SEVERITY D - Stationary use at non-weather protected locations				
Environmental Classes according to IEC 60721-3-4				
Environment	Class	Description	Level	Remarks
Temperature air	4K27	Low	-50°C	
	4K27	High	+45°C	
Temperature change	4K27	Ramp	1°C / min	
Humidity	4K27	RH	10-100 %	
Rain intensity	-	Rain	6 mm/min	Nuclear requirement
Solar radiation	4K27		1090 W/ m ²	
Ice and frost	4K27	N/A	N/A	See section 3.2
Chemically active substances	4CX	Salt and sulphur pollutions	Specified in the Technical Specification	Applies only to Ringhals
Mechanically active substances	4S10	Setting (sedimentary) dust	6 mg/ (m ² *d)	d=days
Mechanical conditions	4M12	Stationary vibration random: acceleration spectral density Frequency range:	0,1 (m/s ²) ² /Hz 5-200 Hz	

4.5 Table 5 - Severity E - Stationary use at underground location

SEVERITY E - Stationary use at underground location				
Environmental Classes according to IEC 60721-3-4				
Environment	Class	Description	Level	Remarks
Temperature	4K25	Low	+5°C	
Temperature	4K25	High	+45°C	Max temperature at underground locations +18°C
Temperature change	4K25	Ramp	1°C / min	
Humidity	4K25	RH	30-100 %	
Condensation	4K25		Yes	
Water from other sources than rain	4Z12		Dripping water	
Solar radiation	-		N/A	
Chemically active substances	-	Salt	~6 g/litre	
Ionising radiation	-		Specified in technical specification	Location specific

4.6 Table 6 - Electrical Environment – Immunity

Immunity–Requirements according to IEC 61000-6-2, generic standards for industrial environment

Table reference	EMC Environmental Phenomena	Parameter Specification	Remarks
Immunity - Enclosure ports			
1.1	Power-frequency magnetic field	50 Hz 30 A/m	See note ²
1.2	Radio-frequency electromagnetic field. Amplitude modulated	80 – 1 000 MHz 10 V/m 80 % AM (1 kHz)	
1.3	Radio-frequency electromagnetic field. Amplitude modulated	1,4-6,0 GHz 3 V/m 80 % AM (1 kHz)	
1.4	Electrostatic discharge	±4 kV contact discharge (charge voltage)	See note ³
		±8 kV air discharge (charge voltage)	
Immunity – Signal ports			
2.1	Radio-frequency common mode	0,15 - 80 MHz 10 V, 80 % AM (1 kHz)	See note ⁴
2.2	Surge Line to earth	1,2/50 (8/20) T _r /T _d μs ±1 kV (open circuit test voltage)	
2.3	Fast transients	±1 kV (open circuit test voltage) 5/50 t _r /t _w ns 5 or 100 kHz repetition frequency	See note ⁴

² Additional test and performance requirements for equipment in switchgear and other areas with high levels of magnetic fields according to IEC 61000-4-8:

- Table 1 level X (special) 300 A/m.
- Table 2 level 4, 1000 A/m during 3 s.

³ Additional test and performance requirements for operator panels and all parts accessible during normal operation according to IEC 61000-4-2 table 1:

- Contact discharge 6 kV (level 3).
- Air discharge 15 kV (level 4).
- Performance Criterion A according to IEC 61000-6-2 Section 4.1

⁴ Requirement also applies for functional earth ports

Table 6 continued - Electrical Environment – Immunity

Immunity–Requirements according to IEC 61000-6-2, generic standard for industrial environment			
Table Reference	EMC Environmental Phenomena	Parameter Specification	Remarks
Immunity - Input and output DC power ports			
3.1	Radio-frequency common mode.	0,15 - 80 MHz 10 V 80 % AM (1 kHz)	
3.2	Surges line-to-earth line-to-line	1,2/50 (8/20) T _r /T _d μs ±1 kV (open circuit test voltage) ±0,5 kV (open circuit test voltage)	
3.3	Fast transients	±2 kV (open circuit test voltage) 5/50 t _r /t _w ns 5 or 100 kHz repetition frequency	Nuclear requirement (±2 kV)
Immunity - Input and output AC power ports			
4.1	Radio-frequency common mode.	0,15 - 80 MHz 10 V 80 % AM (1 kHz)	
4.2	Voltage dips	70 % residual voltage 25/30 cycle at 50/60 Hz	
		40 % residual voltage 10/12 cycle at 50/60 Hz	
4.3	Voltage interruptions	0 % residual voltage 250/300 cycle at 50/60 Hz	
4.4	Surges line-to-earth line-to-line	1,2/50 (8/20) T _r /T _d μs ±2 kV (open circuit test voltage) ±1 kV (open circuit test voltage)	
4.5	Fast transients	±2 kV (open circuit test voltage) 5/50 t _r /t _w ns 5 or 100 kHz repetition frequency	

4.7 Table 7 - Electrical Environment – Emission

Emission - Requirements according to IEC 61000-6-4, generic standard for industrial environment

Table reference	Port	Frequency range	Limits	Remarks
3.1	Enclosure	30 – 230 MHz	40 dB (μ V/m) quasi peak measured at 10 m distance	
		230 – 1 000 MHz	47 dB (μ V/m) quasi peak measured at 10 m distance	
4.1	AC Mains	0,15 - 0,50 MHz	79 dB (μ V) quasi peak 66 dB (μ V) average	
		0,50 –30 MHz	73 dB (μ V) quasi peak 60 dB (μ V) average	