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| Technical Requirements for Electrical Equipment Title 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 | 3 |
| 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 | 12 | 2024-05-07 | 11 |

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 facilities 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 (Extreme operation).

High pressure test 500 kPa (abs) with a pressure change of 0 - 50 kPa/h.

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

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 – Emission 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 |
| | 3K22 | High | +40°C | Technical Specification |
| 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 (Extreme operation). 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 â = 70 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 â = 250 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) | Nuclear requirement. |
| Pressure change | | | 0 - 50 kPa/h | Nuclear requirement. |

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 | Thermal effect of solar radiation is not included in the temperature. |
| | 4K27 | High | +45°C | |
| Temperature change | 4K27 | Ramp | 1°C / min | Averaged over a period of time of 5 min. |
| Humidity | 4K27 | RH | 10-100 % | |
| Solar radiation | 4K27 | | 1090 W/ m ² | |
| Ice and frost | | 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 | Averaged over a period of time of 5 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 | See not ⁵ |
| 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 | |

⁵ 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 shall recover to the required operating state without external intervention after the supply voltage interruption.

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 (μV/m) quasi peak measured at 10 m distance | | |
| | | 230 – 1 000 MHz | 47 dB (μV/m) quasi peak measured at 10 m distance | | |
| 4.1 | AC Mains | 0,15 - 0,50 MHz | 79 dB (μV) quasi peak 66 dB (μV) average | | |
| | | 0,50 –30 MHz | 73 dB (μV) quasi peak 60 dB (μV) average | | |
| 5.1 | Wired network | 0,15 - 0,50 MHz | 97 to 87 dB (μV) quasi peak | 53 to 43 dB (μA) quasi peak | |
| | | | 84 to 74 dB(μV) average | 40 to 30 dB (μA) Average | |
| | | 0,50 –30 MHz | 87 dB (μV) quasi peak | 43 dB (μA) quasi peak | |
| | | | 74 dB(μV) average | 30 dB (μA) Average | |