

Technical Requirements for Electrical Equipment <small>Title</small> Field Mounted Process Instrumentation	Document TBE 104:2
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1 **General**

These Technical Requirements state the general requirements on field mounted Process Instrumentation in nuclear facilities. The requirements concern design, construction and documentation. Some requirements are therefore applicable only for certain types of equipment.

Additional requirements for Equipment containing software is given in chapter 4.

The equipment shall meet requirements in applicable EU-directives.

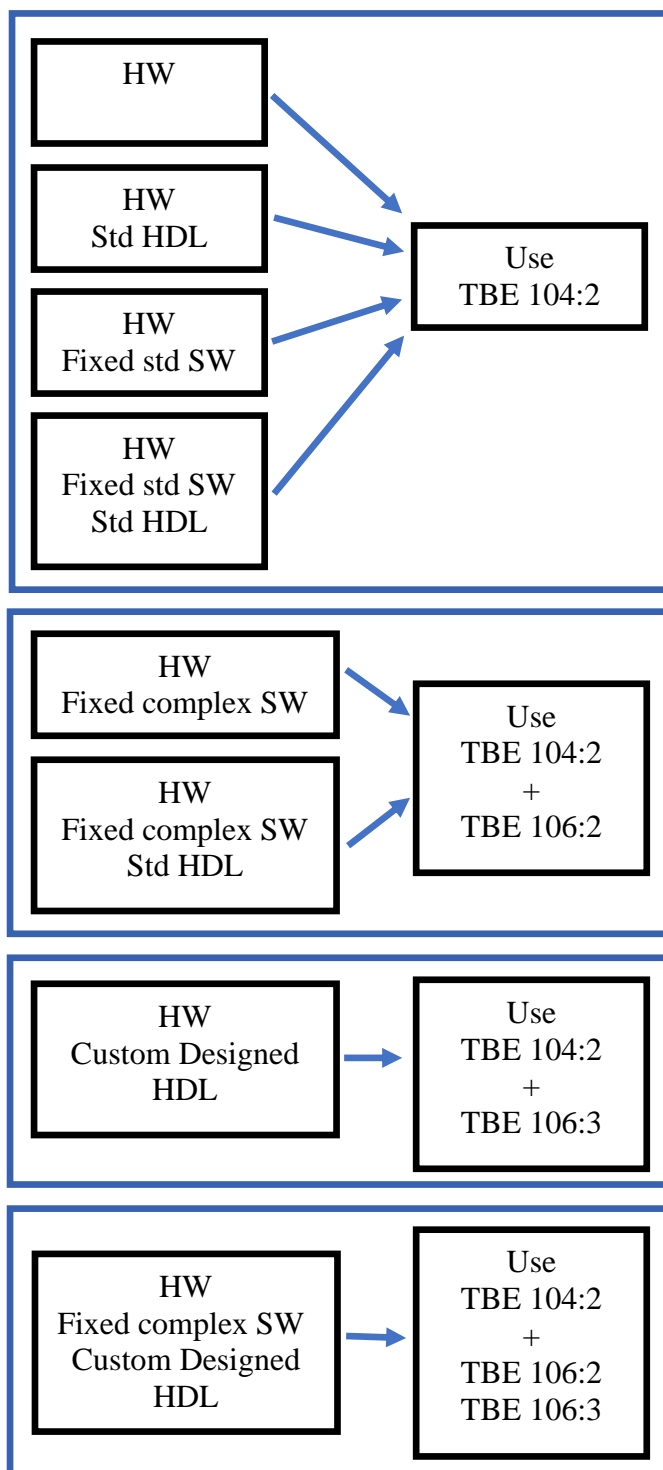
The purposes of these Technical Requirements shall state the general requirements on equipment for measurement, indication, signalling and protection as well as operating and regulating equipment.

In addition to this document, applicable parts of TBE 100:1 “General Technical Requirements and Explanations” apply.

The requirements stated in the “Technical Requirements for Mechanical equipment (TBM)” shall be included, when these are referred to in the Technical Specification.

Detailed technical data for the equipment are given in the Technical Specification (TS). If the requirements of various documents differ, the Technical Specification shall have precedence.

How to use combinations of TBE 104:2 and TBE 106:x



Definitions

Fixed std SW

Application software for single dedicated component and single use/few functions. Normally used/manufactured in large numbers.

Fixed complex SW

Application software for single dedicated component and single use with many functions. Normally used/manufactured in large numbers.

Std HDL

HDL for single dedicated and single use/few functions. Normally used in large numbers.

Custom Designed HDL

Specific circuit, designed by use of a HDL tool used in a custom designed application.

The above figure shows the relation between a specific equipment/component and its HW, SW and HDL elements and the related TBEs to be used. As an example, the interpretation of the upper block is as follow: TBE 104:2 is used as it is if the equipment consists of one of the following alternatives HW only or HW and standard HDL or HW and fixed standard SW or HW, standard HDL and fixed standard SW.

Some of the combinations above might not be relevant in practice.

2 Definitions

For general definitions see TBE 100:1 and KBE 100-X.

Hardware

Physical equipment used in data processing, as opposed to computer programs, procedures, rules, and associated documentation (IEEE, ISO).

HDL-Programmed Device, HPD

Integrated circuit configured (for NPP I&C systems), with Hardware Description Languages and related software tools

NOTE 1 HDLs and related tools (e.g. simulator, synthesizer) are used to implement the requirements in a proper assembly of pre-developed micro-electronic resources.

NOTE 2 The development of HPDs can use Pre-Developed Blocks.

NOTE 3 HPDs are typically based on blank FPGAs, PLDs or similar microelectronic technologies.

(IEC 62566)

MTBF

Mean Time Between Failure

MTTR

Mean Time To Repair

Printed Circuit Boards

The general term for completely processed printed circuit or printed wiring configurations. It includes rigid and flexible, single, double and multilayer boards.

Printed Circuit Board Assembly

A printed board with electrical or mechanical components, other printed boards, or a combination of these, attached to it with all manufacturing processes, soldering, coating etc.

Programmable electronics (PE)

Based on computer technology which may be comprised of hardware, software and of input and/or output units.

Example: The following are all programmable electronic devices

- *Microprocessors*
- *micro-controllers*

- *programmable controllers*
 - *application specific integrated circuits (ASICs)*
 - *programmable logic controllers (PLCs)*
 - *other computer-based devices (for example smart sensors, transmitters, actuators)*
- (IEC 61508-4)

Software

A set of ordered instructions and data that specify operations in a form suitable for execution by a digital computer
(IEC 60880).

Safety Integrity Level (SIL)

Discrete level (one out of a possible four) for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems, where safety integrity level 4 has the highest level of safety integrity and safety integrity level 1 has the lowest

NOTE – The target failure measures (see 3.5.13) for the four safety integrity levels are specified in tables 2 and 3 of IEC 61508-1.
(IEC 61508-4)

3 Product requirements

3.1 Standardisation

The standards referred in the document are:

IEC 61508	Functional safety of electrical/electronic/programmable safety related systems – Part 1-4.
EN 837-1	Pressure gauges - Bourdon tube - Diaphragm and Capsule pressure gauges - dimensions, metrology, requirements and testing. Selection and installation recommendations for pressure gauges
SMS 1560	Pressure gauges - Pointer with pointer socket for dials with concentric scale
EN 472	Pressure gauges - Terminology
IEC 60751	Industrial platinum resistance thermometer sensors
IEC 60584-1/2/3	Thermocouples, Extension and compensating cables – Reference tables, tolerances and identification system
DIN 43772	Control – Protective tubes and extension tubes
IEC 61071	Capacitors for power electronics
IEC 60384	Fixed capacitors for use in electronic equipment
IEC 60947-5-1	Low-voltage switchgear and controlgear - Part 5-1: Control circuit devices and switching elements - Electromechanical control circuit devices

Other requirements of standards are described in the Technical Specification.

The Supplier/Manufacturer shall in the quotation show degree of compliance with the regulations and applicable product standards. This also includes to which standards printed circuit boards and printed circuit board assemblies have been manufactured and mounted. If the standard referred to is divided into requirement levels for different classes, the Manufacturer/Supplier is also required to show which of these classes was applied.

The following documents are examples of applicable standards which can be the basis for the manufacturing of printed board assemblies:

IPC-A-600	Acceptability of printed boards
IPC-A-610	Acceptability of electronic assemblies
J-STD-001	Requirement for soldered electrical and electronic assemblies
IEC 61188-5-6	Printed board and printed board assemblies

The following documents are examples of applicable standards according to which components can be manufactured:

IEC 60747	Semi-conductor devices, discrete devices
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IEC 60748	Semi-conductor devices, integrated devices
IEC 60115	Fixed resistors for use in electronic equipment
IEC 60130	Connectors for frequencies below 3 MHz
IEC 60603-2	Two part connectors

3.1.1 Deviations/Modifications from standards

Concerning EMC and immunity the equipment shall fulfil the requirements in TBE 101, table 6 and 7.

3.2 General technical requirements

As a high degree of uniformity in the plant is desirable, the Supplier/Manufacturer shall choose type of equipment in consultation with the Purchaser.

General requirements on process instrumentation such as measurement range, settings and maximum acceptable errors including hysteresis, repeatability, accuracy etc., are specified in the Technical Specification.

Supplier/Manufacturer shall state the present response times for various functions. Response times shall be verified by test.

Crimping, soldering, wire-wrapping, shrinking and surface treatment are special processes and shall, therefore be performed according to qualified methods by specially trained personnel or by correctly set automatic processes.

3.2.1 Reliability

The Equipment reliability shall be stated by the Supplier/Manufacturer. Information of MTBF and MTTR values shall be given. The Supplier/Manufacturer shall specify how these data has been developed e.g. by calculation or by operating experience.

3.2.2 Components

The Supplier/Manufacturer shall verify that components such as temperature sensors, pressure sensors, level switch etc. are tested and inspected according to applicable standards.

A list containing the parts of the component including technical information such as type, part number, manufacturer, value and tolerance shall be made available upon request of the Purchaser. Original texts on parts may not be removed.

Capacitors installed in power electronics shall comply with the standard IEC 61071.

Electrolytic capacitors shall be of long-life types, e.g. IEC 60384-4 Long-life. Capacitors should not be older than two years at delivery to the Purchaser.

Potentiometers with carbon elements may not be used without the approval of the Purchaser.

3.2.3 Contact rating

The breaking capacity for contacts shall be according to IEC 60947-5-1. For contacts with maximum 110 VDC, Category DC 13 is applicable and for contacts with maximum 220/230 VAC, Category AC 15 is applicable. Other well-known standard may be accepted after the Purchasers approval.

3.2.4 Input and output circuitry

Input and output circuits should not be damaged by short-circuits or open circuits in connected equipment.

3.2.5 Packaging and Handling

Personnel handling sensitive components shall have necessary training and equipped with protective devices to reduce the exposure to ESD. ESD sensitive components shall be packed in ESD-protective packages during transport and storage in accordance with IEC 61340-5-X.

3.3 Testability

The Supplier/Manufacturer shall state how the equipment shall be verified after a replacement of component, change/upgrade of software or in connection with recurring testing.

It shall be possible to verify (simulate) important functions which are specified in the Technical Specification

3.4 Process instrumentation

Materials in contact with the medium shall be selected to suit the medium and measurement range. The requirements stated in the Technical Requirements for Mechanical equipment (TBM) are applicable when referred to in the Technical Specification.

3.4.1 Pressure gauges and differential pressure gauges

Pressure gauges shall be designed in accordance with EN 837-3, SMS 1560 and EN 472. Materials and type of pressure sensing elements shall be suited for the pressure range and the process medium specified.

Information concerning filling fluid in chemical seals shall be made available for approval by the Purchaser.

Differential pressure gauges shall withstand unilateral hydrostatic test pressure without being damaged. The hydrostatic test pressure is normally 1,5 times the design pressure specified in the Technical Specification.

3.4.2 Inline instruments

For pressure retaining instruments applicable parts of TBM “Technical Regulations for Mechanical Equipment” and KBM “Quality Regulations for Mechanical Equipment” should be considered.

3.4.3 Temperature sensors

The insulation resistance between terminals and sheath (earth) should be greater than 1 000 Mohm when measured at 250 VDC, if not otherwise specified.

Resistance temperature sensors shall be of the Pt100 type in accordance with IEC 60751, Class is specified in Technical Specification. Each sensor shall have its own measuring circuit, unless otherwise specified in the Technical Specification.

Thermocouples shall be of the NiCr-NiAl type in accordance with IEC 60584 if not otherwise specified. Hot junctions shall be insulated from any sheath with insulation resistance as specified above.

Thermowells for temperature sensors shall be designed in accordance with DIN 43772. Materials used in thermowells are specified in the Technical Specification.

3.4.4 Switches for temperature, level, pressure and flow

Switches shall have either a changeover contact or one open and one closed contact. The contact function should be distinct.

Specific requirements e.g. adjustable range, set point and maximum error including hysteresis, repeatability, accuracy etc. are specified in the Technical Specification.

Information concerning filling fluid in chemical seals shall be made available for approval by the Purchaser.

3.4.5 Ex-certified products

The equipment shall fulfil the requirements according to EU-Directive 2014/34/EU (ATEX-directive).

3.4.6 Position sensors for valves and dampers including valve controllers

The indicating device shall be designed so that it allows the passage of set points without the settings being changed and without risk for damage.

The design of fastening devices shall consider the effect of radiated and conducted heat from adjacent heat sources so that the indicators do not reach too high temperatures.

Fastening devices shall be designed to facilitate necessary service and maintenance on valves and dampers. If the fastening device needs to be removed during maintenance, this shall be easily performed. Any adjustments to indicating devices after re-mounting should also be easily performed and without impairment of the accuracy or performance of the device.

3.4.7 Mechanical position indicators

Position indicators and limit switches with associated transfer or fastening devices shall be mechanically rigid. The contact function shall be distinct. The effect of the environment, within specified limits, may not give rise to unintentional make, break, contact vibration or contact bounce when the switch is in one of the idle positions.

Switches shall have either a changeover contact or one open and one closed contact.

3.5 Other technical requirements

3.5.1 Operation, adjustment, calibration and troubleshooting

Everything on the component of importance for operation, testing, calibration, adjustment or troubleshooting shall be marked, be easily accessible and have test terminals or be connected to indicating instruments.

The component shall be provided with a robust protection or locking device to prevent changes of settings due to unintentional manipulations. A closed door or cap can be used as such a protection device. Shocks and vibrations that may take place in environments specified for the equipment should not affect operation and trimming devices.

Test points with a peak voltage exceeding 250 V shall be provided with voltage dividers.

Adjustment ranges for operation and trimming devices shall be chosen so that the setting of values can be performed within the whole working range and with the requisite accuracy.

Equipment circuit design and choice of components should be such that stability of set values are achieved.

3.5.2 Arrangement of equipment and components

Equipment should be placed well protected from vibrations, large variations in temperature, contamination and splash of water. Cables and conductors shall be protected from heat-emitting equipment.

3.5.3 Interchangeability

Identical equipment parts are normally to be interchangeable, both with each other and with corresponding spare parts, without any impairment to measurement accuracy or performance. Re-adjustment of the equipment in connection with replacement is acceptable. Replacement intervals for components with limited life, e.g. electrolytic capacitors, shall be specified.

4 Additional requirements for equipment containing software

These additional requirements shall be applicable on all components and equipment using software for collecting, converting data or controlling other equipment.

- This type of equipment is configured by setting different parameters by using buttons, switches on the front panel or by using a specific tool.
- Examples of such kind of equipment are transmitters, switches, converters and sensors.
- Equipment using software may only use fixed application.
- The equipment may only use one or a limited number of input signals and convert them into defined output signals as mA, V or a logical level.

- If two-way communication is possible this shall be blocked.

If any of the above requirements cannot be fulfilled TBE 106:2 shall be used.

The Supplier/Manufacturer shall specify all initial values of the output signals during the start-up sequence of the equipment.

4.1 Product requirements

The method used to develop and manufacture the product shall conform to IEC 61508 SIL2 in combination with documented and traceable operating experience. If another development model has been used corresponding to the same quality level that is documented and reviewable. The Supplier/Manufacturer shall describe the development model used for the equipment.

Documented and traceable operating experiences may to some extent compensate the shortcomings of the method used to produce the software.

The Supplier/Manufacturer shall produce a configuration management plan which provides a basis for defining, controlling and tracing requirements at the completion of different stages during the design process as well as documentation and versions of the software.

The Manufacturer/Supplier shall present all the equipment's implemented barriers concerning Cybersecurity.

4.2 Tools

Tools used for configuration, parametrisation, testing, fault tracing, documentation, etc., shall be evaluated and approved by the Supplier/Manufacturer.

4.3 Nuclear Specific Requirements

4.3.1 Components including HDL

The Manufacturer/Supplier shall state if custom designed HDL-programmed integrated circuits are used

Requirements are specified in Technical Specification as per TBE 106:3

5 Documentation

In addition to the documentation requirements according to TBE 100:1, the following requirements apply.

5.1 Product documentation

Description of the equipment, including data sheets and specification. For PE-equipment the SW function shall be described and the version/revision number of the software shall be stated.

The Supplier/Manufacturer shall present identified potential Cybersecurity risks when using tools or other possible terminals or possibilities for communication connections.

5.2 Design documentation

The design documentation describes how equipment and components are connected together electrically. Normally it includes:

- Internal and external connections
- Circuit diagram
- Type of terminal connections
- Component list
- Measurement specification
- Installation guidance
- Block diagram

It shall be possible to follow signals by means of unambiguous references in the function diagram and to the circuit diagram, within the system and to other connected systems.

5.2.1 For equipment containing PE the following applies:

The parameter list provides a list of timer circuits, counters and so on. There should be a list of the variables used. Inputs and outputs are shown on the circuit diagram and need not be included in the parameter list unless they have particular properties.

The logic diagram and the control block diagram give an overall description of the working of the system. Generally it cannot be replaced by the function diagram, since this has such a high level of detail and information density that it becomes unsuitable for describing the working of the system for normal operation.

5.3 Maintenance documentation

The maintenance guide describes:

- Fault localisation, troubleshooting
- Fault correction
- Preventive maintenance (checks, calibrations, cleaning, replacement of components with limited life in relation to the life of the system/component)
- Changing parameters
- Equipment for performing the above

5.3.1 For equipment containing PE the following applies:

Linking between version/revision numbers for:

- Hardware
- Software
- Tools

5.4 Instructions how to make a back-up and restore the software

The documentation shall be clear and easy to follow in a step-by-step manner. It should also be relevant to the tools supplied or suggested by the Manufacturer at the time of the purchase. The instruction shall be written in Swedish.

5.5 Operating documentation

Documentation that is used for daily operation shall be written in Swedish.

5.6 Inspection documentation

The Supplier/Manufacturer shall provide documentation from the performed Type Tests and Routine Tests according to the agreed inspection plan.

See also KBE 100-X.

5.6.1 For equipment containing PE the following applies:

The Supplier/Manufacturer shall show in writing that the development model/procedures invoked for the method used to produce the software is fulfilled. The Purchaser shall be given the opportunity to review the Suppliers/Manufacturers method of production.

6 Agreement between Manufacturer/Supplier and Purchaser

This checklist should be used as a base between Manufacturer/Supplier and Purchaser when discussing tenders or orders.

1	Review and upgrading of Technical Specification.	
2	Review and upgrading of Inspection Plan	
3	Seismic verification	
4	Requirements on separation - isolation	
5	Applicable standard for used products	
6	Applicable standard for test of used products	
7	Material specification	
8	Protection class	
9	Input and output signals	
10	Connection to process parameter	
11	Accessibility for maintenance	
12	Type of cable	
13	Cable and wire laying	
14	Selection of components e.g. switches, lamps	
15	The component side of each printed board shall be marked, in screen-printing or other durable method	
16	Information on solvents and cleaning procedures for printed board assemblies	
17	Packed, stored and handled to protect from electrostatic discharges (ESD)	
18	Description of development model (PE)	
19	Tools assessed and approved (PE)	
20	Relevant software version (PE)	
21	The equipment reliability. Figures and used references	
22	Performance Response time and verification by test Measuring range, accuracy, bit resolution, time resolution (PE)	
23	Documentation, used language in the document	
24	Statement of document structure and where the information according to the description can be found.	
25	Components including HDL	
26	Product documentation	
27	Design documentation	
28	Maintenance documentation	
29	Operating documentation	
30	Inspection documentation	
31	Operating experiences	
32	Cybersecurity	
33	Mechanical requirements as specified in TBM	
34	Software Development process	
35	Software operating experience	