

Technical Requirements for Electrical Equipment <small>Title</small> Programmable Electronics (PE) with programmable application	Document TBE 106:1-2
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1 Introduction

These Technical Requirements set out the requirements to be met by programmable electronics intended for use in nuclear power plants. The Technical Requirements comprise only requirements for technical systems. Administrative computer systems are not covered by these Requirements. The requirements shall be met by the Manufacturer/Supplier in order to achieve the safety and reliability goals of the Swedish nuclear power plant owners.

The **purpose** of this document is to set out general requirements to be met by programmable electronics and by the process of developing the software.

Overall requirements to be met by the programmable equipment, as well as other instructions for the Manufacturer/Supplier, are stated in other Requirements in accordance with the Technical Specification.

In addition to the Requirements in this document, the relevant parts of the requirements of TBE 100:1, General Technical Requirements and explanations, apply.

PE with programmable application (PE = programmable electronics).

In its basic version, the equipment consists of a general system in which a unique application can be programmed – or configured – by combining different standardised but product specific function modules/blocks/elements. The programming of the various function modules is seldom accessible. Usually it is delivered in a library of modules. After a running-in period, the application software can be locked by burning it into a PROM.

These requirements shall be applied to all components and equipment whose function is realised with software for gathering data, converting data, and controlling or regulating other equipment.

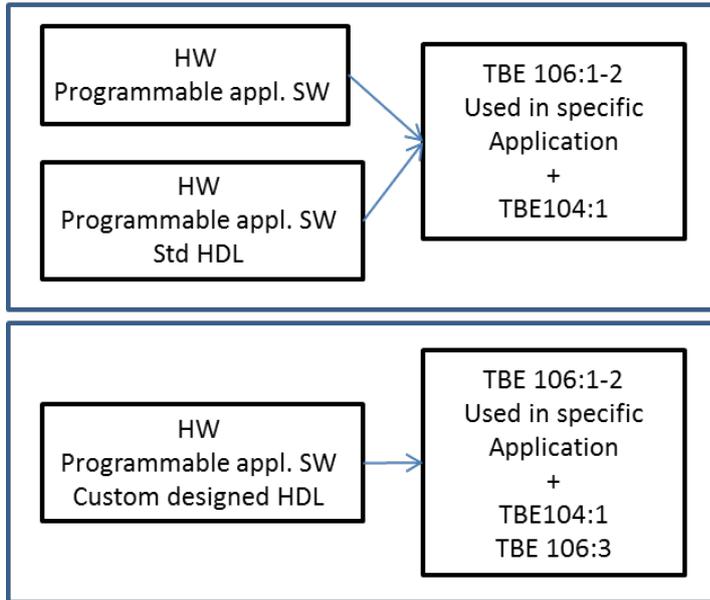
These requirements specify the technical requirements which are necessary in order to attain the sufficient safety when implementing the protective functions with the PE-equipment.

TBE 106 is divided into two requirement levels on the basis of functional requirements and other for the plant specific considerations. The requirement levels cannot be translated directly to the plants' classification principles with regard to electrical function class; instead an assessment shall be made in each individual case when the requirement level is chosen.

The requirement levels are designated TBE 106: X-1 and TBE 106: X-2 where level -1 is the highest requirement level.

For equipment classified as 1E- according to IEEE or category A equipment according to IEC 61226, TBE 106: X-1 shall always be applied.

How to use TBE 106:1-2 in combination with other TBE's



Definitions:

Programmable appl. SW

The specific software with modules (function blocks, "building blocks") that characterise the particular system as produced by the Manufacturer/Supplier of a given PE system. Usually delivered as a software library

Std HDL

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

Custom designed HDL circuit

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

2 Definitions

In cases where definitions are taken from an established standard, the original text is quoted in italic type and the source is given. Other definitions have been written specifically for this document.

Application software, base software, etc.

The software can be divided into the following levels:

1. Microprograms	System software	Basic essential software
2. Compiler		
3. Operating system		
4. Standard software		
5. Application software		
6. Default position parameters (defined operating mode, limit value, etc.)		
7. Operating parameters (operating mode, set point, etc.)		

Application software

A computer program that performs a task related to the process being controlled rather than to the function of the computer itself (IEC 60880).

The part of the software that is linked to the function of the controlled process

Basic essential software

System software and standard software together. These define a general PE system without application software

Default position parameters

These define the position of the equipment involved in a controlled process in certain defined operating modes, such as start up, safe state, etc. In addition, they describe settings of parameters for signal, activation, regulating characteristics, etc.

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 micro-electronic technologies.

(IEC 62566-1)

Module

A logically delimited software section or a subroutine with a defined function and with well defined interfaces. In a PE system this usually means a function block e.g. a logic gate or regulator, which is configured by application programming and which is combined with other modules to form a system function.

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

NOTE – This term covers microelectronic devices based on one or more central processing units (CPUs) together with associated memories, etc.

Example: The following are all programmable electronic devices:

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

(IEC 61508-4)

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.

Software

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

Standard software

The specific software with modules (function blocks, “building blocks”) that characterise the particular system as produced by the Supplier/Manufacturer of a given PE system. Usually delivered as a software library

System software

Software designed for a specific computer system or family of computer systems to facilitate the operation and maintenance of the computer system and associated programs, for example, operating systems, compilers, utilities. System software is usually composed of operational system software and support software. (IEC 60880)

3 Product Requirements

3.1 Standardisation

The method used to produce the product shall conform to a development process which follows the requirements according to IEC61508 SIL2, IEC 62138 or requirement according to ISO 9001 and ISO 90003.

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

Regarding requirements to be met by quality systems refer to KBE 100.

The method used to produce the product shall describe a life-cycle approach from product idea through to phasing out of the product. This also includes describing how the product can be replaced with other compatible equipment and how support works after the product being no longer commercially available.

It is especially important that the Manufacturer/Supplier can 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 including documentation and versions of the base software and application software.

A general inspection plan is set out in KBE IP-106:1-2 with associated examination procedures.

In the Quotation, the Manufacturer/Supplier shall state how the Requirements and applicable product standards are met. 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
IEC 60748	Semi-conductor devices, integrated devices
IEC 60384	Fixed capacitors for use in electronic equipment
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 5.

For emission the equipment shall fulfil the requirements in KBE EP-153.

3.2 General Technical Requirements

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

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.

3.3 Hardware requirements

3.3.1 Battery backup

If battery backup is included, the service life of the batteries shall be stated by the Manufacturer/Supplier.

3.3.2 Storage media

Storage media and equipment for backing up the software (basic essential, application, databases, etc.) shall be stated by the Supplier/Manufacturer.

3.3.3 Image presentation

Image presentations shall be chosen considering the relatively bright lighting which normally prevails in the control room.

3.3.4 Maintenance requirements

It shall be possible to change cards without shutting down the whole equipment/system. Restarting the replaced part is acceptable. The Manufacturer/Supplier shall present the equipment behaviour during the start-up process e.g. data handling, output settings, influence on other system parts etc.

3.3.5 Power supply

The Manufacturer/Supplier shall present how the equipment behaves during disturbances in the power supply out of the specified range. An alarm is necessary when the voltage level diverges from the specified value.

3.3.6 Components

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.

3.3.7 Marking

The component side of each printed board shall be marked, in screen-printing or other durable method, with information of board type, serial number and revision. All markings shall, where possible, be legible even after the printed board has been equipped with components.

3.3.8 Packaging and Handling

Printed board assemblies shall be packed, stored and otherwise handled so they are satisfactory protected from electrostatic discharges (ESD). Circuit boards shall always be packed in ESD-protective packages during transport and storage. Personnel handling sensitive components shall have necessary training and equipped with protective devices to reduce the exposure to ESD.

3.4 Software requirements

3.4.1 Check of software versions

The system or the tool shall be able to compare new and old versions of the software and to report differences.

3.4.2 Upgrading base software

When upgraded basic essential software is offered, the changes made between the software versions shall be specified. The connection to and influence on other parts of the software shall be shown.

3.5 Common equipment requirements (hardware and software)

3.5.1 Expandability of functionality

The Manufacturer/Supplier shall state the scope and possibilities to expand the functionality and performance of the equipment.

3.5.2 Authorisation control

It shall be possible to control authorisation for at least the following:

- *change in application software*
- *change of parameters such as alarm and limit values for activation, (base position parameters)*
- *normal operator management.*

Changes in authorisation protected areas shall automatically be marked with time and authorisation signature.

3.5.3 Cyber Security

Requirements on Cyber Security are specified in TBE 100:2

The documentation shall also comprise communication connections (internal/external), network, tools, storage media, access control etc.

The Supplier/Manufacturer shall state the possibility for encryption/alternative method/solution if reinforced security be required.

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

The Supplier/Manufacturer shall be able to show that data are not distorted/number of retransmissions of telegrams is kept to a minimum.

3.5.4 Testability

The Manufacturer/Supplier shall state how the equipment is to 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 needs periodically testing and are specified in the Technical Specification

3.5.5 Tools

Tools used for programming, image generation, testing, documentation, etc., shall be evaluated and approved by the Manufacturer/Supplier.

3.5.6 Man-machine interface

The Purchaser shall be able to choose colours for different functions.

Alarm texts and other texts shall be writeable with Swedish letters.

The above is also applicable for programming tools, tools for parameter setting, tests, maintenance etc.

Surveillance and manoeuvre shall occur in a manner which is easy, unambiguous and well arranged for the operator.

3.5.7 Reliability

The Manufacturer/Supplier shall state the reliability of the equipment. MTBF and MTTR figures shall be stated. The pieces of information shall be shown at the equipment level or for the configuration which applies for the system in question.

The Manufacturer/Supplier shall also submit references to previously supplied equipment of equivalent size or complexity.

3.5.8 Performance

The Manufacturer/Supplier shall state bit resolution and response time.

General requirements regarding measuring range, setting value and maximum error indication, accuracy, etc., are stated in the Technical Specification.

Unless the Technical Specification stipulates otherwise, the response time for measuring and operating functions shall not exceed 1 s and for safety functions 0.1 s. (These times do not include the running times of apparatus.). First response of a pressed button/keyboard 0.1 s.

Response time for static display, i.e. from pressing a button/keyboard to presentation of entire display: 0.5 s. Response time for entire display, with 50 dynamic points, i.e. from press of a button/keyboard to presentation of entire display is maximum 2 s.

Corresponding response times for trend displays is maximum 4.0 s.

The Manufacturer/Supplier shall state the response times for different functions. Response times shall be verified by testing.

3.5.9 Self-monitoring

There shall be a requisite amount of monitoring of information flows during execution. This shall be specified by the Manufacturer/Supplier.

Implausible signals from the process shall give an alarm and lead to a safe state.

Logging of fault events

All faults that occur on the equipment in service shall be recorded and be printable on paper.

3.5.10 Capacity

The load of the central unit (processor) shall not be higher than that the function with the lowest priority, with a margin, can be guaranteed to be executed within the prescribed response time.

3.5.11 Communication interface

The equipment shall be capable of communicating with other computer systems by standardised protocols.

If a specific communication interface is required, this is stated in the Technical Specification.

3.5.12 Other requirements

For new versions of software, hardware and tools, the Manufacturer/Supplier shall guarantee compatibility with old systems. The Manufacturer/Supplier shall show how the Purchaser will be able to maintain the system for a longer period of time than ten years.

The system should be self-documenting, so that, in addition to application software in the form of code, all information about the current configuration can be printed out on paper in a format that is clear and easy to read. Such a printout should consist of logic or function diagrams in graphical form, as well as parameter lists and signal address lists.

The Manufacturer/Supplier shall specify the communication protocols with reference to applied standard.

USB communication is only permitted for communication with peripheral units.

4 Nuclear Specific Requirements

4.1 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

5.1 General

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

The information below shall be documented and supplied to the Purchaser.

The Manufacturer/Supplier structure, content and designations for the documents may be different, but may also differ depending on the type of equipment.

The Manufacturer/Supplier shall describe their document structure and state in which documents the information below or the corresponding information is described.

If the documentation shall be designed in a specific way, the Purchaser shall specify this.

5.2 Product documentation

As well as describing the equipment, including data sheets and specification, the technical description shall also describe the function of the software. The version/revision number of the software and hardware shall be stated.

5.2.1 Standard software – Module description

Each module shall be well described with regard to function, way of working, inputs and outputs, parameters and other data of interest.

The programming instruction shall describe the procedure for programming and database configuration and give instructions for image generation. Examples of typical cases shall be given.

The legal rules that apply to use of the software, copying of the software, and issues regarding software license, shall be set out.

5.3 Design documentation

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

- Internal and external connections
- Circuit diagram
- Terminal connections
- Card type
- Card position
- Signal names
- Unambiguous references to the function diagram
- Rules for handling/storage

A main document which, together with the circuit diagram and the signal address list, gives a complete picture of the entire function of the system. In most systems there is a facility for automatically generating the function diagram.

Descriptions shall be provided of program function, database and graphical presentation of configuration the system, including communication.

There shall be a graphical overview diagram of software and software modules.

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.

The logic diagram and the control block diagram give an overall description of the function 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 function of the system in normal operation.

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

5.4 Maintenance documentation

The maintenance guide describes:

- Starting and restarting the system
- Backup procedure, restore procedure
- Interpretation of fault signals and fault printouts
- Fault localization, 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
- Linking between version/revision numbers for:
 - * hardware
 - * software
 - * tools
- Rules for handling/storage of the software

5.5 Operating documentation

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

5.6 Inspection documentation

The Manufacturer/Supplier shall show in writing that the development process invoked for the method used to produce the software is fulfilled on the basis of the chosen inspection plan. The Purchaser shall be given the opportunity to examine and review the Manufacturer/Supplier method of production.

The Manufacturer/Supplier shall show the executed type tests and routine tests according to the agreed inspection plan.

See also KBE 100.

5.7 Analyses

Reliability studies (method and results) shall be documented.

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	Description of development and design process	
3	Description of the life cycle of the product. Support	
4	Description of the configuration management plan	
5	Describe how the Requirements and applicable product standards are met.	
6	Battery backup and battery monitoring	
7	Storage media for software backup	
8	Human-machine interface Screens, colours, language Applies also on tools	
9	Compare new and old versions of the software and report differences	
10	Compare the software version currently in the equipment and stored copies	
11	State the scope and possibilities of expandability	
12	Authorisation for different levels of access	
13	Testability after a replacement or in connection with recurring testing.	
14	Tools evaluated and approved	
15	The reliability of the equipment Information + references	
16	Performance Capacity, including margins Response times + verification at test Measuring ranges, accuracies, fault display, bit resolution Time resolution	
17	Statement of document structure and where the information according to the description can be found	
18	Product documentation	
19	Design documentation	
20	Maintenance documentation	
21	Operating documentation	
22	Inspection documentation	
23	Analyses	
24	Interfaces to other systems in the plant	
25	Architectural/Structural requirements	
26	Communication requirements, including requirements for functional separation	
27	Operator communication	
28	Maintainability, requirements regarding certain actions in service (e.g. card and battery replacement)	

29	Requirements to be met by hardware Storage media, environmental requirements, physical dimensions, electrical requirements	
30	Cyber Security	
31	Defined state when fail/error occur	
32	Delivery of source code	
33	Power Supply	
34	The component side of each printed board shall be marked, in screen- printing or other durable method	
35	Information on solvents and cleaning procedures for printed board assemblies	
36	Packed, stored and handled to protect from electrostatic discharges (ESD)	
37	Components including HDL	
38	Show in writing that the development process invoked for the method used to produce the software is fulfilled	
39	Interfaces to the other systems in the plant	
40	Logging function registering all attempts to penetrate the firewall	
41	Verification of that transmitted data information is equal to the received data information	
42	Need of multicast traffic	