

<b>Technical Requirements for Electrical Equipment</b>  Title <b>Power Electronics</b>	Document TBE 120
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TBE 120	6	2020-04-20	5 (E)

# 1      **General**

These Technical Requirements specify requirements for complete assembled power electronics equipment intended for use in nuclear power plants. The requirements concern design, construction and documentation. Some requirements are therefore applicable only for certain types of equipment. The Manufacturer/Supplier shall fulfil the requirements in order to meet the safety and reliability objectives of the Swedish Nuclear Power Plant (NPP) Owners.

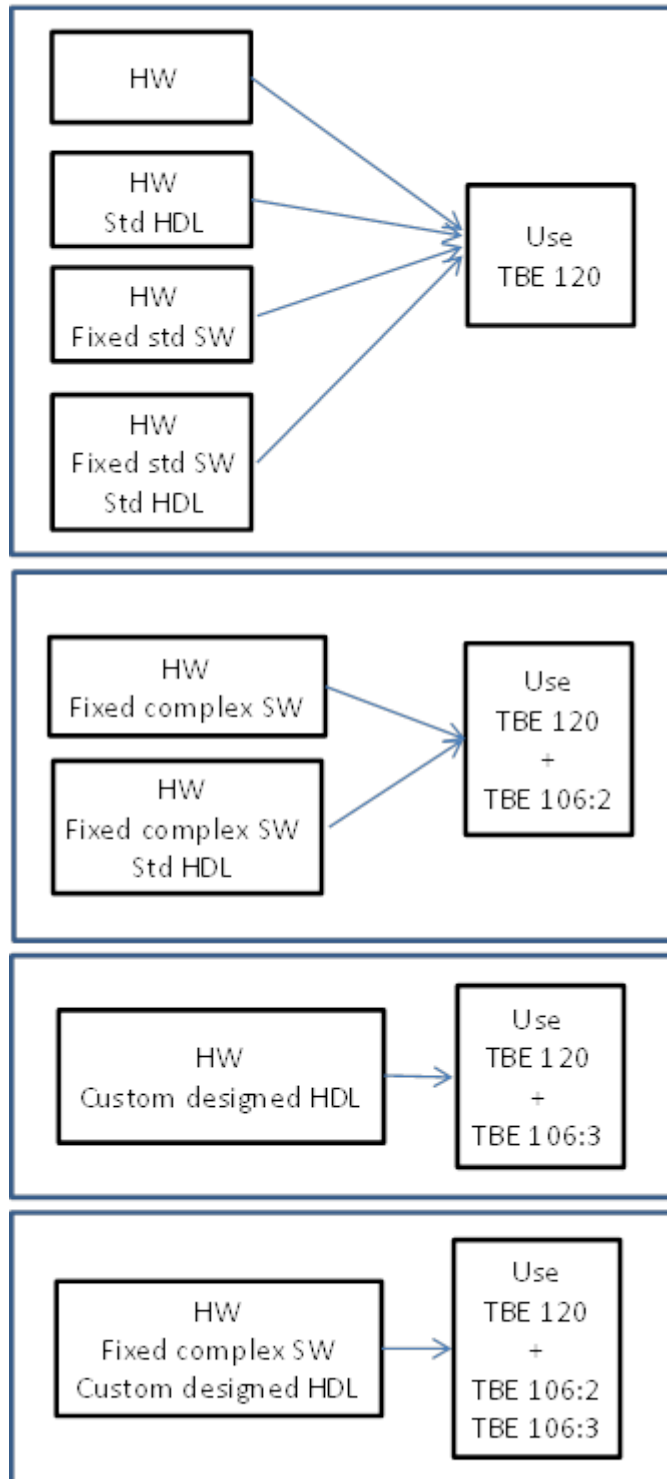
The purpose of this document is to provide general requirements for complete assembled power electronics equipment, i.e. equipment such as converters and soft starters for motor drives, battery chargers, rectifiers, inverters, switching power supplies and uninterruptable power supply systems (UPS) intended for location indoor in electrical equipment rooms.

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

Detailed Technical Data, and in some cases other technical requirements to be followed, for the equipment is given in the Technical Specification. If the requirements of various documents differ, the Technical Specification shall have precedence.

Section 6 is a checklist that should be used when making an inquiry or an order.

## How to use combinations of TBE 120 and TBE 106:x



Definitions:

### **Fixed std SW**

Application software for a 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 circuit**

Specific circuit, designed by use of a HDL tool and 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 120 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.

## 2 Definitions

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

### **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.*

(IEC62566-1)

### **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.

## **3 General Product Requirements**

### **3.1 Standardisation**

Power electronics equipment shall comply with Swedish regulations and applicable standards for the equipment.

Specific requirements on standards will be found in the Technical Specification.

In the tender, the Manufacturer/Supplier shall specify standards to which the product or delivery conforms. 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 (class 2)	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.

#### **3.1.2 Deviations/Modifications from standards**

For power electronics equipment covered by EMC regulations the immunity and emission requirements of TBE 101, Table 5 and 6, shall apply.

## **3.2 General technical requirements**

Since the greatest degree of uniformity in the plant is desirable, the Manufacturer/Supplier is to choose manufacturer and 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.

### **3.2.1 Protection of personnel**

When doors and hatches are closed and locked in the prescribed manner and if a fault occurs, no personal injury shall come to those who are in the immediate vicinity of the equipment. The Manufacturer/Supplier shall provide detailed description of the protection devices.

### **3.2.2 Software**

Software used in the equipment shall fulfil requirements stated in TBE 106:2-x. Acceptable level is given in the Technical Specification.

Restriction in access to software and modification of parameters shall be specified in the Technical Specification.

If other than the above specified development process have been used it shall have followed the IEC 61508, SIL 2.

If higher requirements (e.g. SIL 3) is required, this can be achieved by use of SIL 2 classified components if it is configured according to the requirements in IEC 61508 to fulfil SIL 3.

If another documented and reviewable development process has been used that fulfils the requirement the Supplier/Manufacturer shall compare and specify to what extent the invoked standard or development process fulfils the above specified requirements.

Documented and traceable operating experiences may to a certain extent compensate deficiencies in the production methodology.

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

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

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

### **3.2.3 Components**

Components used in the equipment shall be tested according to latest issue of applicable standards. This is the responsibility of the Manufacturer/Supplier.

Capacitors installed in power electronics shall comply with the standard EN 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.

### **3.2.4 Field bus**

The control system of the equipment with CPU based controller system shall have a design that makes central surveillance possible by using the field bus specified by the Purchaser.

### **3.2.5 Lifting eye bolts**

To facilitate transport, the cubicles shall be provided with lifting eye bolts or prepared to allow mounting of lifting eye bolts.

## **3.3 Rectifier – Additional requirements**

As rectifier means in this document equipment for charging stationary batteries, used for operation of equipment that in case of loss of power shall maintain its operation under specified time.

### **3.3.1 Manoeuvre**

The rectifier shall be provided with a control panel using alphanumeric digit representation and key set for adjustment off all parameters and reading off measuring result, parameters, alarm signals and trouble shooting.

Electric potential separated contacts for alarm shall be provided according to Technical Specification.

### **3.3.2 Cooling**

Rectifiers shall normally be built for cooling using self-circulating air.

If forced cooling with fans is required the fans shall be duplicated and redundant, alternatively the fans shall be exchangeable during operation. Alarm at fan failure shall be provided.

### **3.3.3 Filter capacitor**

The Manufacturer/Supplier shall state the expected lifetime of used filter capacitor.

The rectifiers ripple current shall be within the connected battery specification. The ripple current RMS may as maximum be 2A (RMS) per 100 Ah of the battery ten hour capacity.

### **3.4 Frequency converter for motor operation – Additional requirements**

As frequency converter means in this document equipment which makes it possible to operate a squirrel cage motor with a speed that differ from mains frequencies. The speed of the motor can be governed by the process requirement or by a separate controller.

Technical data for the converter is stated in Technical Specification.

#### **3.4.1 Manoeuvre**

The converter shall be provided with control panel and alpha-numeric digit representation and key set for adjusting off all parameters and reading off measuring result, parameters, alarm signals and trouble shooting.

Electric potential separated contacts for alarm shall be provided according to Technical Specification

#### **3.4.2 Electric connection**

The Manufacturer/Supplier shall state the maximum length between converter and motor for use of normal shielded cable, if the equipment shall fulfil requirement regarding emission. The Manufacturer/Supplier shall state type and manufacturer if special cable shall be used.

### **3.5 Inverter – Additional requirements**

As inverter means in this document, equipment which by use of static component converts direct current voltage to alternating-current voltage with fixed frequency. The inverter may be one or multiphase.

The inverter shall fulfil applicable requirement as for a rectifier.

### **3.6 DC/DC converter – Additional requirements**

As DC/DC converter means in this document equipment which by use of static component transforms dc-voltage from one level to another level, higher or lower.

The DC/DC converter shall fulfil applicable requirement as for a rectifier.

### **3.7 Soft starter – Additional requirements**

As soft starter means in this document equipment for start of a squirrel cage motor with a predetermined ramp. The switch off sequence can use the corresponding ramp.

The soft starter shall fulfil applicable requirement as for frequency converter.



### **3.8 Equipment for uninterruptible power system, UPS – Additional requirements**

As UPS means in this document equipment consisting of rectifier, battery and frequency inverter.

Technical requirements are stated in Technical Specification.

The UPS shall fulfil EMC requirements specified in EN 62040-2.

#### **3.8.1 Scope**

The Manufacturer/Supplier shall, if nothing else is agreed upon, be responsible for all parts involved in the system, rectifier, battery, inverter, switch and by-pass transformer.

Switch and bypass transformer shall be chosen with output stated in Technical Specification as rated power.

#### **3.8.2 Short circuit power**

The UPS shall, without use off the static switch, be able to blow a fuse by an eventual short circuit in connected system within specified time and with fuses specified in Technical Specification. The UPS shall under no circumstances stop and shall after a short circuit event be ready for operation.

The Manufacturer/Supplier shall declare if and which components that shall be exchanged after a short circuit event.

## **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**

Documentation requirements are given in TBE 100:1.

## 6 Agreements between Manufacturer/Supplier and Purchaser

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

	<b>General:</b>	
1	Review and completing Technical Specification	
2	Review of actual Inspection Plan and Examination Procedures	
3	Seismic verification	
4	Personal safety if fault occur in equipment, verification	
5	Requirement regarding separation – isolation level	
6	Type of cable and connection on incoming side	
7	Type of cable and connection on outgoing side	
8	Controller cable, type	
9	Connection of earth wire	
10	Short circuit and overload protection, outgoing and incoming side	
11	Short circuit power	
12	Connection and type of field bus	
13	Accessibility at operation for people with special permission	
14	Accessibility for inspection	
15	Accessibility at maintenance and service	
16	Current version of $\mu$ -processor program, cf. type test version	
17	Exchange of thyristors or similar after short circuit test	
18	Cable and wiring	
19	Selection of equipment e.g. change-over switches, signal system, pilot lamps etc.	
20	Marking plates outside cabinets	
21	Marking plates upon devices	
22	The component side of each printed board shall be marked, in screen-printing or other durable method	
23	Information on solvents and cleaning procedures for printed board assemblies	
24	Packed, stored and handled to protect from electrostatic discharges (ESD)	
25	Documentation, language	
26	Cyber Security	
27	Components including HDL	
	<b>Rectifier:</b>	
28	Type of ventilation	
29	Filter capacitors, type, calculated endurance life in specified environment	
30	Discharge time for capacitors	
31	Surveillance of earth fault on dc-side, adjustment	
32	Alarm relay, number of contact functions	
	<b>Frequency converter:</b>	
33	Type of ventilation	
34	Protection class according to location	
35	Requirement on separate manoeuvre supply	
36	Modular design, exchangeable	
	<b>Softstarter:</b>	
37	Requirements for bypass equipment	
38	Requirement for current limiting	
	<b>UPS:</b>	
39	Type of transformer, checks and testing	

40	Rated power of static switch	
41	Design of bypass equipment	
42	Built-in equipment for earth fault detection on dc link and output side	
43	Modular design, exchangeable	
	<b>Software</b>	
44	Development process	
45	Operating experience	