# Technical Requirements for Electrical Equipment	Document TBE 106:3
	Issue 1
Title HDL-programmed integrated circuits	Date 2020-04-20
	Supersedes -

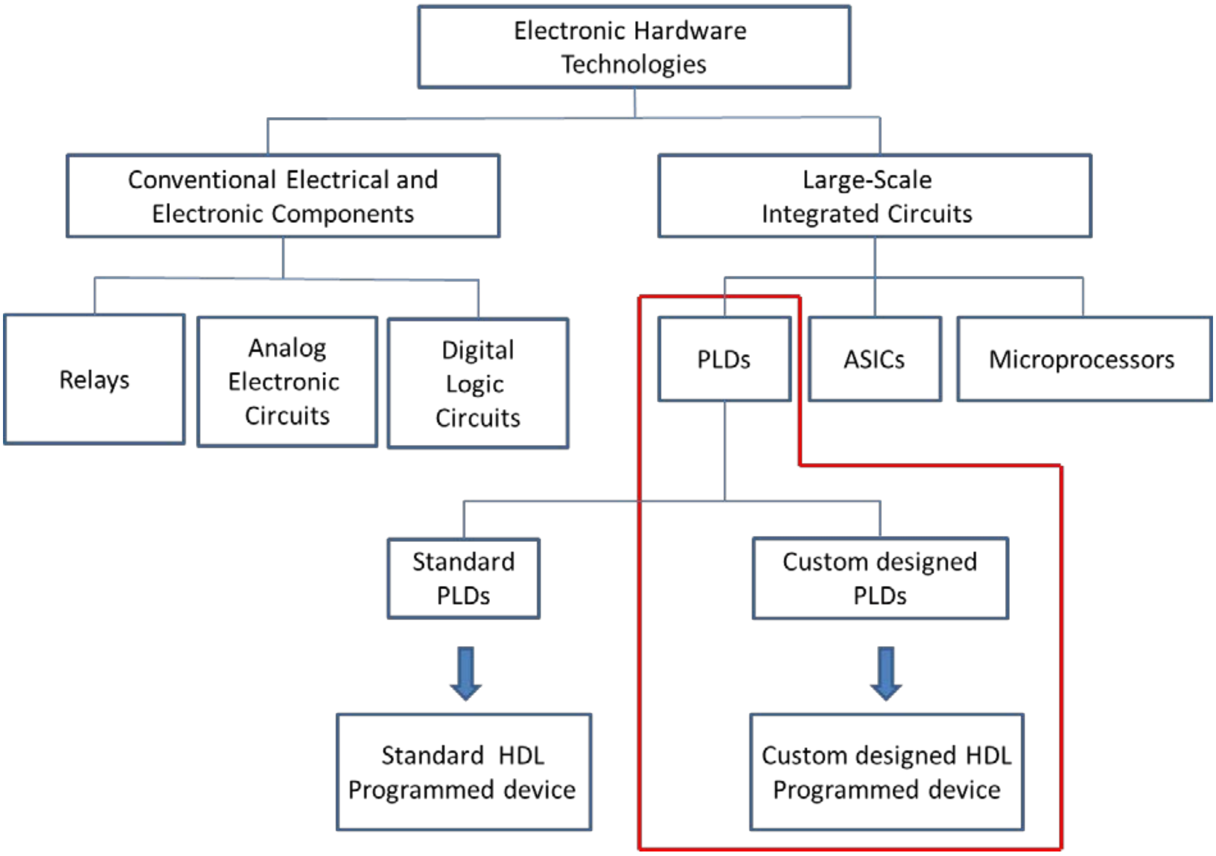
Contents

Approved by: **TBE-Group**

1 General

These Technical Requirements state the requirements on custom designed HDL-programmed circuits (HPD) that are custom designed for specific applications. These requirements concern design, performance and documentation.

Below is a schematic overview of the different technologies and how it is interpreted. This TBE sets requirements on those parts shown inside the red frame.

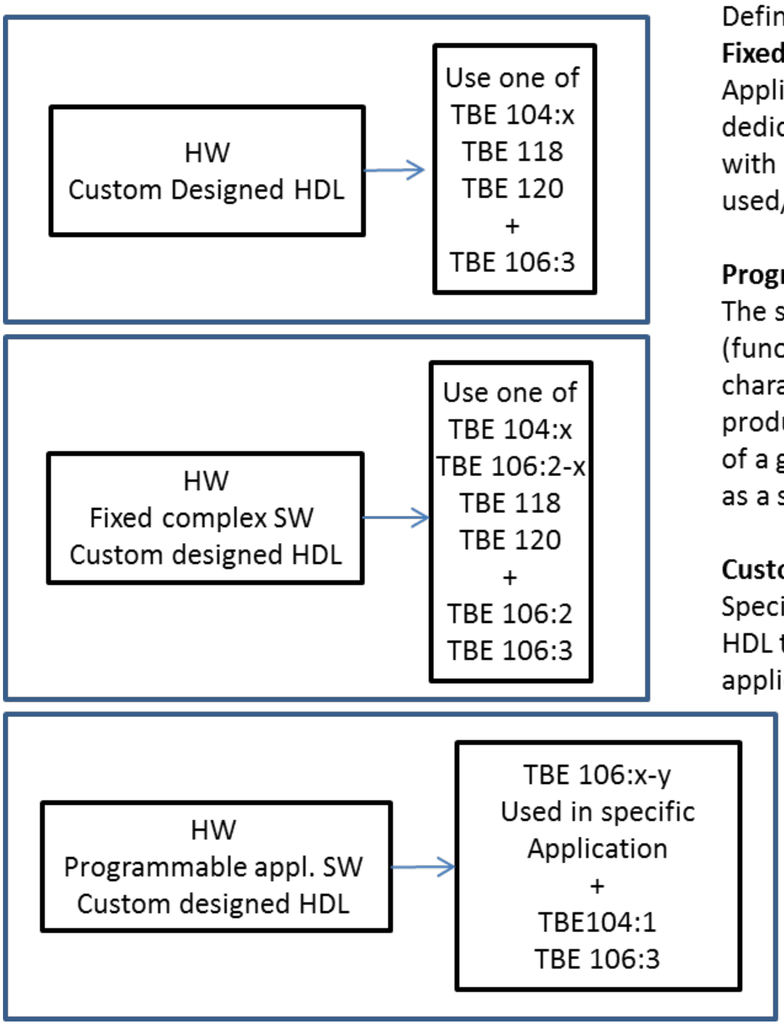

Electronic Hardware Technologies
Conventional Electrical and Electronic Components
Large-Scale Integrated Circuits
Relays
Analog Electronic Circuits
Digital Logic Circuits
PLDs
ASICs
Microprocessors
Standard PLDs
Custom designed PLDs
Standard HDL Programmed device
Custom designed HDL Programmed device

This TBE is supposed to be used only when there is a custom designed device (see red frame) e.g. FPGA (Field Programmable Gate Array)

Custom designed PLD’s are not allowed to have a design including some kind of implemented microprocessor.

ASICs (Application Specific Integrated Circuits) and standard PLD’s are excluded from this TBE. They will be treated as a hardware component.

How to use TBE 106:3 in combination with other TBE’s



Definitions:

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

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

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. Custom designed HPD means that it is developed for a specific application. TBE 104, 118 or 120 is used as it is if the equipment consists of one of the following alternatives:

- HW only
- HW and standard HPD
- HW and fixed standard SW
- HW, standard HPD and fixed standard SW.

The programming of HPDs relies on Hardware Description Languages (HDL) and related software tools. They are typically based on blank FPGAs or similar micro-electronic technologies.

The HPD shall fulfil the basic requirement as specified in IEC 62566-1. They shall be qualified and tested according to Technical Specification (TS). In addition to this document, applicable parts of TBE 100:1 shall apply.

Information security during the development phases shall be considered and applicable requirements within TBE 100:2 shall apply.

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

2 Definitions

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

Component
An electronic component is any basic discrete device or physical entity in an electronic system used to affect electrons or their associated fields. Electronic components are mostly industrial products, available in a singular form and are not to be confused with electrical elements, which are conceptual abstractions representing idealized electronic components.

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

Equipment
An essential or useful auxiliary item that can be attached to or removed from a product without damaging either it or the product to which it can be attached.

FPGA
Field Programmable Gate Array.

HW, 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)

PDB - Pre Developed Blocks

PLD -Programmable logic device

NOTE – A PLD may have different kinds of fabrication base, e.g. PLA (programmable logic arrays), PAL (programmable array logic), CPLDs (complex PLD’s), FPGAs (field programmable gate arrays) and custom microprocessors.

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 IEC 62566-1 for development of HDL-programmed integrated circuits.

If other than the above mentioned development processes have been used, the Manufacturer/Supplier shall compare and specify to what extent the invoked standard or development process fulfils the requirements set out in IEC 62566-1.

The standards referred in the document are:

IEC 62566-1	Nuclear power plants – Instrumentation and control important to safety – Development of HDL-programmed integrated circuits for systems performing category A functions

Additional standards are specified in the Technical Specification.

In the Quotation, the Manufacturer/Supplier shall state how the Requirements and applicable product standards are met.

A general inspection plan is set out in KBE IP-106:3 with associated examination procedures.

3.2 General Technical Requirements

3.2.1 General

The use, selection and configuration of the PLD for safety system application shall be demonstrably fit for purpose, based on the allocated requirements, e.g. including requirements for the following characteristics;

- Capability to carry out safety functions with the required level of performance
- Avoidance of unnecessary complexity (i.e. characteristics that limit verifiability and comprehensibility and preclude a credible safety plan)
- Predictability and determinism in behaviour, including timing
- Explicitly identified underlying assumption, e.g. about the execution environment of the item
- Facilitating adequate verification

3.2.2 Reliability

The equipment reliability shall be stated by the Manufacturer/Supplier. Information about MTBF and MTTR values shall be given. The Manufacturer/Supplier shall specify how these data has been developed e.g. by calculation or by using operating experience from similar applications.

3.2.3 Components

Technical information such as type, part number and manufacturer, shall be available upon request of the Purchaser. Original texts on parts shall not be removed.

The Manufacturer/Supplier shall verify that the components are inspected and tested according to applicable standards.

3.3 Specific requirements

The parts/phases below describe and emphasise some of the requirements in the development of HPD devices according to IEC 62566-1. These parts/phases should be documented in a report.

3.3.1 HPD-Design and HDL-Coding

In this phase a detailed description of the functionality is produced. This is analogous to the production of software code to define the functionality of a software system. The application functionality is typically defined using a high-level hardware description language (HDL), such as VHDL or Verilog, and a number of tools and development kits are commercially available for development and validation of the HDL code. It is also possible to generate the HDL from a higher level description, such as C or Matlab.

Libraries of predefined functions and circuits with appropriate performance and properties should be employed wherever applicable. These should be demonstrated/evaluated to be appropriate for the safety application by analysis and/or testing.

The Manufacturer/Supplier 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 related to the versions of the hardware and software.

3.3.2 Implementation

The Manufacturer/Supplier shall describe the different steps used during implementation.

As minimum the following should be presented. How the configuration is defined how the application is being designed, by identifying the gates required and their interconnections. Place and route is another step of the implementation. This step identifies the best physical positions on the chip for the logic blocks and interconnections.

The outcome of this stage is then loaded onto the circuit to program it.

3.3.3 Tools

The design tools used for HDL programming and synthesis should not make use of any optimization features that may be available. The use of optimization features may cause the circuit described by the HDL code to differ from the netlist, which will make verification more difficult.

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

The level of verification and assessment required for a tool depends on the type of tool and whether the output of the tool can be fully verified or validated.

Tools shall have sufficient reliability to ensure that they do not jeopardise the reliability of the end product.

The modification, upgrade or replacement strategy for tools shall be documented and justified.

The qualitative reliability requirements of a tool shall be determined considering:
1) the consequences of a fault in the tool;
2) the probability that a tool causes or induces faults in the software implementing the safety function;
3) what other tools or processes mitigate the consequences of a fault in the tool.

NOTE Principles of defence in depth and diversity can reduce the reliability requirements on tools.

Tool qualification strategy shall consider:
1) analysis of tool development process and vendor tool history;
2) adequacy of tool documentation to allow verification of tool output and ease of learning;
3) testing or validation of the tool;
4) evaluation of the tool over a period of use;
5) feedback of experience with tool use.

All tools shall be under configuration management to ensure the complete identification of selected tools (including name, version, variant, and possibly configuration) and the tool parameters

Records documenting the error history and limitations of tools shall be maintained throughout the life

Any modification of a tool shall be verified and assessed.

4 Documentation

How the design and coding are done, used language, tools and all verification & validation activities shall be presented.

In addition to the documentation requirements specified in TBE 100:1, TBE 104-x, TBE 106:2-x TBE 118 and/or TBE 120 the following requirements shall apply:

4.1 Product Documentation

The product documentation shall include:

- HPD requirement specification
- Acceptance of selected blank integrated circuits, native blocks and PDBs

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

4.2 Design Documentation

The design documentation shall describe the following;

- description of how the equipment and components are connected together electrically
- description of breakdown into main modules, defensive design choices, identification of the micro-electronic technology, native blocks and PDBs-description of detailed design
- description of different steps during implementation
- Software tools for the development of HPDs

4.3 Inspection Documentation

The Manufacturer/Supplier shall document 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 Manufacturer/Supplier method of production.

The Manufacturer/Supplier shall provide documentation from the performed tests according to the agreed inspection plan.

5 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 according to HDL specific requirements	
3	Requirements on separation – isolation of function realised in HDL	
4	Applicable standard for used components, native blocks, tests etc.	
5		
6	Input and output signals	
7	Connection to process parameter	
8	Selection of components e.g. FPGA	
9	Description of development model	
10	Tools assessed and approved by the Manufacturer	
11	Relevant software version of tools	
12	The equipment reliability. Figures and used references	
13	Performance • Response time and verification by test • Measuring range, accuracy • time resolution	
14	Documentation, language	
15	Description of document structure and where the information can be found.	
16	Product documentation	
17	Design documentation	
18	Inspection documentation	
19	Operating experiences	
20	Ageing aspects of the chip	
21	Electro migration aspects (where the metal atoms of the interconnecting wires are physically displaced by the high intensity electric currents)	