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Technical Requirements for Electrical Equipment

User Guide for TBE/KBE

Contents

Foreword

The user guide deals only with electrical equipment, instrumentation and control equipment. Mechanical equipment is only dealt with where it occurs in conjunction with electrical equipment, instrumentation and control equipment.

Requirements to be met by system design, installation, commissioning etc. in the event of changes and additions are stated in the plant specific instructions. Requirements concerning separation, redundancy etc. and function are not dealt with in this document.

Chapter 2 contains definitions, explanations of terms and abbreviations that are used in the guide.

Comments on the document may be submitted to contact persons in the TBE/KBE group.

1 Introduction

This user guide describes the principles governing the use of the TBE/KBE documents in connection with the acquisition of electrical equipment, instrumentation and control equipment for nuclear power plants. The guide also describes how to fill in forms for technical specifications and inspection plans. The guide is intended for personnel at the nuclear power plants (Purchaser) and at Manufacturer/Suppliers who work with technical specification, inspection preparation, procurement and the documentation of electrical components and equipment.

1.1 Document Owners

The documents are produced and jointly owned by FKA, OKG, RAB and SKB.

1.2 Purpose of TBE/KBE

The TBE/KBE documents have been produced to simplify the specification of requirements to Manufacturer/Suppliers in connection with the procurement of components and equipment. The requirements in the documents are common to the Swedish nuclear power plants and are set on a level that allows their use in safety classified applications or applications that are significant for safety.

To satisfy nuclear power specific requirements for equipment important to safety, the requirements in the TBE/KBE documents shall always be met on procurement of electrical equipment with function class 1E/Cat A and B.

According to practice, the TBE/KBE requirements are also applied to equipment with function class 2E, 3E/Cat. C and O, i.e. equipment that is important for production availability. In these cases, TBE/KBE requirements are applied according to plant specific instructions. With the aid of these instructions, the Purchaser decides in each instance how to apply the requirements. In general this mainly means that the requirements for documented verification according to KBE are not applied equally strictly.

1.3 TBE/KBE Group

The TBE/KBE documents are updated by the TBE/KBE group with representatives of the power companies and SKB in accordance with an agreed activity description.

Comments on and questions about the TBE/KBE documents may be passed to the appointed contact person for the group at each plant. The TBE/KBE group evaluates received comments and suggestions for changes twice a year on an ongoing basis.

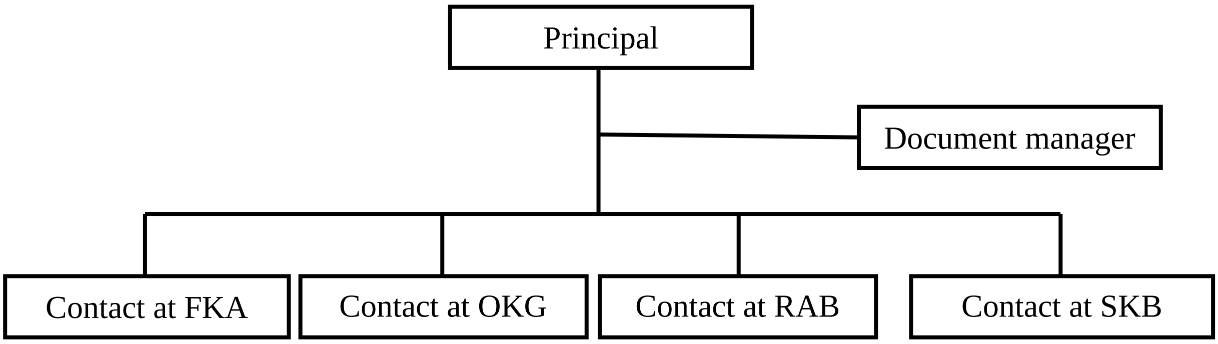

Figure 1: Organization chart and manning for the TBE/KBE group

2 Definitions

Definitions of terms and expressions as they are used in this document (They may occur in other documents with a different meaning).

See also sections containing definitions in the various TBE/KBE documents.

2.1 Terms and Expressions

Control Equipment
Equipment to control and monitor the plant
Detailed Design
In this document, the design phase in which manufacturing and assembly documentation (drawings, wiring tables, specifications etc.) is produced, on the basis of documentation from main design.
Inspection Documentation
Documentation, compiled and approved by the Manufacturer/Supplier, of inspection carried out in accordance with the contract and the final inspection plan. For electrical equipment and control equipment, the inspection documentation is in two parts – routine inspection and type inspection. See KBE EP-180.
Inspection Plan
One of the general inspection plans designated KBE IP is normally used as a preliminary inspection plan for the purposes of inquiry and tender. Before an order is placed, a final delivery linked and product linked inspection plan based on KBE IP is drawn up, incorporating the Manufacturer/ Supplier's procedures and other agreed changes. See KBE 100.
Main Design
In this document, design work on plant and system level. Main design constitutes all or part of the project phase.

Qualification Report
Document (according to template) which is the top document in the qualification of equipment among other things it reports on the type inspection carried out.
Review Certificate
A document, normally a form (not included in the TBE/KBE package), which reports the result of a review of the inspection documentation supplied.
Technical Specification - Manufacturers Specification
A document (included in the TBE/KBE package as a printed form) which sets out the actual design and performance of the component/equipment
Technical Specification - Plant Requirement Specification
A document (included in the TBE/KBE package as a printed form) which brings together all the technical and quality related requirements to be met by a product.

2.2 Abbreviations/Acronyms

DBE
Design Basis Event. Postulated events / incidents in the plant which govern the design of structures and systems.
FAT
Factory Acceptance Test. A special function oriented pre-delivery test. The test shall be carried out by the Manufacturer/Supplier with the presence of the Purchaser before consent for delivery is granted. See KBE EP-192.
FKA
Forsmark Kraftgrupp AB
FSE
Functions, systems and equipment.
IAEA
International Atomic Energy Agency
IEC
International Electrotechnical Commission
IEEE
Institute of Electrical and Electronics Engineers
IP
Inspection Plan
KBE
Quality and Inspection Requirements for Electrical Equipment. General requirements for the inspection procedure. See TBE/KBE document list.
LOCA
Loss of Coolant Accident. A DBE that involves major environmental stresses on equipment located in the reactor containment.
OAT
Operational Acceptance Test. A functionally targeted operational test for electrical equipment after installation and start-up. Compare with FAT and SAT.
OKG
Oskarshamnsverkets Kraftgrupp AB
PGA
Peak Ground Acceleration, See definition of ZPA.
PIE
Postulated initial event

RAB
Ringhals AB
RI
Reactor Containment
SAR
Safety analysis report for the plant concerned
SAT
Site Acceptance Test. A special function oriented test at the Purchaser's site before complex equipment is handed over. Normally done with the equipment connected and operating as far as possible. Compare FAT.
SKB
Swedish Nuclear Fuel and Waste Management Co
SSE
Safe Shutdown Earthquake. An earthquake of specified strength, after which it shall be possible to bring the reactor to a safe state.
SSM
Swedish Radiation Safety Authority
TBE
Technical requirements for electrical equipment. General requirements for environmental compatibility and functionality See TBE/KBE document list.
TBM
Technical Regulations for Mechanical Equipment
TS
Technical Specification, Document that summarizes all technical and quality related requirements on a product. Reference to requirements stipulated in TS also includes requirements stipulated in documents referred to.
ZPA (Zero Period Acceleration)
Acceleration level of the high frequencies in the part of the response spectrum where no amplification effects occur. At increasing frequency the response curve flattens out asymptotically to the ZPA level. ZPA is the maximum applied acceleration and corresponds to the maximum peak value of the time history used to derive the response spectrum. The higher acceleration levels of the response spectrum are caused by resonance phenomena in the affected systems. For ground acceleration the designation PGA (Peak Ground Acceleration) is often used instead of ZPA.

3 General/Preconditions

The need to acquire components and equipment arises as a result of changes to the function of a plant or from the need for spare parts from maintenance activities. In the first case, the technical and functional requirements were determined during the design work, which can be broadly broken down into a number of activities:

- Needs inventory and decisions
- Main design
- Detailed design

For every acquisition issue, some form of preparation shall be carried out, by specifying the need technically and in terms of quality. Put simply, the work of quality control comprises the following activities:

- Technical specification and inspection preparation

- Evaluation and follow up of the inspection activity
- Review of the inspection documentation

Acquisition process means the activities that normally occur in conjunction with the acquisition of components and equipment, from the identification of a need to the conclusion when the documentation obtained is archived. In this document, the acquisition process is made up of the following activities (see also Section 7):

- Needs inventory
- Inquiry
- Tender evaluation
- Ordering
- Manufacturing
- Delivery
- Receiving

Figures 2 and 3 describe the quality management activities related to the TBE/KBE documents and related to the design and acquisition processes.

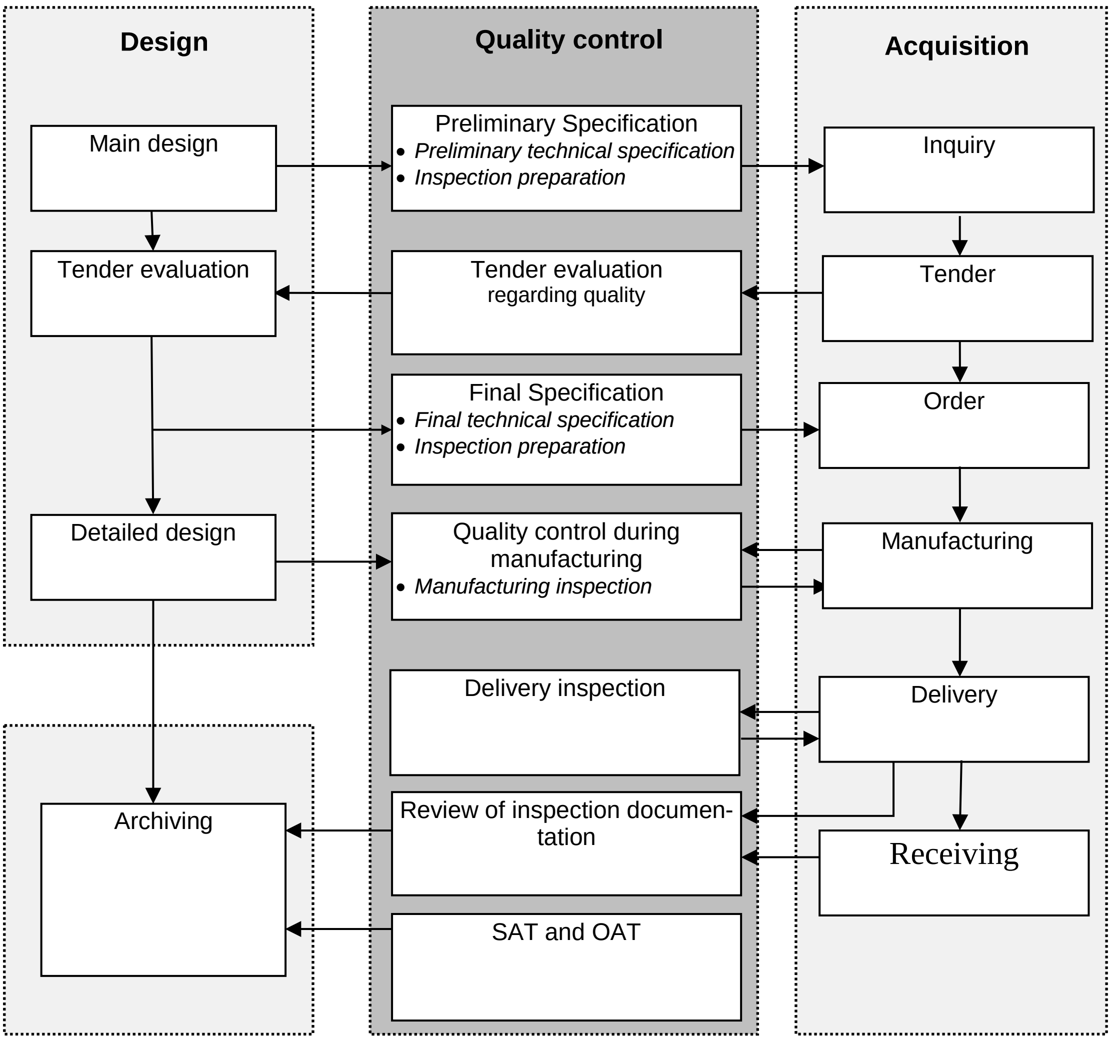

Figure 2: Relations between processes

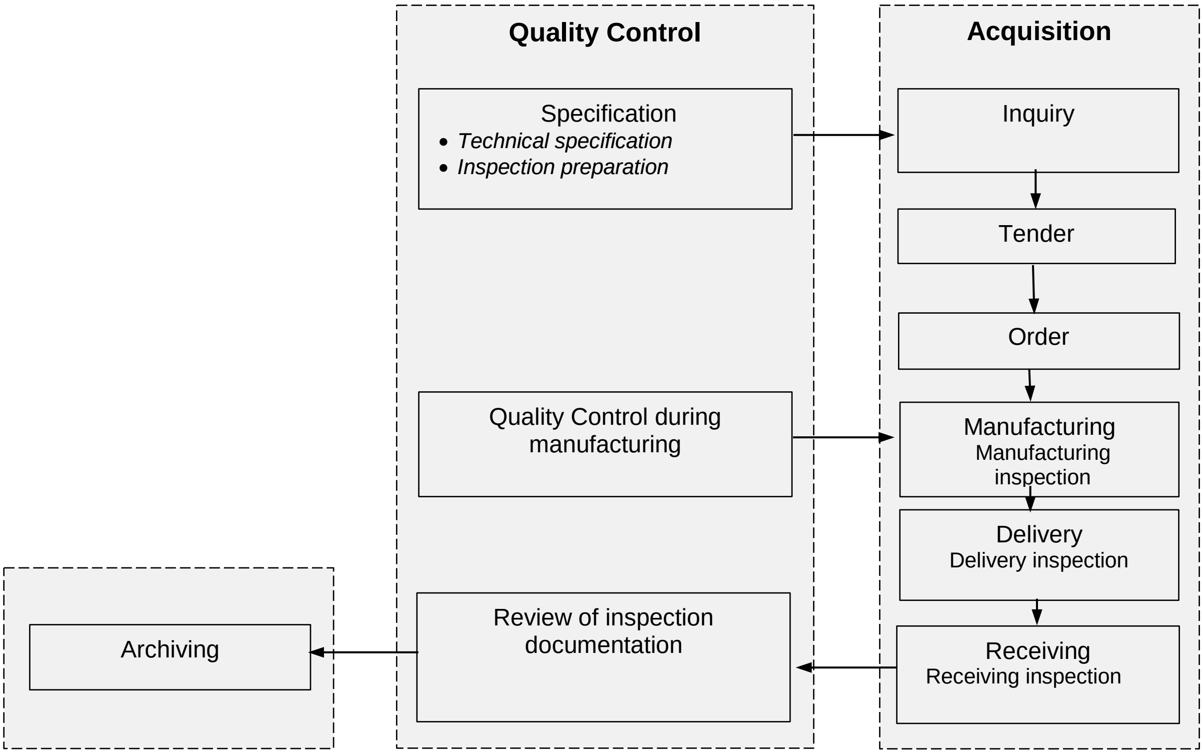

Figure 3: The relationships between processes when acquiring spare parts, i.e. when the design process is not involved.

4 Requirements

The TBE/KBE documents constitute the collected requirements package of the Swedish nuclear power owners regarding the acquisition of components and equipment. In addition to conventional requirements, the package includes requirements that govern nuclear engineering activity. Design, manufacturing and inspection of components and equipment shall comply with current legislation and regulations and with associated standards. Laws and regulations are mandatory and shall be complied with. Certain standards shall be complied with to meet official requirements in the regulations. Other standards are applied voluntarily as an aid to specifying. See Figure 4 below.

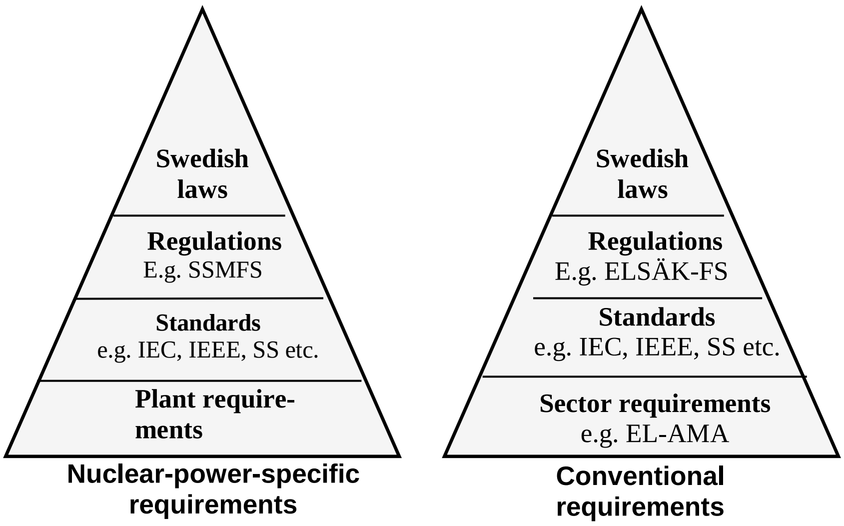

Figure 4: Requirement hierarchy

Note that the requirements in the TBE/KBE package consist predominantly of requirements based on current laws and regulations. The requirements are expressed on component and equipment level with the aid of a Swedish and/or international standard (and in some cases another national standard, primarily American rules, e.g. IEEE). In addition to these requirements there are a small number of requirements based on the need, for large installations such as nuclear power plants, to achieve a uniform execution as regards, for example, dimensioning, materials, connections, dimensions and maintenance aspects etc. See Figure 5.

TBE/KBE is more an aid to assure that all requirements are met, than being a further requirement on top of all other requirements!

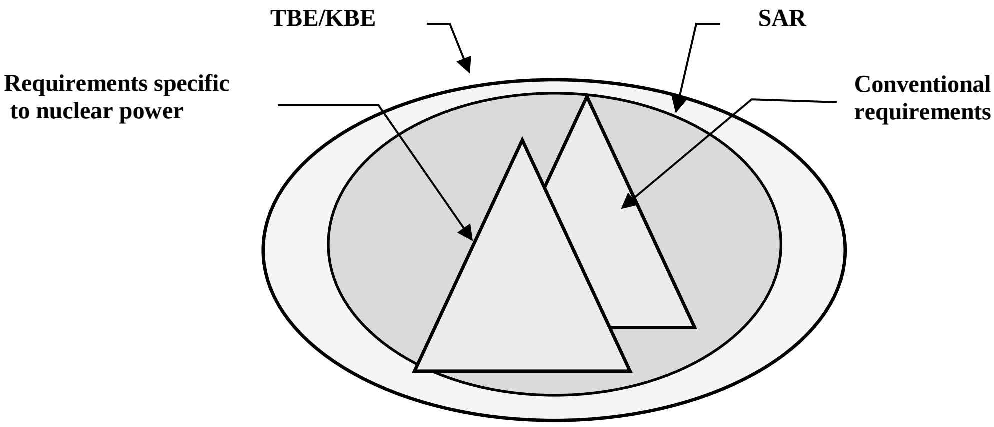

Figure 5: Relation between TBE/KBE and other requirement documents

The mandatory official requirements imposed by SSM are interpreted in the safety analysis report (SAR) for each plant. The content of each SAR differs depending on when the plant was built or modernized. The requirements have been changed over time and new requirements have been added. Examples are function classification (see Section 5), which, for most plants, is done to American rules, but which, for certain modernization projects, is done to IEC rules.

5 Function Classification

The functions of a nuclear power plants are divided into safety classes depending on their importance for safety. Electrical function classification can be done according to American rules and IEEE or according to IAEA and IEC standards. This description is general. A detailed description of the classification is given in the relevant safety analysis report (SAR).

Sections 5.1 and 5.2 are simplified descriptions. For specific definitions, see the standard IEEE 323 and IEC 61226.

5.1 Function Classification according to IEEE and Swedish Practice

Electrical function class 1E
Functions in class 1E - Electrical safety functions - may give an increase in radioactive emissions from the plant in the event of a malfunction after disturbances or incidents.

Electrical function class 2E
Functions in class 2E - Operational functions - cannot cause a significant increase in radioactive emissions to the environment in the event of a fault, but are important for the trouble free operation of the plant.

Electrical function class 3E
Functions in class 3E - Service functions - have no effect on reactor safety or production availability.

5.2 Function Classification According to IEC 61226

Class A
Class A includes the functions, systems and equipment (FSE), which play an important part in maintaining nuclear safety. FSEs according to Class A prevent postulated initial events (PIE) that lead to significant sequences, or that mitigate the consequences of PIE. Class A also includes FSE whose malfunction may lead directly to a significant sequence.

Class B
Class B includes the FSE that supplements Class A FSEs in maintaining nuclear safety. The implementation of a Class B FSE may make a Class A FSE unnecessary. Class B also includes FSEs whose malfunction may generate or worsen a PIE.

Class C
Class C includes the FSE that plays an alternative or indirect part in maintaining nuclear safety. Class C includes FSE that are important for safety but do not belong to Class A or B. They may form part of the plant’s total response to a transient (or Accident) but do not contribute directly to mitigation of the consequences.

Class O
Unclassified FSE have no importance for safety and are therefore not subject to any particular nuclear requirements.

6 Seismic Requirements

6.1 Background

The first nuclear power plants in Sweden initially were designed with no seismic requirements. A general robust design was considered to provide adequate protection against seismic events. As a result of more stringent safety rules issued after the construction, requirements on the ability to withstand earthquakes have been added. For the two latest reactors, Forsmark 3 and Oskarshamn 3, (F3/O3), seismic requirements according to American regulations have been applied for design and construction.

During the continued evaluation of the seismic capabilities of the plants performed by the Swedish utilities, problems have been identified as the specific Swedish response spectra has higher acceleration levels than the corresponding American spectra for frequencies above 10 Hz. This means that international experience and test results cannot be applied directly to the Swedish conditions. Especially for electrical equipment, such as relays and contactors, which are sensitive to frequencies above approx. 33 Hz it has been difficult to analyse and to verify their capability and function, since no international studies for this type of equipment have been made for these higher frequencies.

In order to verify seismic capability for Swedish nuclear power plants (F3 and O3 excluded) sections 6.2 - 6.6 shall be considered.

6.2 Basic Objectives regarding Seismic Capability

Structures and components of essential importance for the safe shutdown and long term core cooling of the reactor shall have a seismic capability sufficient for the seismic loads which can be expected at the frequency of 1E-5/year per unit. This requirement also applies to seismic interaction, which means that structures, piping or equipment not required to be seismically qualified shall not cause damage to equipment that are required for safe shut down during an earthquake.

As examples of seismic interaction requirements the structures, piping, or equipment shall not: loosen, burn, explode, and cause short circuits etc. during an earthquake.

6.3 New Design or Replacement of Equipment

For new design or replacement of component type (but not necessarily for repair of existing seismically qualified equipment) the guidelines in Technical Requirements shall be applied. Applicable seismic requirements are to be specified in the Technical Specification.

These requirements shall include specific required response spectra or response spectra selected according to TBE 102:2. Selected response spectra according to seismic environmental class SL1 - SL6 shall represent the envelop of the specific required response spectra.

For F3/O3 the curve based on Regulatory Guide 1.60, but modified for PGA = 0,15g horizontal acceleration, applies.

Based on the given ground response spectra in section 6.5, Figure 6, the relevant floor response spectra are generated for the node (location) where the electrical equipment is to be placed.

In an early stage of design or purchase the damping for the actual electrical equipment may not be known. Therefore, the response spectra for the node should be generated for a number of different damping values.

When using this type of broadened response spectra it should be noted that the applied energy is proportional to the square root of the bandwidth. This implies that equipment withstanding each single response spectrum may not withstand the applied energy when tested with a broadened response spectrum making up an envelope of the single response spectra.

6.4 Seismic Environmental Classes for Forsmark 3 and Oskarshamn 3 (F3/O3)

F3/O3 are designed for horizontal ground motion with GA = 0,15g.
See section 6.5, Figure 6. Vertical ground motion is assumed to 2/3 of the horizontal.

For F3/O3 there are response spectra based on which height in the building the equipment is located and depending on how the equipment is mounted. There are three seismic environmental classes defined for F3/O3 SL1, SL2 and SL5. For SL1 and SL2 the response spectra are given for horizontal and vertical acceleration respectively. For SL5 no specific response spectra have been given. The combined building responses are calculated according to Regulatory Guide 1.92, Rev 1.

For equipment mounted directly on walls or floors, current requirements specify response spectra according to seismic environmental class SL1 or SL2. For equipment mounted on other structures SL5 applies. See Table 1 below.

Table 1: Seismic environmental class, applicable for F3/O3 only

Seismic Environmental Class	**Equipment Location**	**Replaces Earlier Class**
SL1	Equipment mounted directly to building structure, 0-8 m above ground	Class 3
SL2	Equipment mounted directly to building structure, 8-20 m above ground	Class 4
SL5	Equipment mounted on e.g. pipes, ventilation drums, cable raceways or other structures	Class 5

Response spectra for seismic environmental classes shown above are given in TBE 102:2 and KBE EP-147.

For each equipment required response spectra shall be generated for the equipment mounting position. When the required response spectra have been generated for both horizontal and vertical acceleration, one response spectrum shall be selected enveloping all horizontal and vertical required response spectra for the actual positions.

In these classes the response spectra curves are defined for the damping 4 %, 5 % and 7 %. The damping value of the test spectrum shall not be higher than the lowest damping value of the actual equipment.

For alternative damping values use IEC 60980 to determine amplification factor (ratio between strong part and ZPA) at different damping values for a typical “time history”.

6.5 Ground Response Spectra

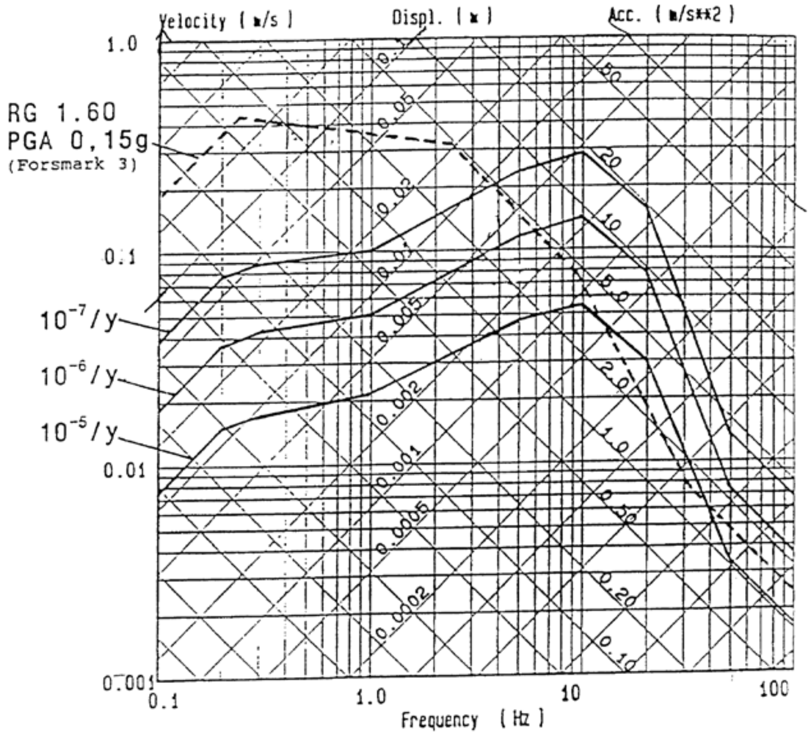

Figure 6: Ground Response Spectra for F3/O3 (dashed

The dashed line in the diagram represents the F3/O3 design requirements for a ground response spectrum, based on Regulatory Guide 1.60, modified for PGA = 0,15g horizontal acceleration. The other curves represent later defined design criteria for ground response spectra, based on specific Swedish conditions, with the frequencies 1E-5/year, 1E-6/year and 1E-7/year. All curves represent 5 % damping.

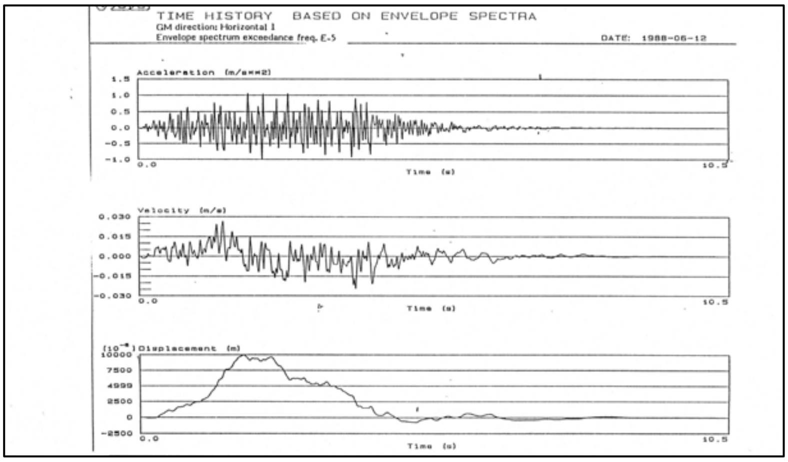

Figure 7: Illustration of a Swedish earthquake

6.6 Example of Relationship between Ground Response, Floor Response and Response for Installed Equipment

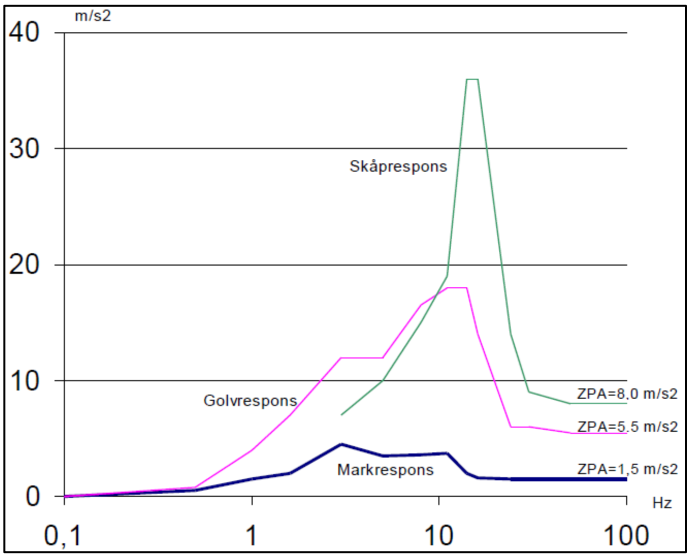

Figure 8 - Example of repeated response spectra calculations.

The ground response spectrum, which is characterized by the local geological conditions, is amplified in the building resulting in a floor response spectrum. A cabinet for electrical equipment is placed on the floor. The cabinet contains electronics and other electrical components. The floor response spectrum is amplified by the cabinet to a new response spectrum for a specific position in the cabinet. The ground response spectrum in this case is for 5 % damping at a maximum ground acceleration of 1, 5 m/s^2 and is used for analysis of buildings. The floor response spectrum in this case is for 4 % damping at the maximum floor acceleration of 5, 5 m/s^2.

The cabinet is exposed to an acceleration characterized by the floor response spectrum. A position in the cabinet give accelerations designated "Skåprespons" in the response spectrum, in this case calculated for 5 % damping. The maximum acceleration is 8, 0 m/s^2. The cabinet has a resonance frequency at 24 Hz, which gives acceleration values of 36 m/s^2.

The cabinet response spectrum according to the diagram illustrates the effect on affected components (single degree of freedom models with 5 % damping) in the analysed position in the cabinet. If the affected component has a resonance frequency at 11 Hz, we read the acceleration 19 m/s^2, but if the resonance frequency is 15 Hz, we read 36 m/s^2. These accelerations are the result of a ground motion as shown in section 6.5, Figure 7.

7 Document Description

7.1 The Document Package

The TBE/KBE package to which this user guide belongs consists of a TBE part containing technical requirements and a KBE part containing verification requirements.

- TBE 100:1 General Technical Requirements and Explanations
- TBE 100:2 General Technical Requirements on IT-security
- TBE 101 Environmental Specification for Normal Operation

- TBE 102:1 Environmental Specification for Accident Conditions
- TBE 102:2 Environmental Specification for Seismic Conditions
- TBE 103 – 122 Product Linked Requirements
- TS Product Linked Forms for Technical Specifications
- KBE 100 General Quality and Inspection Requirements
- KBE IP 103 – 122 Product linked inspection plans
- KBE EP 101 – 194 Inspection procedures to which KBE IP refers

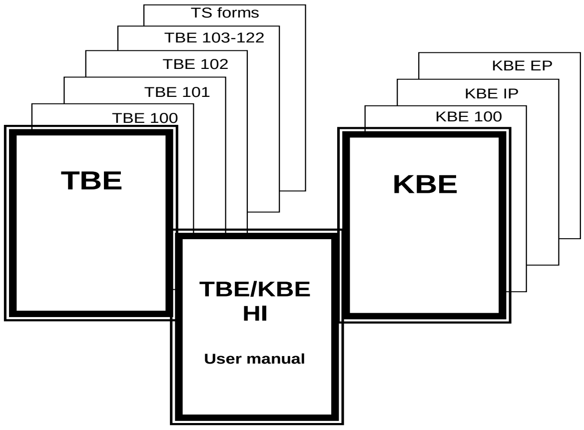

Figure 9: The TBE/KBE documents

7.2 Inquiry Documentation

After an initial inspection preparation, the technical documentation for the inquiry according to section 8.2 consists of:

- TS, Preliminary product linked Technical Specification [1]
- TBE 100:1 General Technical Requirements and Explanations
- TBE 100:2 General Technical Requirements on IT-security
- TBE 101-102 Environmental Specification According to TS
- TBE 103-122 Technical Provisions according to TS
- KBE 100 General Quality and Inspection Requirements
- KBE IP General product linked inspection plan according to TS
- KBE EP 101-194 Inspection procedures according to KBE IP

7.3 Procurement Documentation

After assessment of the tender documentation and renewed inspection preparation according to Section 8.4, the procurement documentation consists of the following documents:

- TS, Final Product Linked Technical Specification[2]
- TBE 100:1 General Technical Requirements and Explanations

1
Printed TS form (with unique identity) possibly with an attachment in the form of a technical report with description of requirements or separate technical requirement specification with unique identity. See chapter 8.2.
2
Printed TS form (with unique identity) possibly with an attachment in the form of a technical report with description of requirements or separate technical requirement specification with unique identity. See chapter 8.4...

- TBE 100:2 General Technical Requirements on IT-security
- TBE 101-102 Environmental Specification According to TS
- TBE 103-122 Technical Provisions According to TS
- KBE 100 General Quality and Inspection Requirements. Final product linked inspection plan stated in TS above (with unique identity).
- Inspection procedures KBE EP and/or the Manufacturer/Supplier’s inspection procedures to which KBE IP refers.

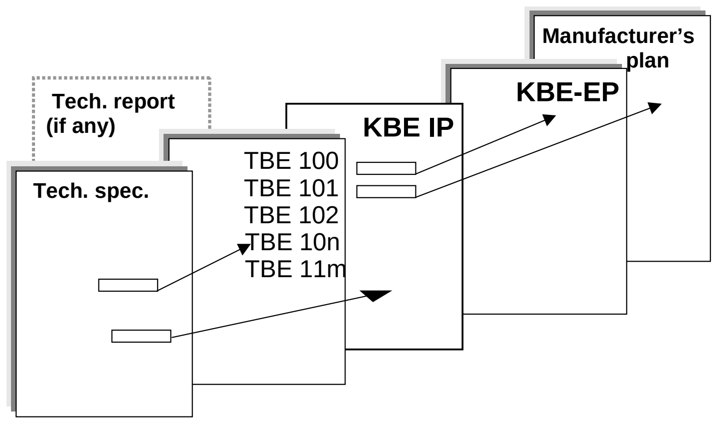

Figure 10: Procurement documentation

When procurement is complete, TS is used as a basis for plant documentation of both component type and individual components (C-doc.). The final inspection plan with resulting inspection report from the Manufacturer/Supplier is used for the inspection documentation of the plant (K-doc).

8 Work Description

The acquisition process is described very briefly in Section 3. A more detailed description is given here. The expression “acquisition process” is used to mean all necessary activities for acquiring a component or equipment, from the identification of a need and the defining of overall requirements to approval of its delivery, including inspection documentation.

For replacement of qualified electrical components (spare parts) a simplified process will be used (see figure 3) within the framework of the plants specific requirements.

It is important to use as far as possible the documentation that was produced in previous stages of the process. Do not re-write the documents for every stage in the process. Add new information to existing documents as the work progresses.

8.1 Main Design

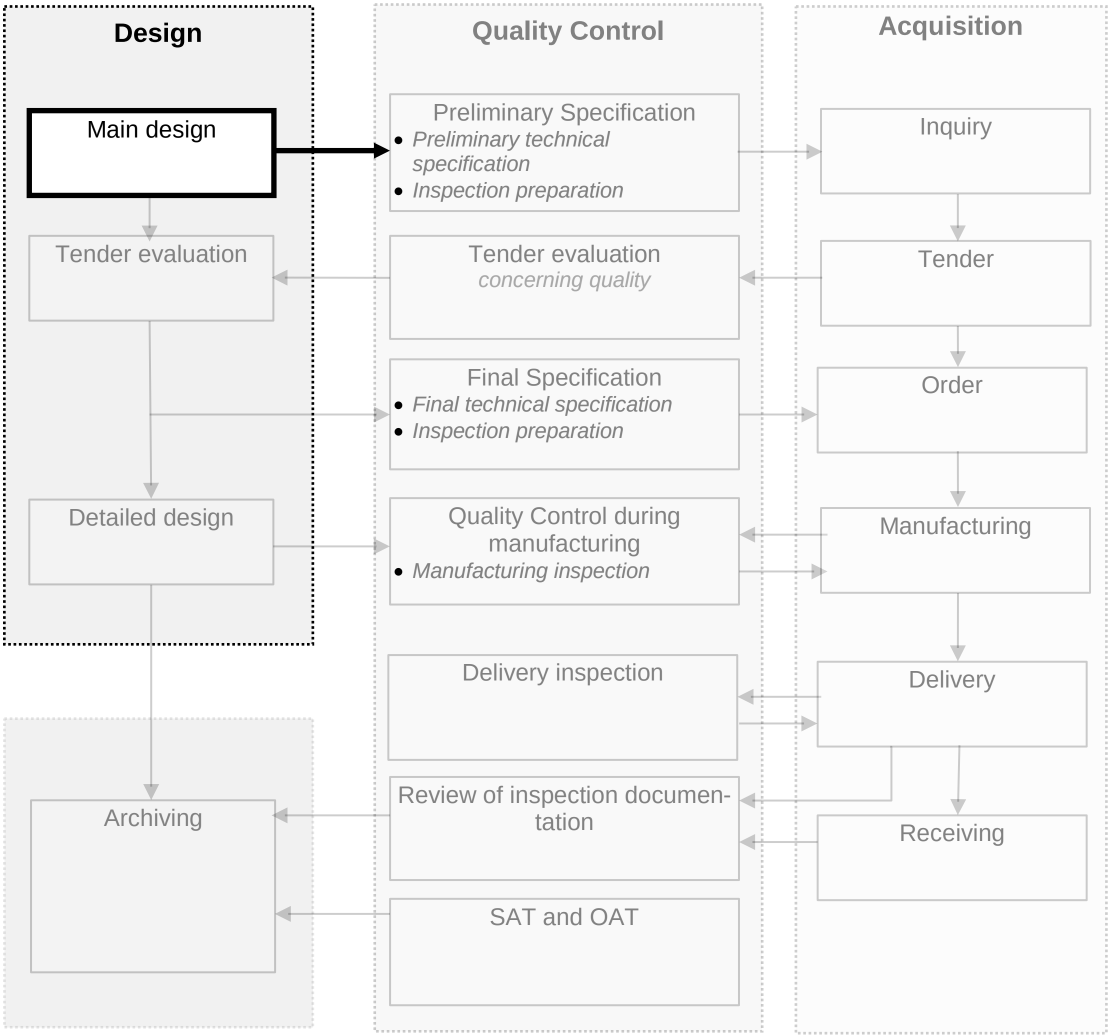

Figure 11: Main design

Changes to a plant and associated acquisition requirements are managed and documented in accordance with the Purchaser's instructions and routines. Main design is done on the basis of the requirements laid down at the time of the change decision. In this phase preconditions for specification of components and equipment are produced (among other things), to be used in acquisition (or later on acquisition at the time of detailed design). Examples of such preconditions are:

- system/equipment number
- type of equipment
- function
- dimensioning
- electrical function class
- environmental requirements
- safety class

8.2 Preliminary Specification

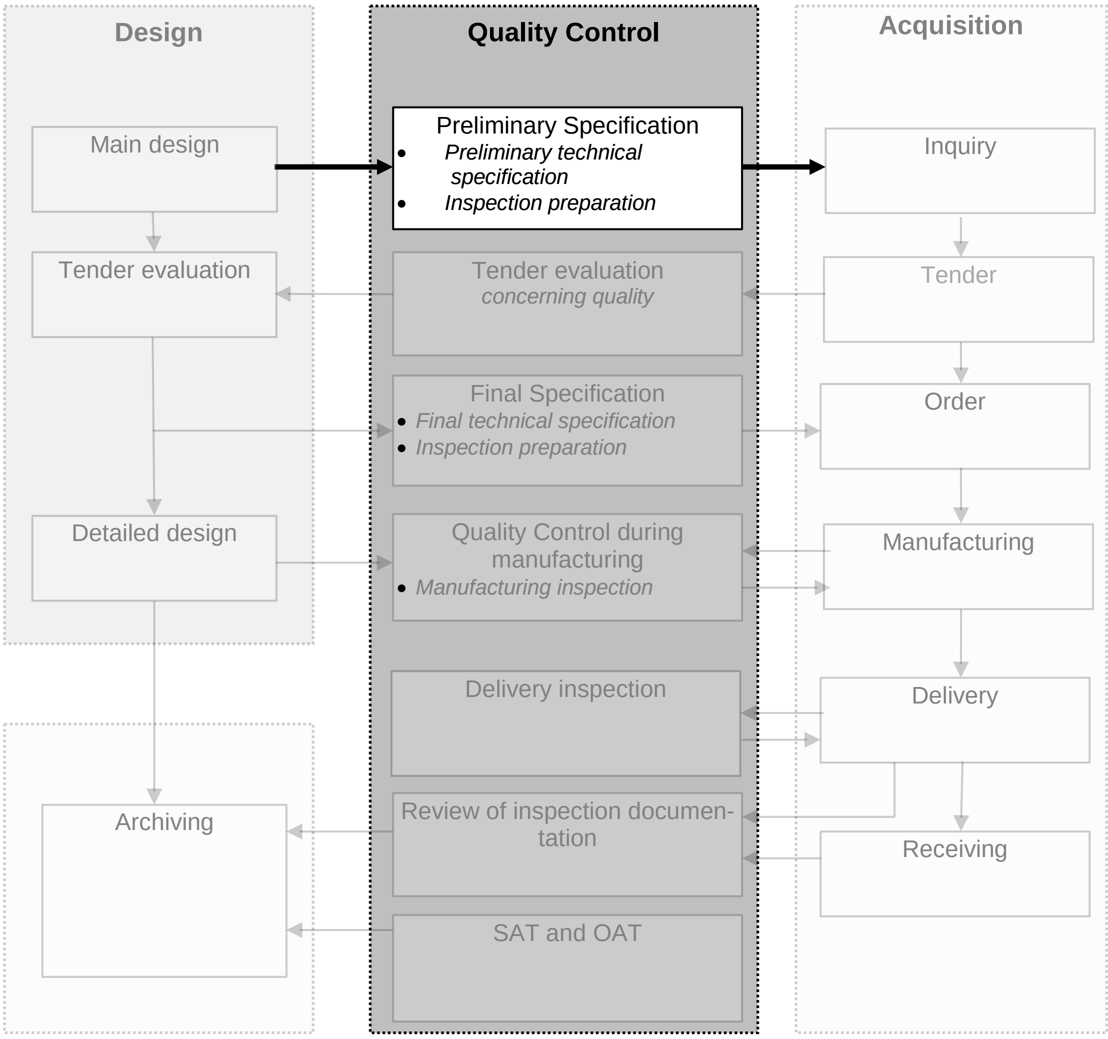

Figure 12: Preliminary specification

See also Section 9, which gives detailed instructions for filling out a TS (Sections 9.1-9.2) and inspection plan (Section 9.3).

Specification is done on a printed TS form. Alternatively a separate technical specification may be used, based on needs and prerequisites. The TS is the top document for the component/equipment.

On the TS form the Purchaser specifies the details in the header of the form, as well as the function requirements. Often it is necessary to refer to a separate specification of requirements which was produced in the main design stage. Where the choice is made to produce separate technical specification it is important that the same details are dealt with as in the printed form.

When specifying, consideration shall be given to the requirements and preconditions from the mechanical design, e.g. the mechanical connection of sensors (thread size etc.). These requirements are normally specified in the TS for mechanical equipment. It is very important that these requirements/specifications are coordinated.

8.3 Inquiry and Tender Evaluation

The technical documentation for the inquiry is sent to a selected number of Manufacturer/Suppliers for submitting a tender. Received tenders shall be evaluated.

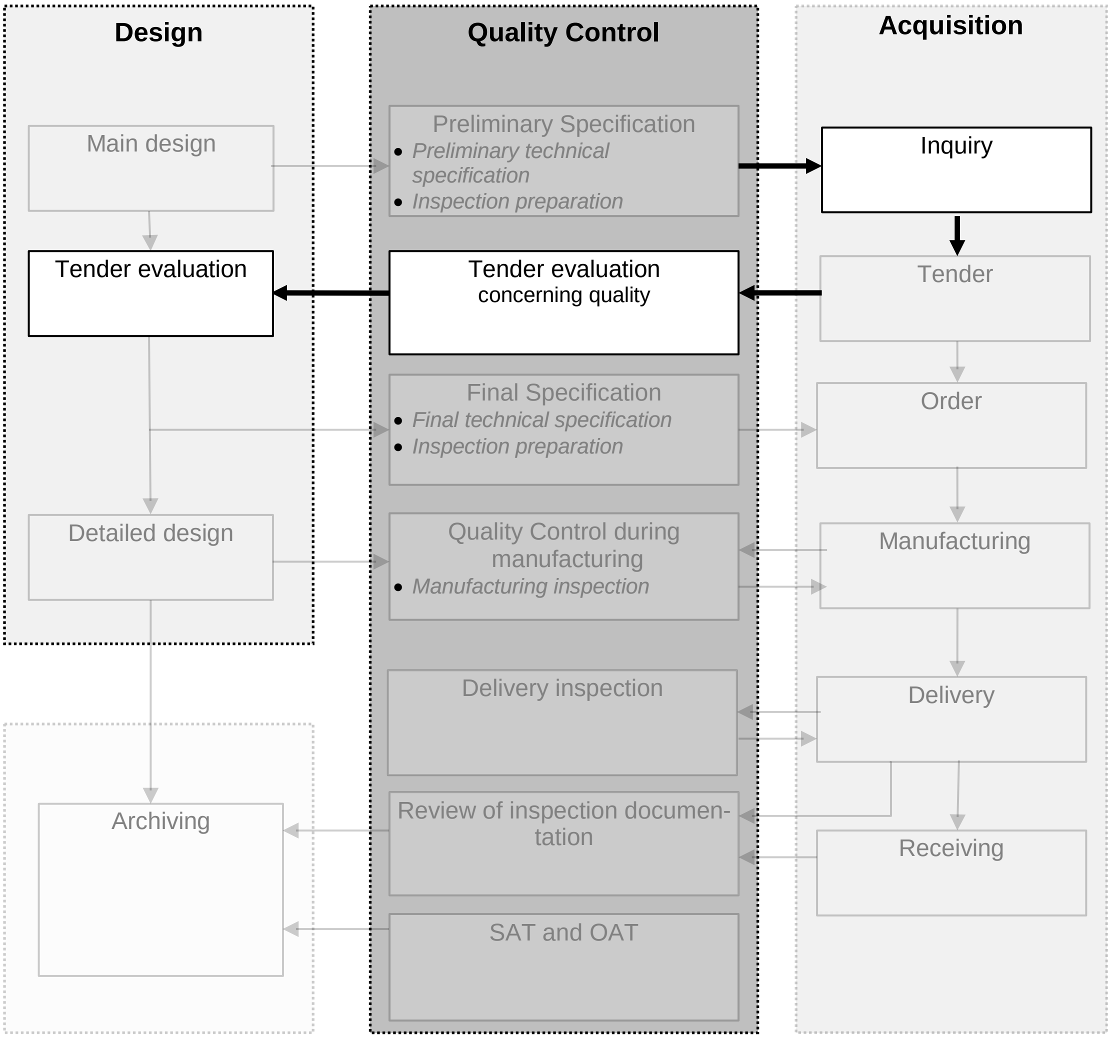

Figure 13: Tender evaluation and inquiry

This involves technical, quality related and financial evaluation of the tenders.

In conjunction with inquiry and evaluation, an assessment of the Manufacturer/Supplier shall be carried out. The Manufacturer/Supplier is assessed in terms of, among other things, quality system, previous experience, product quality, stability and ability to supply in the future.

8.4 Final Specification

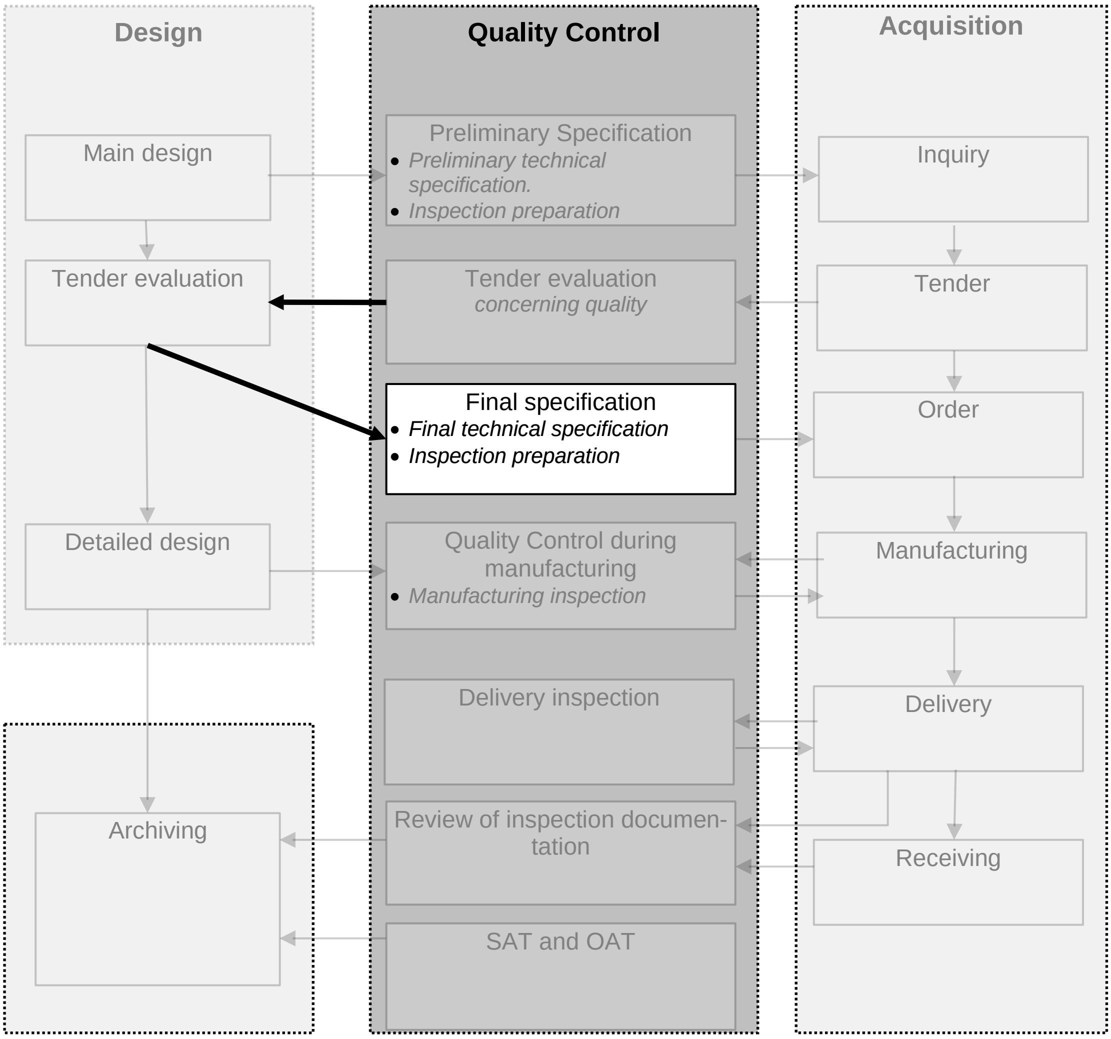

Figure 14: Final specification

When the Manufacturer/Supplier have been chosen, it is appropriate to carry out an inspection preparation as follows:

1. With the aid of information from the Manufacturer/Supplier, product data are added to the Technical Specification (article data) (See also Section 9.2).
2. An expert goes through the general inspection plans with the Manufacturer/Suppliers expert representative.
3. During this review, a note is made for every operation in the general inspection plan:
   - the Manufacturer/Supplier's name for his corresponding operation
   - procedure deleted (reason to be stated)
4. The scope of the original general inspection plan is not changed. The notes mentioned at number 2 above are added to the previously drawn-up inspection plan to create a Manufacturer/supplier- and product-linked inspection plan. This provides a good comparison between the original requirements (based on a general inspection plan) and the final version.

5. As the inspection documentation is supplied and approved, it is archived according to the normal procedures.

This inspection preparation then provides a starting point for continued work.

8.5 Manufacturing and Manufacturing Inspection

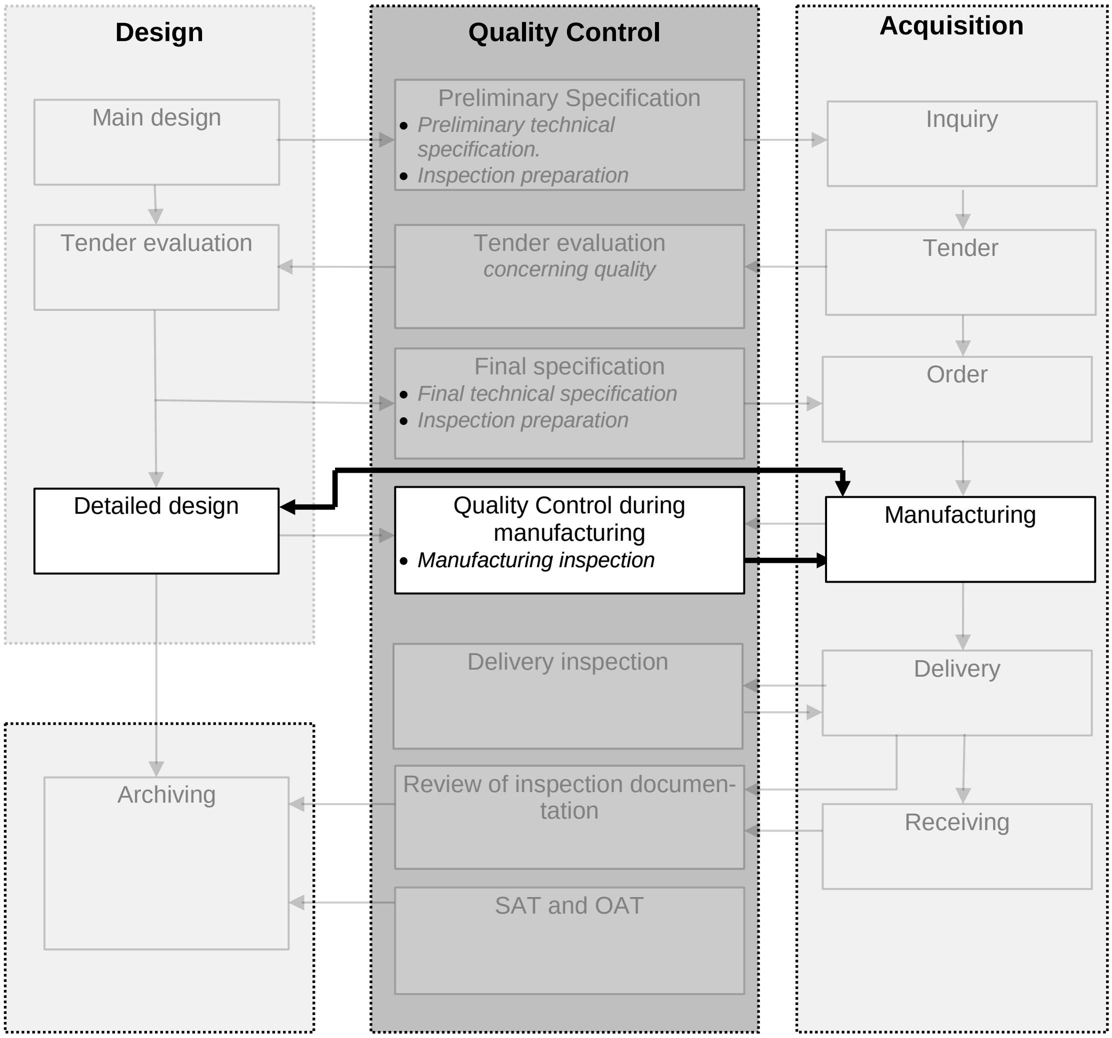

Figure 15: Manufacturing inspection and manufacturing

Manufacturing inspection is controlled entirely by the inspection plan (Section 9.3). Among other things it states which inspection procedures are to be performed as type inspection and routine inspection, and the tests at which the Purchaser intends to be present.

If type verification is based on previous type tests it is particularly important that the Manufacturer/Supplier can provide evidence that identity applies between the type-inspected and supplied equipment. (see KBE EP-180).

Before the equipment is delivered, the Purchaser shall have had the opportunity to be present at a pre-delivery test. For complex equipment this generally takes the form of a function test (Factory Acceptance Test, FAT). For simpler components and if experience of previous deliveries has been good, the pre-delivery inspection may be omitted.

8.6 Delivery and Delivery Inspection

A release note is passed to the Manufacturer/Supplier when the following conditions are satisfied:

- The manufacturer/Supplier has stated in writing that the delivery or specified part-delivery, including inspection report, other documentation and visual inspection, are ready for delivery inspection and approved by the Purchaser.
- Delivery inspection at the Manufacturer/Supplier has been done by the Purchaser or by an inspector engaged by the Purchaser. Delivery inspection at the manufacturer can be omitted if experience of previous deliveries has been good, if the delivery is not complex or if the risk of shortcomings is considered low in other respects. A decision on omitted customer witnessed delivery inspection at the Manufacturer/Supplier should not be communicated to the Manufacturer/Supplier before delivery consent is given.
- Preliminary or final inspection of the Manufacturer/Supplier inspection report for the delivery shall have been done and been approved internally by the Purchaser.

8.7 Receiving

When the arrival inspection against the order (correct goods and quantity) has been done, receiving inspection can be done.

The scope of the receiving inspection varies depending on the type of component and may, for instance cover visual inspection, insulation inspection, calibration, function check and the like. The scope is governed by instructions at the particular plant.

8.8 Review of the Inspection Documentation

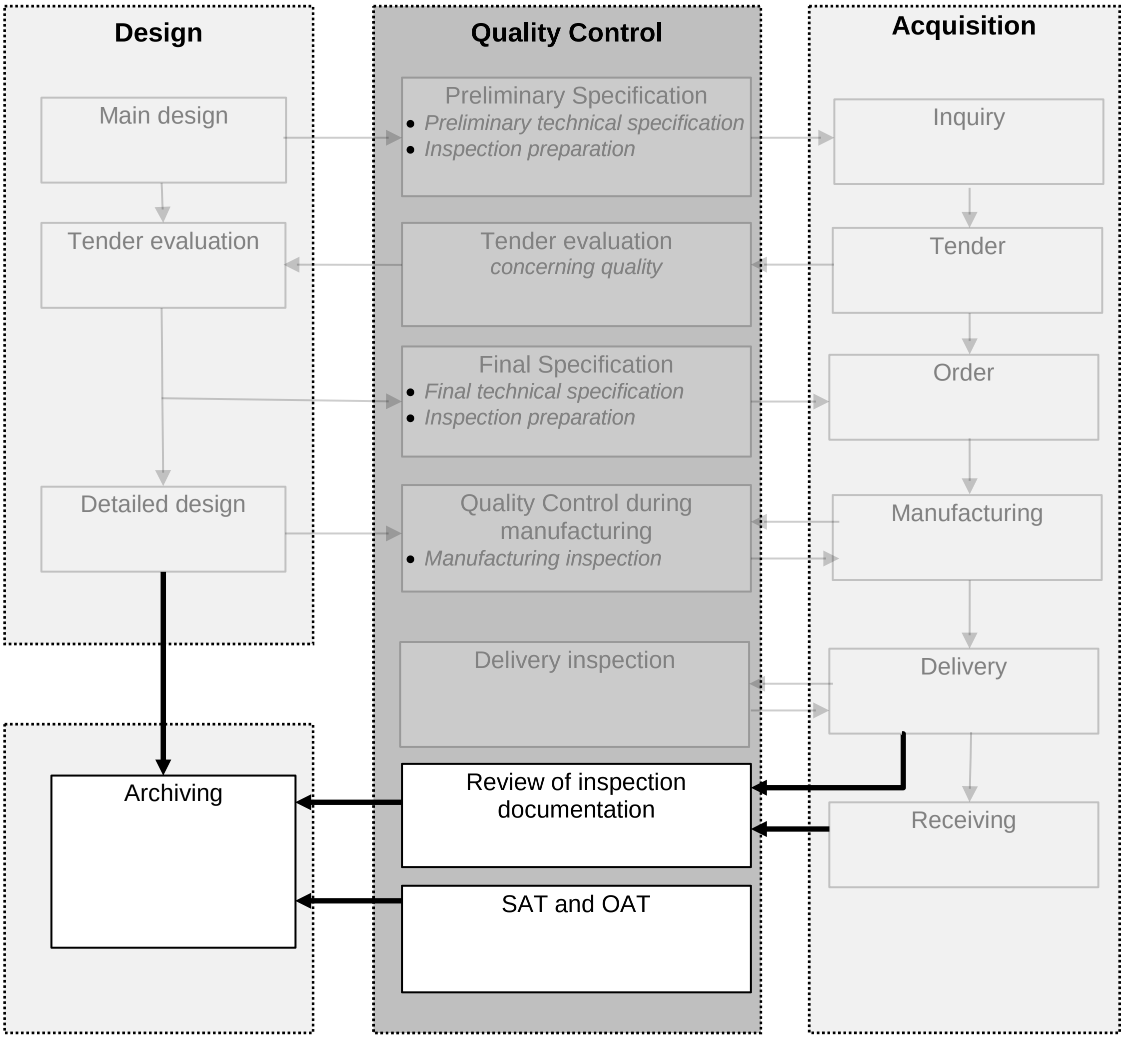

Figure 16: Review of inspection documentation

The review is to check that the Manufacturer/Supplier provides the agreed inspection documentation, and that the documentation verifies that the agreed tests have been performed with an approved result.

8.9 SAT and OAT

The scope of the SAT and OAT is defined in connection with ordering and is implemented after the installation.

8.10 Archiving

On the basis of the inspection documentation supplied, the Purchaser can write a qualification report, a review certificate and, where applicable, a deviation report. These documents, together with the Manufacturer/Suppliers documentation are then included in the final documentation.

9 Instructions for Detailed Completion

This section describes in detail how to fill out:

- Section 9.1: TS form “Plant Requirement Specification”
- Section 9.2: TS form “Manufacturers Specification”
- Section 9.3: Form for scope of inspection “Inspection plan”

Specifications and Inspection Plans shall be reviewed in case of re-purchase.

9.1 TS form “Plant Requirement Specification”

This document is filled in by the Purchaser and constitutes the Purchaser’s requirements to be fulfilled by the Manufacturer/Supplier.

The TS form for “Electrical Equipment” and “Field Mounted Component” are used below as examples.

- Section 9.1.1: Form header
- Section 9.1.2: Requirement Specification
- Section 9.1.3: Process Data
- Section 9.1.4: Service Conditions
- Section 9.1.5: General Technical and Quality Requirements
- Section 9.1.6: General Technical and Quality Requirements – Mechanical parts
- Section 9.1.7: Surface treatment, Painting system

In some cases it may be appropriate to refer to a separate requirement specification.

Write the requirement specification so that it can be used with more than one Manufacturer/Supplier.

Requirements not stated in the applicable TBE shall be stated. However, it is not appropriate to state requirements that are included generally in the TBE.

It is important that the administrator should be thoroughly familiar with the requirements imposed in TBE 100:1, TBE 100:2, KBE 100 and in the product-specific TBEs that apply to the equipment.

9.1.1 Form Header

Details of the plant, systems, location, classification, document registration, revision etc. are to be stated in accordance with internal company instructions. The details are not primarily directed at the Manufacturer/Supplier. The status of the specification — approved for inquiry, approved for procurement/ ordering, approved for manufacturing — shall be apparent from the revision markings.

TECHNICAL SPECIFICATION
Plant Requirement Specification

Electrical Equipment

					00 Document Reg. No. / Page No.		
01 Plant Forsmark 1	System 323			In-Plant Identification P1	Art No		
02 Safety Class (SC) SC 3	Functional Class 1E			Location	Type Approval / Qualification Report		
03 Status	Prepared	Reviewed	Approved	04 Revision	Prepared	Reviewed	Approved
Förfrågan							
Upphandling							

Figure 17: Form header and revision fields

Document Reg No / Page No
Document identity (reg no.) and page number

Plant
Name of plant, e.g. Forsmark 1

System
System membership, e.g. system number 323

In-Plant Identification
Object designation, e.g. P1

Art No
Plant owner’s article number or equivalent(not used in this phase)

Safety Class
Safety class according to classification list

Functional Class
Electrical function class according to classification list

Location
Location in the plant, with the aid of room number(s)

Type Approval/ Qualification Report
Reference to qualification report (not used in this phase)

Status / Prepared/Reviewed/Approved
Controlled document management in accordance with plant specific rules

9.1.2 Requirement Specification

The design of the form in terms of fields to be filled out is adapted to the various types of component and equipment that occur.

Requirement Specification

21 Type of equipment/component			
22 Functional specification			
23 Accuracy			
24 Power supply	Input	Output	Output load
25 Degree of protection >IP 55	Mounting	Electrical connection	
26 Remarks			

Figure 18: “Requirement Specification”, example of the appearance of a form for electrical equipment

Product type and functional requirements are described in as much details as is judged to be necessary. The function of most process components can be described in terms of their accepted name: transducer, solenoid valve, squirrel-cage motor etc. and the specific characteristics required. Obviously, complex equipment such as control equipment, switchgear etc. requires a more detail functional description.

Generally, input and output data, power and auxiliary voltage supply, rated data, accuracy, mounting, electrical connections and physical limits/interfaces are to be stated to the appropriate extent.

Use standard/accepted terms to the greatest possible extent. Avoid using the possible Manufacturer/Supplier designations, catalogue numbers etc. to describe the requirements.

Power and auxiliary voltage
If the equipment is to receive power or auxiliary voltage from networks in the plant with a rated voltage of 220 V or 380 V, these values shall be stated, not 230 V or 400 V respectively.

Degree of protection
In the process areas, the lowest permitted degree of protection is IP54 to IEC 60529. For components that may be exposed to sprinkling or hosing in connection with decontamination, IP55 shall be specified.

For components located in reactor containment, RI, IP55 is generally applicable. However, according to the assembly instructions, certain enclosures in addition to these shall be provided with drain holes at the low point to prevent condensation collecting in normal service operation due to humidity cycling.

For components to be placed in enclosures (equipment cabinets and boxes), IP20 shall be specified.

9.1.3 Process Data

The process data needed to be able to specify the component/equipment shall be stated.

Process Data

41 Process connection	Dimension	Material	Medium
42 Design Pressure (abs)	Design Temperature	Operating Pressure (abs)	Operating Temperature
43 Transients			
44 Remarks			

Figure 19: "Process data". Example of a form for a Field Mounted Component

Process Connection
Type of connection to the process, e.g. thread, weld, flange

Dimension
E.g. thread size

Material
E.g. stainless steel, grade 2333

Medium
Medium in contact with the component, e.g. reactor water, air

Design Pressure
Design pressure (state unit)

Design Temperature
Design temperature in ºC

Operating Pressure
Operating pressure (state unit)

Operating Temperature
Operating temperature in ºC

Transients
E.g. pressure surges (magnitude/duration)

9.1.4 Service Conditions

It is a general rule that components and equipment shall continue to function under the actual environmental conditions to which they are subjected in normal operation and in extreme/accident operation of the plant.

For equipment that is subjected to raise environmental stresses due to internal temperature rise, process impact, other local factors or extreme/accident operation of the plant, the actual expected values shall be stated. For example, pressure and temperature transients in the process, e.g. loss of power supply, loss of ventilation etc.

Service Conditions

51 **Normal operation** Enligt TBE 101 Stränghet C	52 **Extreme operation**	53 **Accident Conditions** Funktionskrav enligt nedan
Additional	Additional	Accident Transients
Amb Temp. (long term) C:	Amb Temp. (short term) C:	Seismic SSE SL3 Seismic Category 1A
Amb Temp. (short term) C:		
Humidity, % RH:		
Vibration, m/s^2, Hz		LOCA BWR/PWR generic Time: days Radiation dose: kGy
Radiation, kGy/year:		
54 Remarks		

Figure 20: Service Conditions

It is important that the user of TBE/KBE knows which environmental factors are specified in the four basic severity levels in TBE 101 so that any additional stresses can be specified here.

The additional requirements not covered by TBE 100 – 102 are specified under “Service Conditions”; see also Section 9.1.4.2.

9.1.4.1 Normal Operation

This section gives instructions for filling in Section 9.1.5 “General Technical and Quality Requirements”.

“Normal operation” is the state of the plant in power production, routine shutdowns, start-up etc. without faults in cooling functions and within the design values for outdoor temperature and cooling water.

The conditions that prevail during the operation of systems that include the component or equipment are controlling, even if the system is not normally in operation.

For the majority of components and for most equipment, the standardized environment descriptions (severity levels) stated in TBE 101 can be used without special additions. Note that TBE 101 <u>does not</u> describe requirements to be met by e.g. equipment installed under water, or the specific environmental requirements that apply in computer rooms.

The basic severity levels A, B, C and D describes generally the environment that is expected to exist in the stated areas including certain margins. Severity levels A and B excluding the environmental factor ionising radiation agree to a large extent with the practice that prevails in the process industry.

Table 2: Examples of severity in different types of room

TBE 101 – Severity A	Applicable to equipment installed in electrical rooms or similar mild environments. Ionising radiation level is insignificant.
TBE 101 – Severity B	Applicable to equipment installed in process locations outside the reactor containment. Equipment may be subjected to ionising radiation.
TBE 101 – Severity C	Applicable to equipment installed inside the reactor containment. Equipment is subject to ionising radiation.
TBE 101 – Severity D	Applicable to equipment installed at non-weather protected locations.

Severity A shall not be used for areas where ionising radiation occurs. Severity B is appropriate in “red” areas if expected radiation doses are low.

9.1.4.2 Additional Requirements

Service Conditions

51 **Normal operation** Enligt TBE 101 Stränghet C	52 **Extreme operation**	53 **Accident Conditions** Funktionskrav enligt nedan
Additional	Additional	Accident Transients
Amb Temp. (long term) C:	Amb Temp. (short term) C:	Seismic SSE SL3 Seismic Category 1A
Amb Temp. (short term) C:		
Humidity, % RH:		
Vibration, m/s^2, Hz		LOCA BWR/PWR generic Time: days Radiation dose: kGy
Radiation, kGy/year:		
54 Remarks		

Figure 21: Service Conditions

Known actual values for temperature, radiation, mechanical stresses, transients etc. are to be stated each on a separate line under “Additional” or “Accident Conditions”. The dose rate shall always be stated for severity levels B and C.

Ambient temperature

The basic severity levels in TBE 101 dealt with in the previous section cover continuous ambient temperatures up to 40 °C in A-areas and up to 55 °C in B- and C-areas[3].

Additional requirements according to severity B (55 °C) or a higher value with regard to heat are to be specified for equipment that is subjected to a higher ambient temperature due to internal heating, the impact of nearby process parts or by other local causes. If the temperature rise is short term, the expected time and frequency are to be stated.

Generally, an additional requirement of least 70 °C shall be specified for components intended to be installed close to hot process parts.

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[3] From the point of view of aging, it is assumed that the mean temperature around safety-classified equipment in A-areas is of the order of 25 °C and that the highest internal temperature ("hot spot") is 40 °C.

Components located inside enclosures (equipment cabinets and boxes) shall be assumed to have an ambient temperature 15 °C above the temperature that applies to the enclosure unless other values are known (based on population rules, for example). Ambient temperature plus 15 °C therefore determines which severity is to be specified.

Humidity
Additional requirement severity C concerning humidity is to be specified if the humidity in A-areas significantly exceeds 50% RH.

EMC
Immunity and emission requirements according to TBE 101.

For equipment containing electronics located in areas with a higher interference level (e.g. some switchgear) additional requirements are specified as regards immunity to interference.

Ionising radiation
It is a general rule to avoid locating electrical equipment in "hot/red" areas. Components that shall be located close to a process (e.g. valve actuators, transducers etc. including associated wiring) shall be located as far as technically possible from the parts of the process that cause the radiation (and also heat).

The total radiation loading for a single component or piece of equipment is calculated from actual operating dose rates and design life.

If the total radiation dose does not exceed the order of 1 kGy, no special measures are required as regards the environmental factor ionising radiation. The dose is not specified in TS and verification is not needed in the environmental qualification. However, exceptions apply for components with modern electronics and for fibre optic cables. For these components accumulated radiation dose is maximum 10 Gy.

If the total radiation dose is higher than of the order of 1 kGy, the environmental factor ionising radiation shall be considered for components and equipment that contains polymer materials essential for correct operation. The radiation dose is stated in TS and verification of the radiation resistance shall be included in the environmental qualification of the component type. The majority of temperature-resistant instrumentation components intended for installation in or adjacent to hot process parts can withstand doses up to 100 kGy without major problems. However, as stated earlier, this does not apply for electronics and fibre optic cable. For electronics, the maximum radiation dose is 10 Gy.

If the total radiation dose exceeds 100 kGy, special measures should be taken, since the performance of polymer and other materials subject to aging may be reduced. The design life can be maintained by planned replacement of parts subject to aging.

If the total radiation dose exceeds the order of magnitude of 10 MGy during the time for which the component is installed, the use of materials other than metallic and ceramic materials is excluded if the properties of the material are significant for safe operation or environmental protection.

The operating dose rate is stated in the TS in kGy/year or mGy/h according to station-linked preconditions. Primarily, the dose rates shall be based on actual measurement data from the plant. In the individual case, an assessment of the total integrated dose in normal service and at DBE shall be made.

Obtain readings from radiation protection in every doubtful case. Do not accept “don’t know” answers.

The DBE dose is added to the operating dose in accordance with any requirements in the relevant SAR if operation of the component is required from the point of view of reactor safety in the DBE case.

Verification of the immunity to ionising radiation for components located in the primary space of the reactor containment or in active process areas should generally be done in accordance with KBE EP-151, Severity C, 50 kGy, unless other more precise figures have been produced.

9.1.4.3 Extreme Operation

Service conditions

51 **Normal operation** According to TBE 101 Strictness C	52 **Extreme operation**	53 **Accident conditions** Functional requirements as below
Additional	Additional	Accident Transients
Ambient temp. (long-term) C:	Ambient temp. (short-term) C:	Seismic SSE SL3
Ambient temp. (short-term) C:		Seismic Category 1A
Humidity, % RH:		
Vibration, m/s^2, Hz		LOCA BWR/PWR generic
Radiation, kGy/year:		Time: days
		Radiation dose: kGy
54 Remarks		

Figure 22: Extreme operation

State any extreme external conditions that may apply in normal and abnormal system operation - but not DBE - and which are not covered by the basic severity levels in TBE 101.

Requirements for function in extreme operation with 90 °C, 8 h, per year, are included in TBE 101, Severity C.

9.1.4.4 Accident Conditions

Service conditions

51 **Normal operation** According to TBE 101 Strictness C	52 **Extreme operation**	53 **Accident conditions** Functional requirements as below
Additional	Additional	Accident transients
Ambient temp. (long-term) C:	Ambient temp. (short-term) C:	Seismic SSE SL3
Amb Temp. (short-term) C:		Seismic Category 1A
Humidity, % RH:		
Vibration, m/s^2, Hz		LOCA BWR/PWR generic
Radiation, kGy/year:		Time: days
		Radiation dose: kGy
54 Remarks		

Figure 23: Accident condition

DBE Conditions
State in accordance with plant-specific preconditions the DBEs at which the equipment shall operate.

LOCA
Additional requirements in accordance with TBE 102:1.

Any requirements for function at LOCA are to be stated, including the function time requirement.

Function in accordance with specification in conjunction with a pipe break environment is not always possible for electrical components. The function that shall be satisfied in conjunction with LOCA shall therefore be separately specified in the function requirements. For example, one may specify measurement with greater permitted inaccuracy than normal, active function in both or only one direction, lowest insulation level, a particular fault function that is not permitted to occur etc. These are important details for a correct accident test program and qualification at reasonable cost. Where equipment that is already qualified is purchased, this also makes it easier to evaluate the qualification level against the current application.

Earthquake – SSE
Additional requirements in accordance with TBE 102:2.

Requirements for function in the event of an earthquake are to be stated, including requirement level and seismic category, which defines the function requirements during and/or after an earthquake, or only passive requirements.

TBE 102:2 and KBE EP-147 are not sufficient as basis only, the following should be added:

- Actual floor response spectrum which is compared with seismic environmental classes
- Reinforcing factors in cabinets
- Damping for relevant equipment

The function to be fulfilled during and/or after the earthquake shall be separately specified in the function requirements above. It shall, for example, be clear whether malfunction can be accepted during but not after the earthquake (e.g. electromechanical components with moving parts). Compare the reasoning about function requirements at LOCA above.

External pipe break
Additional requirements in accordance with TBE 102:1.

Any requirements for function on external pipe break are to be stated, including the function time requirement. Requirements for mechanical resistance to missiles and jets are to be stated.

Severe accidents
The environment in the event of severe accidents is not described in TBE 102:1 and function requirements cannot be specified with the methods used in the sections above. Environmental and functional requirements shall, if necessary, be specified in accordance with plant-specific preconditions. Severe accidents may include sequences of events with severe core damage “filter scenario” or a “beyond design” earthquake.

9.1.5 General Technical and Quality Requirements

This section specifies technical and quality-governing provisions, supplementary requirements with regards to environmental resistance, and the scope of inspection/inspection plan.

General Technical and Quality Requirements

71 Technical and Quality Requirements TBE 100	KBE 100	TBE 108	
72 Environmental Specifications TBE 101, Severity: C	TBE 102:1	Additional Environment severities Humidity, % RH:	Radiation
73 Additional Requirements			
74 Safety Class (SC) SC3	Functional Class 1E	General Inspection Plan KBE IP	Final Inspection plan
75 Remarks			

Figure 24: General Technical and Quality Requirement

Technical and Quality Requirements
TBE 100, KBE 100 (pre-printed on the form). Product-specific TBE from the series TBE 103 – 122 is to be stated. Certain equipment requires more than one TBE to be stated.

Environmental Specifications
TBE 101, Severity A, B, C or D. Accident profile, e.g. TBE 102:1 BWR 2

Additional Requirements
Seismic requirements, e.g. TBE 102:2 SL 4, 4% damping

Safety Class
Safety class

Functional Class
Electrical functional class (see Section 5)

General Inspection Plan
General inspection plan from series KBE IP 103-122

Final Inspection Plan
Delivery-linked inspection plan specified at procurement

9.1.6 General Technical and Quality Requirements - Mechanical Parts

General Technical and Quality Requirements - Mechanical parts

81 Technical Specification reference		Inspection Plan	Safety Class (SC)
82 Quality Class	Tightness Class	Cleanliness Class	Inspection Class
83 Technical and Quality Requirements (TBM/KBM)			
84 Remarks			

Figure 25: General Technical and Quality Requirements – Mechanical parts

For components that contain pressurized parts in contact with media (e.g. a thermowell for a Pt100 sensor, flow sensors, and other “in-line” components) the requirements that apply according to TBM/KBM are to be stated directly. It is permissible to refer, for example, to a separate specification for the mechanical component. TBM/KBM does not impose requirements for measuring instrumentation connected via instrument pipes, e.g. pressure transducers with valve block.

9.1.7 Surface Treatment, Painting Systems

Any specific requirements for surface treatment and painting due to corrosive environment, for example, or the need for decontamination are stated in TBM. Normally, the TBE requirements indirectly provide sufficient requirements to be met by the manufacturer, i.e. the manufacturer's standard methods can be accepted.

Surface treatment, Painting system

91 Surface treatment	Painting system

Figure 26: Surface treatment, painting systems

State for instance, the Manufacturer/Suppliers standard unless there are particular requirements. Specific requirements can be found in TBM.

9.2 TS form "Manufacturers Specification"

This form is used to specify data and performance of the equipment/component that has been evaluated against the requirements and is to be procured.

The details are obtained from the Manufacturer/Supplier and at the end of the procurement process they should have been verified by the Purchaser in accordance with the TBE/KBE requirements.

It is a general rule that requirements specified in TS should not be changed when the performance of the chosen equipment deviates from the requirements. The deviation report is handled separately and will be referred to in the TS.

9.3 Inspection Plan

9.3.1 General

Inspection plans are used as a tool for specifying the scope of inspection for purchased equipment (or for a defined part of a project) and to structure the inspection report in accordance with the requirements imposed for final approval and plant archiving. The inspection plan and the technical specification are the main documents required for inquiry and procurement and at inspection during and after manufacture.

9.3.1.1 General Inspection Plans

There are general inspection plans KBE IP for different types of equipment and components. Normally, the same serial number applies for equipment-linked TBE and associated KBE IP, and only one KBE IP should be used as a basis for the scope of inspection. However KBE IP-104, -105 and -106 deviate from this rule.

General inspection plans KBE IP-xxx are normally used when inviting bids for equipment for which no final inspection plan has been produced before or where the inspection plan is obsolete.

The manufacturer/Supplier produces a draft final inspection plan for the component type or for the current delivery, in accordance with instructions in KBE 100, and encloses this, as well as applicable procedures, to the tender.

9.3.1.2 *Final Inspection Plans*

After evaluation of the scope of inspection proposed in the tender, a final inspection plan is prepared.

A final product-linked or order-linked inspection plan shall always be produced before an order is placed. Interaction with the Manufacturer/Supplier is described in KBE 100. Final inspection plans for electrical equipment are normally drawn up by the Purchaser on the basis of information supplied by the Manufacturer/Supplier. On re-purchasing, the final inspection plan that was used for the main procurement procedure is used. Normally the type inspection report is replaced with a certificate of identity from the Manufacturer.

9.3.2 Codes in the Inspection Plan

In the inspection plans, a number of codes are used to indicate the scope, responsibility, any independent monitoring, and documenting. The codes are explained in the inspection plan, but the following should be known for the operational work.

9.3.2.1 *Type of inspection Operation (first letter in the box)*

A = Routine (100 %) Inspection
The operation shall be carried out for all supplied units during the manufacturing process or a final inspection before delivery.

S = Sample Inspection
The operation shall be carried out on a selection from the delivery, using statistical methods. Parameters shall be stated in the inspection plan. Normally applied only to components in delivered in large quantities and to sample pieces from cables.

T = Type Inspection
This operation shall be carried out on at least one component or piece of equipment representative of the delivery. Type verification of conventional requirements for standard components and equipment (environmental compatibility, performance) is normally done by the manufacturer/Supplier at market launch of the product and in such cases this operation relates only to reporting of the documentation.

Note that type-tested examples shall not be included in the delivery.

Code A, T or S shall be stated for all procedures that involve an inspection activity for the delivery in question. The code may be omitted if the operation relates only to documentation or checking.

9.3.2.2 *Responsible for Documented Inspection (second letter)*

Inspection performed and documented by:
E = Manufacturer
D = Supplier
B = Purchaser

This code defines the responsibility for ensuring that the operation is carried out with a satisfactory result and documented. Normally, the Manufacturer (E) is responsible.

9.3.2.3 Inspection Supervision (third letter)

Inspection supervised by:
B = Purchaser
C = Inspector engaged by Purchaser
D = Supplier

This code indicates that the operation shall be supervised by a body independent of the manufacturer. The person responsible for the inspection operation (normally the manufacturer) shall engage this supervision in accordance with rules in KBE 100. The absence of the code (-) means that no independent supervision is required.

9.3.2.4 Documentation (fourth letter)

R = Technical Report
P = Inspection Record
I = Certificate

This code indicates particular requirements that apply to the process of documenting the operation.

The absence of the code (-) indicates that there is no need to document the inspection operation. The manufacturer’s internal methods have been judged by the Purchaser to be sufficient to ensure that the operation will be correctly performed.

The code stated at Delivery Release Inspection or KBE EP-180 means that a summarizing certificate/report on inspection procedures performed shall be provided.

R Technical Report means a more extensive report with analyses, assessments etc.

P Inspection Record means the same as Certificate but with the necessary measured values reported.

I Certificate means certification that an inspection has been performed with a satisfactory result.