

## Quality Assurance Procedure

# DESIGN PROCESS AND CONTROL

### *Abstract*

This document describes the design process applicable to the LHC Project from conceptual design to the release for procurement and manufacturing. It defines the design control and documentation and assigns the relevant responsibilities

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## 1. PURPOSE

This procedure applies to the design and development of LHC systems, sub-systems, assemblies, sub-assemblies and parts from the conceptual design to the release for procurement and manufacturing.

It establishes design control policy and defines responsibilities and procedures for preparing and verifying engineering design documents.

## 2. POLICY

To implement uniform methods of design and drafting in all engineering groups involved in the construction of the LHC to ensure that it meets the specified requirements.

To define the checks and verifications applied to the design and development activity.

To control and verify the design, assign design function responsibilities, define technical interfaces and verify that the design output meets the design input requirements.

To expose the design to persons with viewpoints and opinion other than those of the design and development teams.

To maximise protection against oversight that might adversely affect the LHC quality, safety and performance.

To ensure through proper documentation that the design decision process is recorded for reference in the production, commissioning, operation and maintenance of the LHC.

To ensure that the design change history is properly documented.

## 3. SCOPE

This procedure applies to all design activities associated with defining, developing, producing, installing and maintaining the LHC and its systems, sub-systems, assemblies, sub-assemblies and parts. It is applicable to design teams at CERN, in Institutes and Contractors.

## 4. RESPONSIBILITIES

Managers, Supervisors, Project Engineers (PE) and Designers at CERN, Institutes, and Contractors are responsible for:

- Making all participants aware in performing good engineering and management practices to meet Project cost, schedule, safety and technical objectives.
- Ensuring that engineering calculations related to safety are carried out by suitably qualified personnel.
- Ensuring that non-staff personnel assigned to design and drafting activity is suitably trained in the use of Computer Aided Design tools (CAD) and has been informed of CERN practices before starting work
- Ensuring that detailed designs are consistent with the approved LHC configuration.

The Project Management, the Project Committees and Approval Groups provide additional checks, through reviews, that detailed designs are consistent with the LHC approved configuration.

The LHC Project organisation chart assigns responsibilities for the development, design, manufacturing and commissioning of the LHC systems, sub-systems, assemblies and parts to the Divisions and Groups, at CERN and in collaborating Institutes, that are participating in the Project.

Division and Group Leaders at CERN have the responsibility to prepare and allocate work packages corresponding to the main systems, sub-systems, assemblies and parts of the LHC.

A Project Engineer is assigned to each work package.

The Project Engineer of a work package has the responsibility to:

- Plan and supervise the design of the products included in the work package.
- Supervise the production of specifications, drawings and layouts.
- Assess the safety requirements of the products and co-ordinate the review of those requirements with CERN's Technical Inspection & Safety Commission (TIS)[ 1 ].
- Supervise the building and testing of models and prototypes.
- Supervise the collection and recording of test data.
- Define the quality assurance category of the product and its sub-assemblies and parts as described in "Quality Assurance Categories" [ 2 ].

Supervise the processing of modifications in accordance to " Configuration Management-Change Process and Control "[ 4 ].

## 5. DESIGN PROCESS

The design process, from design input to design output and including design control is shown on figure1.

### 5.1 CONCEPTUAL, BASIC AND DETAILED DESIGN

The "Large Hadron Collider Conceptual Design" [ 3 ], defines the initial functional and technical requirements of the LHC.

The requirements contained in the Conceptual Design report are updated where necessary and released by the appropriate Project Committee.

The design process begins with the translation of the conceptual requirements into a functional specification. Once reviewed the functional specification requirements are further refined into basic and detailed design with the production of engineering drawings, engineering specifications, procurement documents, manufacturing and tests instructions.

The detailed design activity is carried out at CERN, in Institutes, or Contractors.

When the design process is completed, the design is released for procurement or for fabrication in a CERN workshop.

### 5.2 STATUTORY AND REGULATORY REQUIREMENTS

The codes, standards, and practices used for dimensioning the product, selecting materials, defining manufacturing, assembly, testing and operation procedures shall be defined in the design documentation. Whenever possible International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) standards and practices shall be used. When ISO or IEC documents fall short of defining the requirements, they are to be complemented or replaced by Deutsches Institut für Normung (DIN) documents, or by a national code or standard approved by CERN.

These rules are independent of any national codes and standards applicable in the country of manufacture of the product.

### 5.3 SAFETY REQUIREMENTS

In application of CERN's TIS directives [ 1 ], the PE shall establish whether the product being designed requires a safety assessment to be carried out by TIS. If required, the TIS safety assessment should be carried out early enough in the design for its conclusions to be incorporated in the final design.

### 5.4 DOCUMENTATION REQUIREMENTS

Throughout the design process the design activities shall be recorded in documents. Documents shall be stored in the Engineering Data Management System and reviewed prior to being released.

#### 5.4.1 ENGINEERING SPECIFICATIONS

Three types of Engineering Specifications are used to document the design process, the **Functional Specification**, the **Design File** and the **Interface Specification**.

The purpose of the **Functional Specification** is to ensure that all personnel involved in the design process use the same verified input information to carry out the design.

The Functional Specification shall outline the requirements of the product's design by refining and completing the conceptual design described in the "LHC Conceptual Design"[ 3 ] and in the LHC Parameters and Layouts database [ 5 ]. It shall establish that the design requirements are appropriate and address the intended use of the equipment.

The functional specification should address at least the following points:

- The performance objectives, operating conditions, and the requirements for reliability, availability, maintainability.
- Mechanical, electrical, cryogenic, radiation resistance and other technological constraints to be respected by the design.
- Safety and regulatory requirements constraints.
- Manufacturing and installation constraints.
- The basic technical interface requirements of the design.
- Requirements for calculations, test and development work, including the construction of prototypes.

This list is not exhaustive and should be completed as appropriate for each individual case.

The documents, database records, and other information and data used to establish the specification shall be listed as references.

The purpose of the **Design File** is to record the design decision process and to describe the design choices that have led to the final design.

The design file shall present a short description of the evolution of the completed design with the results obtained by analysis, measurements and tests that demonstrate that all the requirements and constraints set out in the functional specification are met.

The purpose of the **Interface Specification** is to ensure that all groups and individuals involved by the product and its operational environment are aware of the product's interfaces and given the opportunity to review and approve these interfaces.

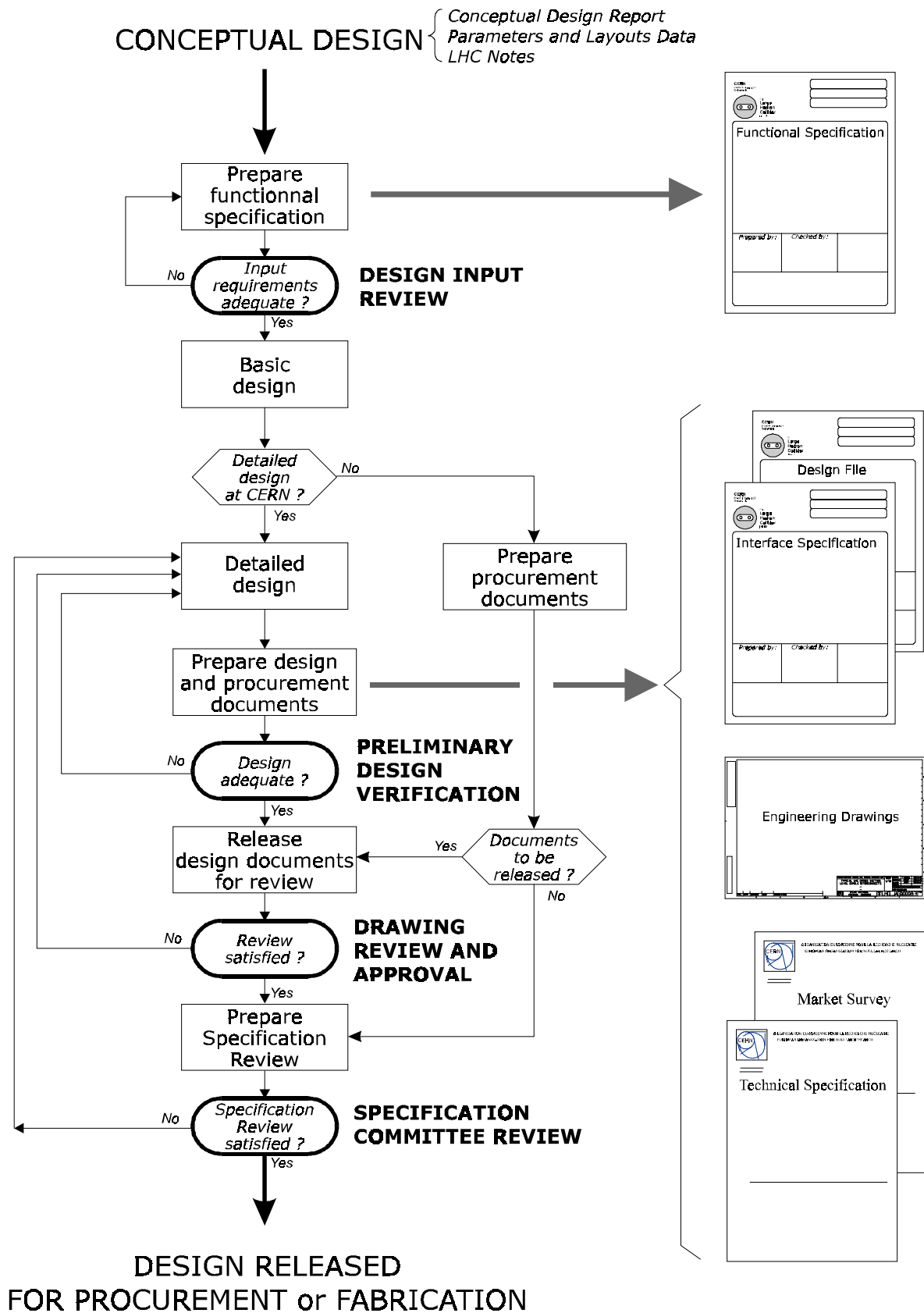


Figure 1: Design Process

The interface specification shall describe and document, in particular with the help of drawings, the product's physical and functional boundaries with other systems, sub-systems and equipment. It shall also describe and document the responsibility boundaries of all groups or individuals involved in the design.

Engineering Specification shall be prepared in accordance with "Document Standards" [ 6 ] and managed as described in "Document Process and Control" [ 7 ].

#### 5.4.2 TECHNICAL DESCRIPTION OF MARKET SURVEYS

The purpose of the **Technical Description of Market Surveys** is to provide the basic technical description of products for which a Market Survey is carried out. Market Surveys precede Invitations to Tender to inform industry about future requirements. They also tell CERN what the market can offer and which firms could qualify to receive an Invitation to Tender.

Engineering Specification shall be prepared in accordance with "Technical Specification and Market Survey Standards" [ 8 ] and managed as described in "Document Process and Control" [ 7 ].

#### 5.4.3 TECHNICAL SPECIFICATION

The **Technical Specification** is the technical description part of Invitations to Tender and Price Enquiries.

Its purpose is to provide the detailed technical description of products for which an Invitation to Tender or a Price Inquiry is carried out. Invitations to Tender, also referred to as Calls for Tender, are used to obtain price quotations from Industry for requirements above 200 000 CHF. Price Enquiries are used for requirements below 200 000 CHF.

Together with engineering drawings the Technical Specification shall provide all the technical information required for the procurement process.

Engineering Specification shall be prepared in accordance with "Technical Specification and Market Survey Standards" [ 8 ] and managed as described in "Document Process and Control" [ 7 ].

#### 5.4.4 ENGINEERING DRAWINGS

The Project Engineer shall provide the design office with all the necessary information to prepare engineering drawings. Design criteria approved by the PE should include as appropriate: performance objectives, operating conditions, requirements for reliability, availability, maintainability and safety, and the definition of technical interfaces.

The PE shall provide the CDD manager with the information necessary to enable drawing registration and drawing review and approval. This includes the equipment codes to be used and their description, the QAC of the products, the names of designers, drawing controllers and approvers, the applicable drawing release procedure and the CAD software used.

Engineering Drawings shall be prepared in accordance with the appropriate Design Standards:

- "Design Standards-Mechanical Engineering and Installations" [ 9 ].
- "Design Standards-Electrical Schematics" [ 10 ].
- "Design Standards-Fluids Schematics" [ 11 ].

They shall be managed as described in "Drawing Management and Control" [ 12 ].



## 6. DESIGN CONTROL

Formal design control is secured by conducting at appropriate stages of the development Project Reviews, Collaboration Reviews, Critical Products Reviews and Design Reviews.

The design reviews are:

- Design Input Review.
- Preliminary design review.
- Drawing Review and Approval
- Specification Committee Review.

### 6.1 DESIGN INPUT REVIEW

The Design Input Review shall be carried out by the PE and his design team. Its purpose is to ensure that the basic design description is complete and unambiguous and correspond to the conceptual design requirements.

### 6.2 PRELIMINARY DESIGN REVIEW

The Preliminary Design Review shall be carried out by the PE and his design team. Its purpose is to ensure that the basic and detailed design correspond to the basic design description and that the design documentation is ready to be submitted for review and approval.

### 6.3 DRAWING REVIEW AND APPROVAL

All engineering drawings are subject to a Review and Approval process before they are released for distribution.

The Review and Approval process of engineering drawings is described in "Drawing Management and Control" [ 9 ].

### 6.4 SPECIFICATION COMMITTEE REVIEW

The Specification Committee Review is the main formal review before a design is released for procurement. It shall ascertain that design requirements are met by the proposed design in respect of:

- Engineering and functional considerations.
- Cost.
- Schedule.
- Quality Assurance requirements.
- Statutory and regulatory requirements.
- Safety requirements.

The results of the Specification Review shall be documented in a meeting's minute.

## 7. DESIGN CHANGES

A formal Engineering Change Request (ECR) is required to initiate a revision of a design when that design has been released for procurement/production and is included in the LHC baseline. ECR's shall be prepared and processed as described in "Configuration Management-Change Process and Control" [ 4 ].

When a design document, such as a drawing, has been released but has not yet been placed under Configuration Control that document can be modified at the initiative of the PE. A new revision of the document shall be created and this revision must be submitted to the same release procedure as the original document.

## 8. RELATED DOCUMENTATION

- |        |  |   |
|--------|--|---|
| [ 1 ]  | TIS/DI 97-46   | List and Summaries of TIS Safety Documents                |
| [ 2 ]  | LHC-PM-QA-201.00   | Quality Assurance Categories                              |
| [ 3 ]  | CERN/AC/95-05(LHC)   | Large Hadron Collider Conceptual Design                   |
| [ 4 ]  | LHC-PM-QA-304.00   | Configuration Management-Change Process and Control       |
| [ 5 ]  | From the CERN home page ( <a href="http://www.cern.ch/">http://www.cern.ch/</a> ), go to <i>LHC Project</i> and then <i>LHC Design</i> |   |
| [ 6 ]  | LHC-PM-QA-405.00   | Document Standards  |
| [ 7 ]  | LHC-PM-QA-303.00   | Documents and Parameters Process and Control              |
| [ 8 ]  | LHC-PM-QA-406.00   | Technical Specification and Market Survey Standards       |
| [ 9 ]  | LHC-PM-QA-402.00   | Design Standards-Mechanical Engineering and Installations |
| [ 10 ] | LHC-PM-QA-403.00   | Design Standards-Electrical Schematics                    |
| [ 11 ] | LHC-PM-QA-404.00   | Design Standards-Fluids Schematics                        |
| [ 12 ] | LHC-PM-QA-305.00   | Drawing Management and Control                            |