Quality Assurance Procedure

DRAWING AND 3D MODEL MANAGEMENT AND CONTROL

Abstract

This document presents an overview of the management of engineering drawings and 3D models\(^1\) for the LHC project. It describes the drawing identification system, the drawing and 3D model release procedures, and how drawings produced at CERN and drawings produced by Institutes, Contractors and Suppliers are managed.

\(^1\) 3D models are tri-dimensional computer representations of real life objects produced by Computer Aided Design systems.

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1. PURPOSE

To present an overview of the management of engineering drawings and 3D models for the LHC project. To describe how drawings produced at CERN and drawings produced by Institutes, Contractors and Suppliers are managed. To describe LHC drawing identification system and drawing and 3D models release procedures.

2. POLICY

CERN operates and maintains a central computer repository of all engineering drawings, accessible world-wide via the Internet. The system, known as the CERN Drawing Directory (CDD) [1], is a component of the Engineering Data Management System (EDMS) used for the LHC engineering data and it provides the following main functionality:

- Registration of new drawings.
- Creation of new revisions of existing drawings.
- Submission of drawings and 3D models for review and approval.
- Changing drawing life-cycle labels.
- Viewing and printing.

3. SCOPE

The CDD system is the repository for all drawings produced at CERN and in collaborating Institutes, Contractors and Suppliers. It shall be used for all LHC engineering drawings.

4. RESPONSIBILITIES

Managers, Supervisors and Project Engineers (PE) at CERN, Institutes, Contractors and Suppliers shall assure that personnel occupied with design activities and drawing management are aware of and understand the procedures described in the present document.

Project Engineers in charge of the design and/or procurement of equipment shall initiate and co-ordinate the preparation, verification and release of the 3D models of that equipment required for transport and installation simulations, or any other studies for which the availability of 3D models is necessary.

5. DRAWING MANAGEMENT PRINCIPLES

Drawings for the LHC Project are produced by different methods and on different sites. Irrespective of the method and site of production, all drawings are managed in a common way in the CERN Drawing Directory. In this system drawing data storage and printing are fully computerised and are common to the different production methods:

- Drawing descriptive data such as number, title, author, date, project codes, function, revision index, etc. is stored in a central relational database.
- Graphic data for all Computer Aided Design (CAD) produced drawings is stored in Hewlett-Packard Graphics Language\(^1\) (HPGL), a vector format, on computer media attached to the CERN computer network.

\(^1\) HPGL and HPGL2 are trademarks of Hewlett-Packard Company
The CDD system maintains the links between the descriptive data stored internally, the graphic data on the CERN computer network and the address of the source drawing data in the CAD file system.

New drawings, drawing revisions and review and approval signatures are registered in CDD using forms available on the World Wide Web (WWW).

Drawing registration, revision, review and approval are controlled by access rights established for all LHC design work packages. Access rights are managed by the CDD administrator who can be contacted by electronic mail at cdd.support@cern.ch.

All the revisions of a drawing are saved in CDD. The source CAD data of the last revision of a drawing is saved in the CAD system's database. CAD system managers and design offices shall define their own policy for saving older revisions of source CAD data.

Upon release the graphic file of a drawing is updated with the names of the reviewers and the dates of the reviews. The source drawing data in the CAD system remains unchanged.

Released drawings can be accessed from the WWW and viewed on computer displays with the CERN's HPGL viewer application [2].

Individual copies of released drawings may be printed from the viewer application. For users on the CERN site high capacity plotter-copiers are available for printing multiple copies. These plotters are equipped with paper folding equipment and reductions are possible.

6. DRAWING CATEGORIES

Drawings for the LHC Project are organised in 2 categories, CERN drawings and external drawings.

6.1 CERN DRAWINGS

The main characteristics of CERN drawings are the following:
- They are produced in one of the CERN design offices.
- They are prepared with one of the CAD systems used at CERN and they are formatted in accordance to the appropriate CERN design standard.

The CAD systems used at CERN for the LHC Project are AutoCAD2, including add-on applications, and Euclid3. Pro-Engineer4 is also used for specific design work.

6.2 EXTERNAL DRAWINGS

External drawings are produced outside CERN in Institutes, Contractors and Suppliers. They may be delivered to CERN in 2 different formats, native CAD files or plot files.

The main characteristics of external native CAD files are the following:
- They are prepared with one of the CAD systems used at CERN and they are formatted in accordance with the appropriate CERN design standards, [3], [4], [5].
- A copy of the native CAD data is transferred to CERN and stored in the corresponding CERN CAD database. The transfer to CERN of the CAD data shall take place before drawings are released.

2 AutoCAD is a registered trademark of Autodesk, Inc.
3 Euclid is a registered trademark of Matra Datavision
4 Pro-Engineer is a registered trademark of Parametric Technology Corporation
The main characteristics of plot files are the following:

- They are prepared with a CAD system used at an Institute, Contractor or Supplier and they are formatted in accordance with the Institute’s, Contractor’s or Supplier’s own design standards.
- They are identified by the Institute’s, Contractor’s or Supplier’s own drawing number and by the LHC drawing number.
- Every drawing shall have a blank area reserved for writing CERN’s identification data.
- They shall be delivered to CERN in the form of HPGL plot files.

The document LHC-PM-QA-306.00 "Drawing Process–External Drawings" describes the detailed requirements for external drawings.

7. DRAWING IDENTIFICATION AND REVISION

Engineering drawings for the LHC are identified by a unique fixed length alphanumeric number. Drawing numbers are 12 characters long with the following structure:

- **Project code**: a project identification code. For the LHC project the code is LHC
- **Equipment code**: an LHC item identification code (5 chars/digits)
- **Number**: a sequential number (4 digits).

```
PROJECT CODE   EQUIPMENT CODE   SEQUENTIAL NUMBER
LHC            |                |                
```

The list of valid equipment codes is given in documents LHC-PM-QA-204.00 “Equipment Naming Conventions” and LHC-PM-QA-207 “Naming Conventions for Buildings and Civil Engineering Works”.

Drawing sequential numbers are automatically assigned by the CDD application, based on Project and Equipment codes.

The main data items associated with each drawing in CDD are:

- The drawing number and its components, **Project code, Equipment code, Number**.
- The drawing size.
- The title in English only or English and French.
- The author.
- A code identifying the design office to which the author is attached.
- The date of creation.
- The activity to which the drawing relates.
- The function (assembly, layout, detail...).
- The Quality Assurance Category as described in document LHC-PM-QP-202.
- A code identifying the CAD software used to produce the drawing.
- The address of the source file in the CAD database.
**Drawing revision**

New drawings are created with a blank revision index.

For each revision a new index is automatically assigned by the CDD application. An index is composed of 2 letters, starting with AA, followed by AB, AC and so on up to AZ. The index following AZ is BA, followed by BB, BC etc. From AA to ZZ 676 revisions indexes may be recorded. Only the second character of the revision index is written in the drawing title block.

The main data items associated with each drawing revision are:

- The current revision index (blank, AA, AB, ...).
- The author, date and description of the modification.

### 7.1 CIVIL ENGINEERING DRAWINGS PREPARED BY CONSULTANTS

The identification of civil engineering (CE) drawings prepared in the framework of the contracts between CERN's ST Division and the CE Consultants is detailed in the document "QAM for LHC Civil Engineering Consultancy Services" [ 8].

The use of this identification system is strictly restricted to drawings prepared by the CE Consultants.

To assist LHC Project personnel that need to access these drawings, the structure of the identification system is repeated here.

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**8. DRAWING OPERATIONS GUIDELINES**

Detailed Information on the use of CDD can be found in the CDD Manual and on the WWW at the address http://wwwlhc01.cern.ch/cdd/

For convenience a summary description of the main drawing operations is repeated here.

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**8.1 CDD ACCOUNT PREPARATION**

All personnel required to use CDD shall be registered and given a CDD account. This account needs to be created prior to using CDD. To obtain an account with the appropriate access rights, the requester shall send an electronic mail to the CDD administrator with the following information:

- The name and first name of the requester and his/her e-mail address.
- The name of the Institute, Contractor or Supplier to which the requester is attached.
- The equipment codes that shall be used to register drawings and their full text descriptions.
- The names and first names of designer(s) allowed to create and update drawings.
The names and first names of designer(s) allowed to perform the technical verification.

The name and first name of the PE allowed to give the release authorisation.

The name of the Approval Group allowed to perform the project co-ordination approval.

The CAD software used to prepare the drawings.

The category of drawings (CERN drawings or external drawings).

8.2 DRAWING REGISTRATION

Drawing registration is the process of entering a drawing’s descriptive data in CDD. CDD will then return the next available sequential number for the given Machine code - Equipment code combination. This number shall then be copied in the drawing’s title block.

Once registration is completed the drawing is ready for review and approval.

8.3 DRAWING REVIEW AND APPROVAL

The drawing review and approval process is shown in annex A1.

All engineering drawings are subject to a review and approval process before they are released for distribution.

The review and approval process comprises 2 or 3 stages. Each stage of the process is recorded on the drawing with the name of the controller and the date of control.

The review and approval process applicable to a drawing is dependent on:

- The scope of the drawing.
- The quality assurance category of the item represented on the drawing.

Drawings of general interest and drawings implicating more than one LHC system, are designated **Project Level drawings**. They shall be submitted to the 3 stages of the review and approval process.

All other drawings are designated **Group Level drawings**. Group level drawings with a quality assurance category A shall be submitted to the 3 stages of review and approval. Those with a quality assurance category B or NONE shall be submitted to the first 2 stages of review and approval only.

The first stage of review and approval is a **technical verification** by a drawing controller. This verification shall assure that the drawing dimensions and notes are unambiguous, correct and complete and that the drawing conforms to the proper practises and appropriate CERN design standards. The drawing controller shall be a competent designer other than the author of the drawing.

The second stage of review and approval is a **release authorisation** by the PE in charge of the item represented on the drawing. It shall assure that the drawing conforms to the basic design and that it depicts what was required. It shall assure that requirements for performance, operating conditions, reliability, availability, maintainability and safety of the assembly or part depicted on the drawing are met.

The third stage of review and approval is a **project co-ordination approval** given by the Approval Leader after the drawing has been circulated, seen and commented by all members of the appropriate Approval Group. At the end of the review process the Approval Leader evaluates the comments made and makes the final decision to release the drawing or to request corrections. The Project Co-ordination Approval shall establish that all requirements for installation and integration of the item in the LHC environment are met and that all interfaces with other systems are correctly defined.
The review and approval process of a drawing is started by the author informing the drawing controller and the PE that the drawing is ready for review and approval. Once a drawing’s review and approval process has started, the author shall not modify in any way the source CAD data.

8.4 DRAWING RELEASE

Drawing release is the process of preparing the graphic file of a drawing, editing it with review and approval data and loading it in the CDD file system from where it can be accessed for display and printing.

Upon release the title block of each drawing is updated to record:

- The authority effecting the release, either **PROJECT ENGINEER** or **PROJECT LEADER’S OFFICE**.

- The life-cycle label of the drawing, indicating the life-cycle phase of the item represented on the drawing.

Drawing subject to the first 2 stages of review and approval are released within 24 hours of the release authorisation. The title block is updated as shown in figure 1.

![Figure 1: Title block - Drawings Released by a PE](image1.png)

Drawing subject to the 3 stages of review and approval are pre-released within 24 hours of the release authorisation by the PE. At this stage of pre-release, the title block is updated with the label UNDER APPROVAL to indicate that the approval process is under way. See figure 2.

![Figure 2: Title block - Drawings Pre-Released for Approval](image2.png)

Finally, these drawings will be released within 24 hours of the closure of the approval process by the Approval Leader. The title block is updated as shown in figure 3.
All drawings are first released with the FOR INFORMATION life-cycle label.

### 8.5 EXTERNAL PLOT FILES

External drawings delivered as plot files have a CERN identification stamp added on when they are released. This stamp is updated upon release of the drawing in the same way as a CERN drawing title block. An example is shown in figure 4.

![External Plot File Identification Stamp with Review and Approval Data](image)

**Figure 4:** External Plot File Identification Stamp with Review and Approval Data

### 8.6 DRAWING REVISION

A new revision of a drawing shall be created whenever any modification of a released drawing is required.

A new revision of a drawing cannot be created until the previous revision has been released.

New revisions shall be submitted to the same review and approval process as the original drawing.
8.7 DRAWING LIFE-CYCLE LABEL

By default drawings are released with a FOR INFORMATION life-cycle label. Either the PE or the Approval Leader can then change this to reflect the evolution of the drawing during the item's life cycle.

<table>
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<th>LIFE-CYCLE</th>
<th>LABEL</th>
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<tbody>
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<td>Definition of the equipment</td>
<td>FOR INFORMATION</td>
</tr>
<tr>
<td>Tendering</td>
<td>FOR TENDER</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>FOR EXECUTION</td>
</tr>
<tr>
<td>Installation and operation</td>
<td>AS BUILT</td>
</tr>
<tr>
<td>Phase-out</td>
<td>OBSOLETE</td>
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Table 1: Life Cycle Labels

9. 3D MODEL MANAGEMENT PRINCIPLES

Complete verification of a 3D model, i.e. the measurement of its geometry and characteristics, would normally require the use of a full featured CAD system. As this is not a practical solution, the verification of a 3D model before it is released for general use is carried out in two separate stages:

1. A technical verification done by a designer with access to the CAD system
2. A release authorisation given by the project engineer in charge and carried out using a 3D model control drawing (see §9.1 below).

Once released a 3D model is transferred from the designer working area of the CAD database to the reference model library, which is a protected area of the CAD database. At the same time, copies of the model in data formats suitable for access and viewing through the WWW are prepared.

3D models prepared with a CAD system other than CERN's 3D CAD system are first converted to the CERN CAD system and then managed as all other models.

9.1 3D MODEL CONTROL DRAWING

The purpose of the 3D model control drawing is to enable the review and approval of 3D models using the same tools and procedures as for engineering drawings.

The control drawing contains one or more views of the 3D model and may include characteristic dimensions, e.g. the overall dimensions, the position of interface features, a change from a previous version, and so on.

After the first release of a model the control drawing is used to track all modifications.

3D model control drawings of an equipment may be linked, in the drawing management system, to the corresponding manufacturing drawings. It then provides a convenient way to keep all the engineering information of that equipment together.

9.2 3D MODEL REVIEW AND APPROVAL

The 3D model review and approval process is shown in annex A2.

All 3D models are subject to a review and approval process before they are released.
The review and approval process comprises 2 stages. Each stage of the process is recorded on the control drawing with the name of the controller and the date of control.

The first stage of review and approval is a **technical verification** by a 3D model controller. This verification shall assure that:

- The 3D model has been constructed in respect of CERN's CAD practices and standards as described in "Design Standards - Mechanical Engineering and Installations" [ 3 ],
- The control drawing has been prepared in respect of the same CERN's CAD practices and standards.

The second stage of review and approval is a **release authorisation** by the PE in charge of the item represented by the 3D model. It shall assure that the 3D model conforms to the equipment's manufacturing data and that it depicts the equipment's external envelope and interfaces.

### 10. ANNEXES

A.1 Review and approval process of drawings.
A.2 Review and approval process of 3D models.

### 11. RELATED DOCUMENTATION

[ 3 ] LHC-PM-QA-402.00 Design Standards - Mechanical Engineering and Installations
[ 7 ] LHC-PM-QA-204.00 Equipment Naming Conventions
[ 8 ] JV1-07 QAM for LHC Civil Engineering Consultancy Services
[ 9 ] LHC-PM-QA-207.00 Naming Conventions for Buildings and Civil Engineering Works
Annexe A1: Review and approval process of drawings

1st STAGE

CAD Drawing Preparation

Registration in CDD

Technical Verification

2nd STAGE

Release Authorisation

Approval Required?

Yes

All Project Level Drawings and all Group Level Drawings in QAC "A"

Drawing pre-released UNDER APPROVAL

Coordination Approval

Approval Group Members
- requirements for installation, interfaces, and integration in Collider environment

DRAWING RELEASED
BY PROJECT ENGINEER

3rd STAGE

DRAWING RELEASED
BY PROJECT LEADER OFFICE

Drawing title block after release by PE

Drawing title block after release by PLO

Drawing title block prior to release

Designer

Designer

Drawing Controller
- quality of presentation
- respect of standards
- completeness

Project Engineer
- quality of contents
- conformity of design

No

Group Level Drawings in QAC "B" or "NONE"
Annexe A2 : Review and approval process of 3D models