

# EXPERIENCE AND BENEFITS FROM PLM-BASED PARTS MANAGEMENT AT EUROPEAN XFEL

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## Abstract

In large-scale projects, parts management offers reliable methods and tools for efficient fabrication of high-quality accelerator components. Facilities like the European XFEL are assembled from thousands of parts. The parts are produced by the many project partners and have to be provided in time. For successful long-term operation of the facility, the parts have to be of excellent quality. Parts management is a foundation for planning, coordinating and tracking fabrication processes, for conducting Quality Assurance and Quality Control (QA/QC), and for achieving compliance with legal regulations in certain areas. The paper shows how parts management is used at the European XFEL and discusses experience and benefits.

## INTRODUCTION

DESY has developed a parts management solution, which is used in the series production of accelerator components for the European XFEL. The parts management solution stores assembly instructions and drawings for each component, and it tracks the assembly progress of each individual component. It offers procedures for quality inspections, for handling non-conformities and for managing changes, and it tracks the current whereabouts and the entire history of each part. The solution is based on DESY's Product Lifecycle Management (PLM) System and integrates several laboratories and suppliers. The paper shows examples of parts management at the European XFEL and discusses experience and benefits.

## MOTIVATION AND REQUIREMENTS

Parts management is introduced in response to requirements on the fabrication of accelerator components:

- **Distributed fabrication scenario:** Project partners are distributed over several countries, and each partner collaborates with further suppliers and sub-contractors. Responsibilities have to be clarified and information flows need to be agreed to ensure timely delivery of all parts.
- **Collaboration across disciplines:** Design and fabrication engineers have to work hand in hand. If for example during production the need for changes arises, the change information has to be propagated back to the design documents and needs to be communicated to all partners to ensure the parts continue to fit together.
- **Quality assurance & control (QA/QC):** Parts have to undergo acceptance tests when they are received (and sometimes even at intermediate steps in fabrication). Acceptance test results have to be recorded, signed-off and processed in a reliable and orderly way.
- **Legal regulations:** Compliance with legal regulations, like e. g. the pressurized equipment directive, requires that certain (parts of) equipments are uniquely identified, and that their complete fabrication and usage history is tracked throughout the entire lifespan of the XFEL facility. Compliance with these regulations is mandatory for receiving and keeping the permission of operating the XFEL facility.
- **Operation, Maintenance and Upgrades (OMU):** Many OMU activities need access to complete and up-to-date documentation of the facility, such as e. g. QA/QC records and maintenance instructions. This documentation has to be captured during installation and commissioning and has to be continued as the facility evolves.

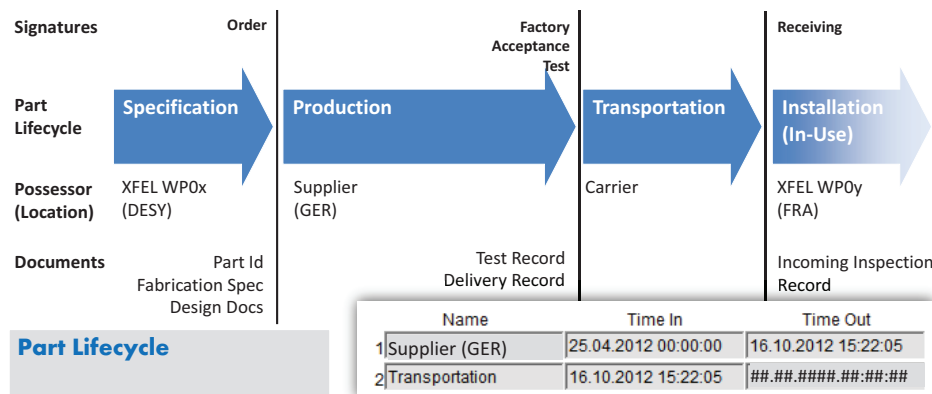
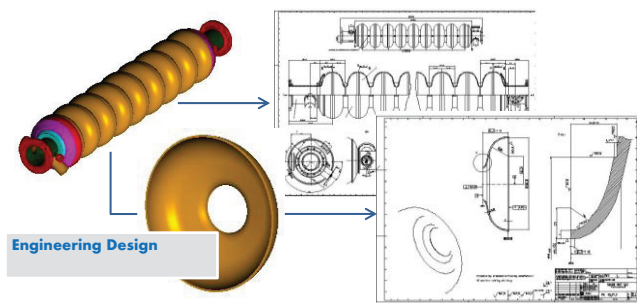


Figure 1: Part lifecycle for a supplied (purchased) part with its location log.



EDMS-ID	Name	Description	Quantity	Work Status
D0000000562257.A.1.1	Cavity for XFEL	cavity for XFEL (CAV) for the production of the cavity with ring and below (CAV_RB)	1	Released
D0000000562177.A.1.1	Dumb-bell	dumb-bell (DB) for the production of the "cavity for XFEL" (CAV)	8	Released
D000000056107.A.1.1	normal half cell	normal half cell (HCN) for dumb-bell production	2	Released
D0000000543267.A.1.1	Nb-sheet	265x265x2.8 Nb-sheet for half cell production	2	Released
D0000000561927.A.1.1	Stiffening ring	stiffening ring (SR) for dumb-bell production	2	Released
D0000000562097.A.1.1	Long end group	long end group (ELG) for the production of the "cavity for XFEL" (CAV)	1	Released
D0000000561767.A.1.1	Conical disc long side	conical disc long side (CDL) for long end half cell unit production	1	Released
D0000000561677.A.1.1	Connecting flange	connecting flange (CF) for long/short end half cell unit production	1	Released
D0000000561587.A.1.1	Connection end tube	connection end tube (CET) for long/short end half cell unit production	1	Released
D000000055927.A.1.1	long half cell	long half cell (HCL) for long end half cell unit production	1	Released
D0000000543267.A.1.1	Nb-sheet	265x265x2.8 Nb-sheet for half cell production	1	Released
D0000000562007.A.1.1	Short end group	short end group (ESG) for the production of the "cavity for XFEL" (CAV)	1	Released
D0000000561947.A.1.1	Conical disc short side	conical disc short side (CDS) for short end half cell unit production	1	Released
D0000000561677.A.1.1	Connecting flange	connecting flange (CF) for long/short end half cell unit production	1	Released
D0000000561587.A.1.1	Connection end tube	connection end tube (CET) for long/short end half cell unit production	1	Released

EDMS-ID	Serial Number	Description
D0000010376949.A.1.1	CAV00007	Cavity for XFEL
D0000010373888.A.1.1	EGS_P00096	Short end group
D0000010342389.A.1.1	EGL_P00062	Long end group
D0000010372629.A.1.1	DB_P00007_P00034	Dumb-bell
D0000010372669.A.1.1	DB_P00011_P00021	Dumb-bell
D0000010372749.A.1.1	DB_P00017_P00055	Dumb-bell
D0000010372809.A.1.1	DB_P00057_P00167	Dumb-bell
D0000010372868.A.1.1	DB_P00026_P00107	Dumb-bell
D0000010372868.A.1.1	DB_P00163_P00178	Dumb-bell



Figure 2: Different elements of part documentation representing a physical part in the DESY EDMS.

CONCEPT

Parts management is a general concept for defining and organizing fabrication processes, and for structuring fabrication information. It provides reference processes for e.g. fabrication planning, acceptance testing, handling non-conformities and managing change, and it organizes collaboration with suppliers. The XFEL parts management solution is based on the DESY EDMS, a web-based Product Lifecycle Management (PLM) system which is the central collaboration and documentation platform for the European XFEL [1].

Part Lifecycles

Parts management organizes processes along the part lifecycle. Figure 1 shows an example lifecycle for supplied parts, i.e. parts like drive units, pumps or mechanics that are purchased from a supplier and then used in accelerator beamline components. In this example, the lifecycle begins at the laboratory that is contributing the part. The lab specifies the part and places an order with a supplier. The supplier produces the parts, performs final factory acceptance testing and delivers the parts in this case to another lab, which is then assembling them on accelerator modules.

Parts management defines who needs to perform which activities in which lifecycle stage. By receiving the resulting documents, production progress and part location can be tracked, and the next steps can be initiated.

Part Documentation

From a technical perspective, parts management provides work instructions and receives accomplishment records. Fabrication processes can be coordinated and tracked as soon as the expected sequencing of documents is pre-defined, thus complete and up-to-date part documentation is the key to effective parts management.

The documentation of any part comprises two elements: The general design & manufacturing documentation for the general type of part, and the specific documentation of that particular individual physical part. The former is called the fabrication or manufacturing documentation, the latter the inventory or physical documentation:

- The manufacturing documentation defines “how the part shall be realized”. It contains e.g. specifications, process instructions, quality management plans, and test cases.
- The inventory documentation keeps track and records the history of each individual physical part. It contains e.g. inspection sheets and test results, and routing, installation and usage records.

Figure 2 illustrates the part documentation elements for an s.c. rf cavity. The manufacturing documentation (second from top) is organized around the bill of materials, a hierarchical list of all (intermediate) parts that have to be assembled during production. The inventory documentation (third) consists of individual “physical part records” which link to the parts’ specific records and list identifiers of the used (sub-) parts and materials. All the elements are linked, they also link back to the engineering design (top).

Workflows

Pre-defined workflows ensure that documents are processed in an orderly, timely and reliable manner. Workflows are used for critical activities, such as e.g. reviews and approvals. Figure 3 shows as an example the workflow for handling non-conformities: Non-conformity are reported by quality engineers. Fabrication managers assume the role of non-conformity coordinators and deter-

mine who needs to be involved in the reviewing and decision-making process. The non-conformity report (NCR) is distributed and iterated until all participants agreed on a decision. The workflow ensures all participants are informed, involves deputies in case of absence, puts deadlines on responses, etc.

**EXAMPLES**

European XFEL has introduced parts management for numerous components, including the fabrication of the super-conducting cavities, the assembly of the cold accelerator modules, the production of the warm magnets, and the final assembly of the undulator segments. The following sections describe parts management experience for selected examples.

*Cavity Production*

The cold linac of the XFEL contains more than 800 s. c. cavities which are provided by DESY. The Nb sheets for the cavities are delivered to DESY to DESY by different suppliers. DESY inspects and forwards the sheets to the cavity manufacturers. The cavities are produced by two manufacturers.

Parts management is used for the processing of all Nb sheets and for quality management in cavity production. The cavity manufacturers are connected to the DESY EDMS and upload their quality documents directly during production, allowing the project team to immediately inspect and double-check the documents. The solution is also used for handling non-conformities and for accepting delivered cavities [2].

The solution provides reliable documentation, allows quick reaction during production, and is mandatory to be compliant with the pressurized equipment directive. It is also necessary to handle the huge amount of about 10<sup>6</sup> documents which are created during cavity production.

*Accelerator Modules*

The XFEL accelerator modules contain more than 400 individual parts, among them eight of the super-conducting cavities. The parts are provided from various labs and companies which are distributed across Europe.

Parts management introduced a manufacturing bill of material, which has become the central structure for coordination and information exchange. Many project partners and sub-contractors are connected to the DESY EDMS and included in these procedures. Incoming parts are thus often already registered in EDMS, so the assembly team can access their entire documentation and history (Figure 4). Approvals and non-conformity handling use EDMS workflows which include participants at different locations.

The solution was essential in identifying and clarifying responsibilities and interfaces. In particular, the MBOM helped to describe in an organized way which parts will be provided by what partner.

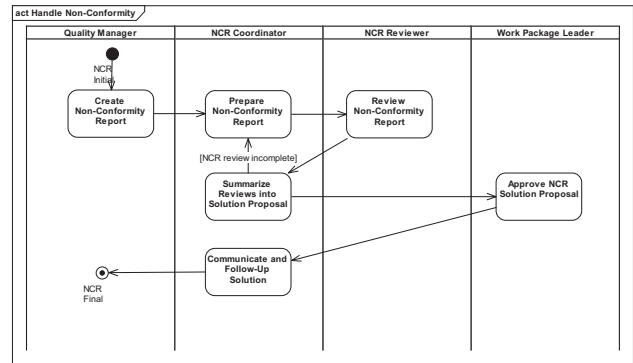


Figure 3: Workflow for handling non-conformities.

**CONCLUSION**

The described parts management solution has become a valuable contribution to the production of large series of accelerator components in the XFEL project. It supports collaboration in distributed manufacturing environments, including suppliers and sub-contractors outside the project, and helps managing production quality. It is routinely used in several XFEL work packages.



Figure 4: Example physical part record of a coupler during assembly to an accelerator module.

**ACKNOWLEDGMENT**

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**REFERENCES**

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