PARTS MANAGEMENT DURING FABRICATION AT THE EUROPEAN XFEL

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Abstract

This presentation describes policies and methods for parts management during fabrication at the European XFEL. The objective is to provide procedures for reliably gathering, recording, processing and archiving the complete mandatory fabrication information. The solution is a foundation for conducting Quality Assurance and Quality Control (QA/QC), as it ensures that acceptance tests are recorded, signed-off and followed-up in a reliable and orderly way. It achieves compliance with legal regulations in certain areas. One example is the Pressure Equipment Directive (PED), which for certain (parts of) equipment requires that the complete fabrication and usage history is tracked throughout the entire lifespan of the XFEL facility. In addition, the solution provides a basis for building the necessary documentation for later installation, operation and maintenance activities. The solution is established in the series production of several accelerator components. It uses DESY's Engineering Data Management System as central collaboration and documentation platform.

SCOPE AND MOTIVATION

Parts* tracking for the European XFEL covers the lifecycle phases fabrication and operation including maintenance and upgrade activities and ensures reliable gathering, recording, processing and archiving of all required information. Based on a central collaboration and documentation platform – the DESY Engineering Data Management System (EDMS) – parts tracking is a foundation for:

- Quality assurance & control (QA/QC):
  Parts undergo acceptance tests at certain steps during fabrication, e.g. upon receipt, to pass pre-defined quality gates during the assembly process and again before shipment. All acceptance test results have to be recorded, signed-off and processed reliably.
- Compliance with legal regulations:
  Legal regulations, like e.g. the Pressure Equipment Directive (PED) require certain parts to be uniquely identifiable and their complete fabrication and usage history traceable throughout the entire lifespan of the XFEL facility. Complying with these regulations is mandatory for receiving and keeping the operating license for 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 and repair records, as well as maintenance instructions. This documentation should be captured as soon as it is generated i.e. during the installation and commissioning phases and has to be updated continually as the facility evolves.

* "Part" is a generic term for component, equipment, device, etc.

CONCEPT AND APPROACH

The parts tracking solution separates inventory and manufacturing documentation. Every individual part of the XFEL facility is represented by one physical part item in the EDMS that gathers the inventory documentation. Physical parts are produced according to a manufacturing definition comprising the manufacturing documentation:

- The manufacturing documentation defines how a specific part type is produced. As shown in Fig.1 (left), it is linked to a generic fabrication part and contains all the manufacturing instructions and quality management plans.
- The inventory documentation comprises all information concerning each individual physical part and keeps track of the parts' complete usage history. It contains e.g. all inspection sheets, test results, acceptance or installation records, as well as every repair record for each individual physical part. (Fig.1, right)

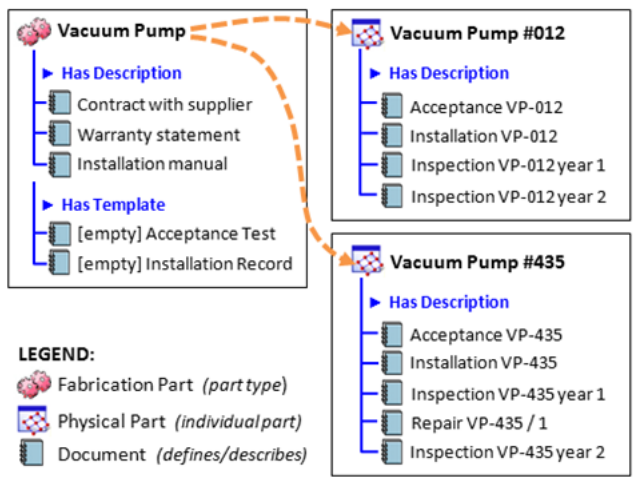

Figure 1: Example illustrating the separation of the manufacturing documentation for a generic fabrication part (left) from the inventory documentation for each individual physical part (right).

More complex components (e.g. cavity, cryomodule, undulator) are hierarchically decomposed into smaller, better manageable units, yielding the so-called Product Breakdown Structure (PBS). The level of detail to which a certain PBS is created depends on its purpose and is adapted to the product´s life cycle phases. A PBS for

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design / construction is called Engineering Bill of Material (EBOM), while the one for fabrication purposes is referred to as Manufacturing Bill of Material (MBOM). The MBOM as the fabrication part structure contains all parts that are handled during assembly, quality assurance inspections, and maintenance or repair processes. [1]

Since the XFEL project adopted the MBOM as the main structure for regulating and controlling all manufacturing processes and workflows, this specific PBS is discussed in detail in the following.

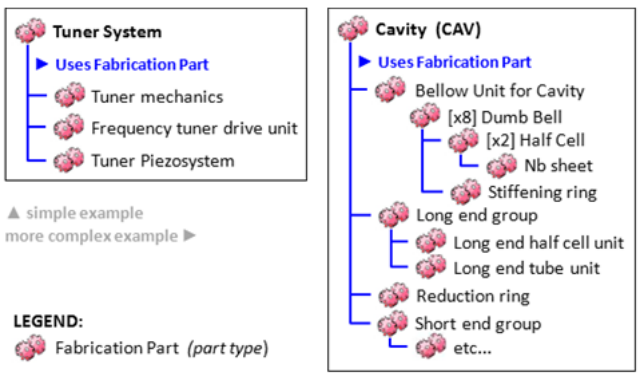

Figure 2: Examples of a Manufacturing Bill of Material (MBOM): for tuners (left) and for cavities (right).

Figure 2 shows two MBOM examples. The tuner system MBOM (left) contains pre-assembled components that are received and processed during the final assembly, but no elementary parts such as individual piezos or their fixtures. The cavity MBOM (right) is more detailed because all parts subject to the regulations of the PED have to be tracked and quality-controlled to ensure traceability down to the original Niobium sheets.

Physical parts are generated from the MBOM by serializing the complete MBOM structure in a top-down approach, or by serializing each fabrication part individually. The latter approach represents the real world assembly process, but requires to manually arrange the physical part structure (BOM). This physical part structure has to reconcile with the MBOM.

During the assembly process all information concerning one individual physical part is recorded and linked to the physical part it describes. The sum of all information for one physical part is referred to as inventory and may include e.g. material certificates, inspection sheets, acceptance test results, installation and/or repair records and more. The complete documentation of a component comprises the physical part structure (BOM) and all related inventories.

Parts and/or components need to pass predefined quality gates at intermediate steps, or the end of an assembly process. Quality engineers confirm the completeness and consistency of a part´s documentation for each particular quality gate by releasing the part for further usage.

In case a part fails a quality gate or any irregularity in the manufacturing process is discovered, a non-conformity report (NCR) is recorded and processed. Experts need to decide how each non-conformity is handled and inititate appropriate follow-up activities.

Systematic deviations may lead to changes in the manufacturing process or even in the part design. These activities are handled by a change management process.

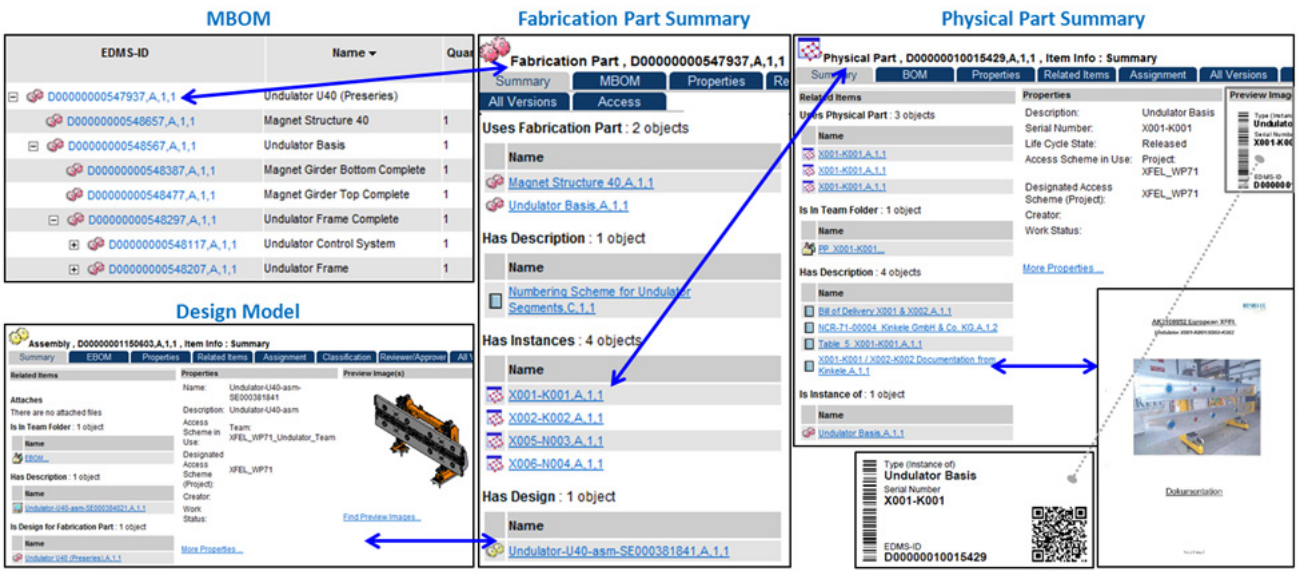

Figure 3: Traceability in the EDMS (Undulator): For any MBOM element (top left), the summary page (middle) displays an overview of this fabrication part, links to its physicals parts (top right) and to the CAD design model (bottom left). The physical part offers a label (right) and provides links to its inventory documentation (bottom right).

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IMPLEMENTATION IN THE EDMS

The DESY EDMS provides all necessary capabilities for creating and processing manufacturing and inventory documentation as described in the previous section.

Figure 3 illustrates how traceability between EBOM, MBOM and the physical part structure is realized in the EDMS using the example of undulator fabrication. All links are bidirectional, enabling navigation in the reverse direction as well.

To ensure reconciliation of the physical part structure and the MBOM structure, the EDMS provides a "reconciliation" report. It compares both structures and indicates any deviations. The report can be adjusted to different processes and user requirements.

Each physical part in the system is identified by an automatically generated unique identifier (EDMS-ID). The identifiers are guaranteed to remain unique for the XFEL facility and throughout its entire lifetime. In addition, a serial number specified by the responsible work group is attributed in order to count the created physical parts. A manufacturer serial number as a third identifier can also be added to facilitate communication with the respective supplier.

The EDMS automatically generates a data matrix label for each physical part. As shown in Figure 4, the label displays the type of the part, the work group defined serial number, and the unique EDMS-ID in human readable format. The label also contains a one-dimensional barcode, as well as a two-dimensional data matrix code of the EDMS-ID to retain the option of future data access via smart devices. For example, a smart device "reading" the two-dimensional data matrix code will open an internet browser pointing to the EDMS summary page of this part.

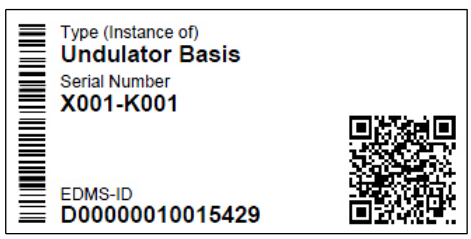

Figure 4: An automatically generated physical part label.

Labels can be printed and attached to real world physical parts if necessary. All visible major components installed in the XFEL tunnel will have to be labelled.

For physical parts the stock location can be tracked and remains traceable over the parts' entire lifetime. This allows work groups to notice any shortage of the available stock early, or to detect delays during the manufacturing process and/or at test facilities. Project planning can be adjusted accordingly.

In addition, the EDMS provides version control, access control and full history tracking for every object. Review and approval workflows, as well as change management are also provided to ensure and facilitate proper information sign-off and processing. Further dedicated functionality for, e.g. reporting and non-conformity handling is implemented in the near future.

The EDMS guarantees so-called transaction safety. This is particularly important for parts affected by legal documentation requirements. The cavities, for example, are subject to the PED requiring lifelong availability of the equipment history records and traceability of documents. In order to satisfy these requirements, the EDMS has to ensure not only the availability of all records, but it also has to guarantee that no record can be modified once it is archived. The EDMS implementation of the cavity production process (and corresponding documentation) has been reviewed and accepted by the German Technical Inspection Association (TÜV*). [2]

CONCLUSION & BENEFITS

Since parts tracking has been specified as mandatory for the entire XFEL project, all work packages (WP) define their deliverables and which parts have to be tracked within an MBOM structure. In doing so, the procedures and processes for acceptance tests, QA/QC, nonconformities and requirements for parts delivery and handling are defined as well.

All partial MBOMs of the sub-assemblies / components will be brought together in a greater structure resulting in one final XFEL MBOM. This allows checking for the completeness and availability of all manufacturing parts.

In addition, the consolidation process of the MBOM as fabrication part structure, exposes interfaces to (and dependencies on) other WPs which, in turn, lead to improved communication between all involved parties and more interaction concerning common subjects, such as: Specifying and organizing responsibilities, scheduling, and the hand-over of components for follow up activities, etc.

All information of the XFEL project is structured according to the different types of BOMs and cross-linked to facilitate navigation for users. It is provided web-based in the DESY EDMS system for the entire XFEL collaboration.

ACKNOWLEDGMENT

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[1] J. Dammann et al., "Making Engineering Data Available at the European XFEL" IPAC 2011, San Sebastian, Spain, September 2011, THPC080, p.3077 (2011); http://www.JACoW.org

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* TÜV: an acronym for „**T**echnischer **Ü**berwachungs-**V**erein" (ger.)