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THE ADVANCED PHOTON SOURCE UPGRADE (APSU) SUPERCONDUCTING UNDULATOR (SCU) COMPONENT DATABASE (CDB) UTILIZATION

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Abstract

The Component Database (CDB) is a document management platform created for the use of the Advanced Photon Source Upgrade (APSU) Project. It serves two major functions: (1) a centralized location to link all data relating to field-replaceable upgrade components, and (2) a way to track the components throughout the machine's 25-year lifetime. There are four (4) Superconducting Undulators (SCUs): two (2) Inline 16.5mm period devices, one (1) Canted 16.5mm period device, and one (1) Canted 18.5mm period device. Throughout the production process for these devices, tracking components between the different designs of SCU's has proven to be a logistical issue, as there are uniform components among all 4 devices, but many unique components as well. As the scope evolved from a Research and Development (R&D) activity to a production scope, the CDB has been critical in communicating with a growing team, allowing anyone to identify a part or assembly and access all its design and manufacturing data. The 4.8-meter long SCUs are the first of their kind, requiring thorough onsite inspections, intricate assembly procedurals, and approved safety protocols. This is ideal information to document in an electronic traveler (e-traveler), which can then be attached to an item within the CDB. By providing a straightforward process for technicians to follow, the risk of miscommunication and unsafe practices are minimized. The CDB plays a vital role in simplifying and optimizing the transition of the SCU from an R&D unit to a production scope, from procurement to inspection, assembly and installation, and throughout the lifespan of machine maintenance.

INTRODUCTION

The Advanced Photon Source Upgrade (APSU) Project will replace the current storage ring with a combination of new and refurbished components. The result will be a new machine producing X-rays up to 500 times brighter than the current device. The design phase is complete, procurements are well underway, and the year-long shut down for installation is set to start in April 2023 [1]. Four of the Insertion Device (ID) straight sections will be equipped with new 4.8-meter long Superconducting Undulators (SCUs) of various magnetic periods, which accommodate canted and inline configurations. These complex devices produce photons at different energies to be used by the ID beamline users. A single cryostat and base assembly can house two undulator magnet pairs, the cryogenic cooling system, and vacuum chamber (Fig. 1) [2]. With the various designs for the inline 16.5mm period device, canted 16.5mm period device, and canted 18.5mm period device, the need for a streamlined database to organize procurements and procedures, and to effectively communicate this information, was evident. The Component Database (CDB) has proven to be vital in the transition of SCUs from a Research and Development (R&D) scope to a production process. The defining feature of the CDB is that it is an integrated system that links many other databases and can pull data seamlessly from many sources.

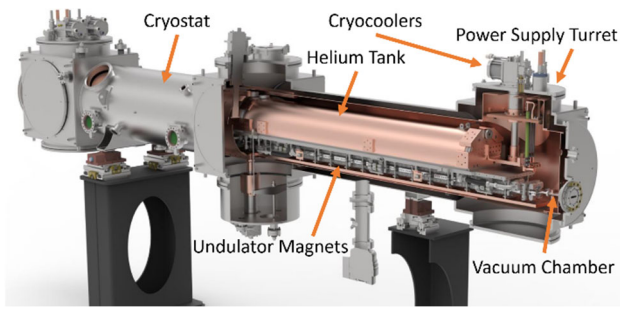

Figure 1: Cross-section rendering of the inline 16.5mm Superconducting Undulator, showing the cooling system, magnets, power supply turrets, and vacuum chamber.

OVERVIEW

The CDB is used Project wide and became increasingly more important as APSU procurements ramped up and the project transitioned into the production phase. The CDB is organized into two layers, the *Catalog* level and *Inventory* level. At the *Catalog* level, components are organized by Technical System and then by Function. Specifically, for SCU's, this path is *Insertion Devices* and then *Undulator-Superconducting*. Once here, a list of all components relating to the device are listed along with important information, such as model number, images, a description, and inventory information. There is also a search bar at the top of the CDB page allowing for ease of access if the model number or a key word is known. This allows anyone, project-wide, to quickly access information, even if they are not intimately familiar with the assembly and subassembly breakdown of an SCU. Selecting a part will redirect the page to that part's *Catalog* level where all general information on it can be found. Here, the *Inventory* sub-section is listed as one *Instance* entry for each item ordered, and if selected will display all the information collected for that item. This includes location, status, date received, the purchase requisition, links to vendor documentation and drawings, and an electronic traveler (e-traveler) that is filled out by the technicians and engineers after the part is inspected.

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The *Item Membership* and *Assembly Listing* sub-sections can organize CDB entries by assemblies and subassemblies. Within the top level SCU entry, there are many sub-assembled items. This helps to narrow one's search and focus on information about a particular system within the SCU. Starting at the Inline Top-Level Assembly and using this *Assembly Listing* feature, information can be found about a sub-assembly such as the Power Supply Turret as shown in Fig. 2. This breakdown of assemblies also correlates to the physical assembly process. A given subassembly of the SCU can be linked with a documented procedure and e-traveler to give instruction for assembly of a particular system before it is incorporated into the top-level SCU assembly. One can use the *Item Membership* function to navigate the CDB in the opposite direction, by seeing everywhere that a subassembly or component is used. In the case of the Power Supply Turret, it can be seen that it is used in all variations of the SCUs (Fig. 3).

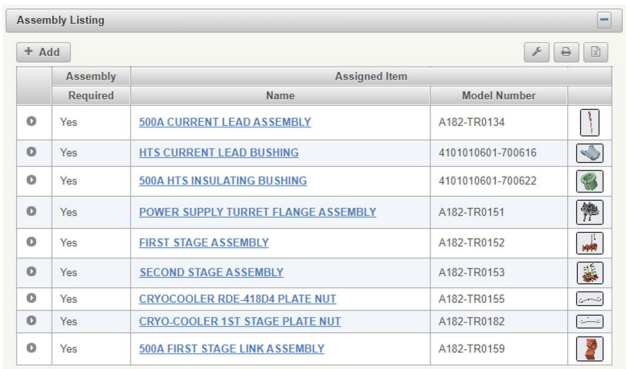

Figure 2: Component Database *Assembly Listing* feature for Power Supply Turret Assembly.

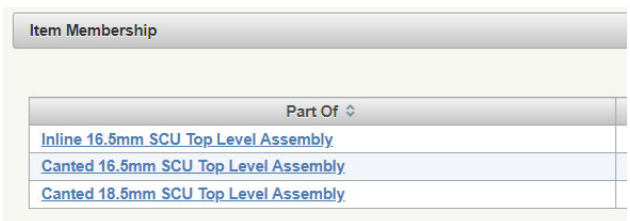

Figure 3: Component Database *Item Membership* feature for Power Supply Turret Assembly.

The CDB is a useful tool for the SCU group. With individual team members able to contribute in their various disciplines, the information is shared in a timely matter and is in an accessible space for all. There are three main pillars to the CDB utilization for SCU's: technical utilization, procurement tracking, and communication. A project of this size, duration, and cost needs a platform that can handle the significant quantity of information necessary for the upgrades design, installation, operation phases.

TECHNICAL UTILIZATION

The CDB has tools that allow for customization of information storage for the various component entries that come with varying types of data files. Inspection data, assembly and manufacturing notes, non-conformity tracking, and models are all linked to the CDB *Instance* level. Being able to pinpoint a failure point is critical for a successful project, so the ability to reference this data in the future is essential.

Archives

Prior to the availability of the CDB, vendor-supplied documentation was sent as physical copies in the shipping crates during the delivery of the parts. These paper-copies were then stored in filing cabinets and there was no certainty that the vendor would save the information for their own records. Integrating this data was a major turning point in the SCU group's CDB utilization. This involved digitizing the information and organizing it accordingly with its *Instance* entry. Moving forward, vendor documentation is requested in an electronic format, for easier upload to the CDB. Loading this information in the CDB ensures that this information will be accessible for years to come. Throughout the lifetime of these components, this information will be available to new engineers and technicians.

New Component Deliverables

The APSU procurement process is well-defined and encourages obtaining as much information from the vendor as possible. By defining the contract deliverables in a clear way from the start, vendors are able to incorporate hold points into their schedules for APSU oversight and approval. The data requested is integral to the lifetime operation of these components.

An example of deliverable data for the SCU vacuum chambers (Fig. 4a) is the request for dimensional data verifying the thin wall, proof of thermal shock results of the bimetal component, and vacuum certification documentation. Throughout the contract, the vendor was able to supply pieces of this data, which was then stored at the *Instance* level. By the end of the contract for the first article, the vendor was able to tailor the deliverable information so that its integration with the developed e-traveler was seamless.

Another piece of information that was captured in the CDB was an approved non-conformity Supplier Disposition Request. The vendor produced a component that was out-of-spec according to the drawings but was acceptable for the form, fit, and function of the part. If the chamber is inspected in the future and does not match the drawings precisely, the justification is easy to find.

PROCUREMENT TRACKING

After a requisition is routed and assigned a req. number, this information is correlated with its CDB entry. Throughout the procurement process, more information can be added to the CDB from the contract paperwork. The technical advantages to using the CDB have been discussed, but the extension to the capability for onsite management is another major factor of using the CDB, especially for the SCU team.

When a component is received on site, it goes through a Quality Assurance (QA) process. This inspection information is input into the CDB in an e-traveler within that *Instance* part. The status, location, designation, and in-

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tended use of each part is recorded to avoid duplicate purchases and inventory misplacement. This is particularly important for parts such as the SCU cryocoolers (Fig. 1) that will be rotated between devices, for maintenance purposes, and requires spares. SCU procurements are managed by multiple team members and the deliverables are stored in multiple buildings, so the CDB plays a vital role in the tracking of all the inventory.

The feature linking Argonne's Procurement And Requisition Integrated System (PARIS) to inventory items in the CDB allows employees to easily reference the requisition and contractual information. Often, the same vendor is working on multiple Purchase Orders for different components for the SCU's at the same time. An example is Anderson Dahlen, who is currently fabricating items for the inline and canted SCU scopes. They are producing the SCU vacuum chambers [3] (Fig. 4a), thermal shields (Fig. 4b), and cryostats (Fig. 4c). Tracking this work in the CDB allows the control account manager to access the information and determine priorities, notify the technical representative engineer of the work, and in turn convey this information to the vendor.

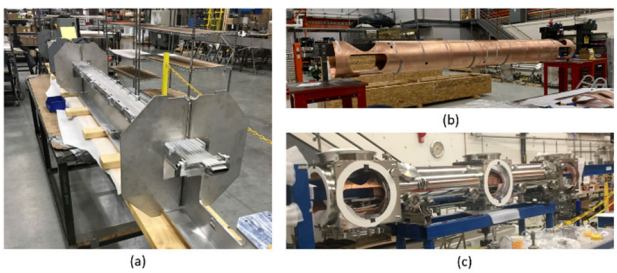

Figure 4: The SCU vacuum chamber (a), thermal shield (b), and cryostat (c) first articles onsite at APS.

COMMUNICATION

Efficient and effective communication is a critical component of a project of this scale and duration. It is equally important to leave information in an accessible and centralized database for future APSU team members to reference. Communication across different levels within the organization is vital to the success of the APSU.

Organization

Information is constantly uploaded to the CDB as it becomes available throughout the procurement and manufacturing process. Once the scope of work is defined for onsite inspection or assembly, the responsible engineers and technicians can review the data and component and create procedures for future work. These processes can be captured in Work Control Documents (WCDs) and e-travelers, which connect seamlessly with the CDB. The organizational value of the CDB allows for a centralized repository of information for the whole team.

In the future this repository will become increasingly important if an operational issue is detected. For example, if an SCU is in operation and it is experiencing unexpected quenching of the superconducting magnets, this is potentially caused by a head leak due to incidental contact with a system operating at a different temperature, such as the vacuum chamber. Using the SCU vacuum chamber deliverables, a SCU team member can pull the dimensional data for information on any discrepancies and begin troubleshooting to find the root cause.

The link to procurement information also becomes important for project management reporting. Components can be located by requisition number and an algorithm can pull inventory status allowing for a high-level view of the project.

Safety

Hazards are identified while developing the WCDs, which is a collaborative effort of the engineers, technicians, and a safety representative. Safety concerns are made clear and each employee must review and sign before performing any work. APSU SCU assembly presents unfamiliar situations as the SCU group transitions from building an R&D unit to a production scope. As previously mentioned, e-travelers can be linked to *Inventory* items in the CDB and lay out procedures for authorized workers to follow. The process can be broken down to check points and can be organized for clear data entry of relevant information. Linking these documents to the associated component in the CDB will ensure that the technicians will have clear direction for the work at hand, lowering the potential for safety incidents and increasing efficiency, productivity, and quality of work.

CONCLUSIONS

The CDB plays a vital role in the success of the APSU SCU scope. The three most impactful aspects of the CDB are storing technical data, tracking procurements, and effectively communicating across all levels of the organization. An electronic platform ensures that this information will be accessible for years to come.

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