Status update on the design and construction of the Active Cells Facility and Remote Handling Systems

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Abstract. The Remote Handling Systems at ESS are responsible for making sure that the radioactive waste from the target station monolith operation can, in a safe way for operators and public, be lifted and transported from the monolith vessel to the Active Cells Facility, adequately treated for interim storage and eventually shipped off site. Connected to the target station building, a mock-up and test stand area will be available that will be used for operator training as well as for monolith systems cold testing.

This paper will report on the construction progress of the Active Cells Facility starting with first concrete casting quarter one of 2017. The design concepts and chosen technical solutions of the Active Cells Facility have previously been presented at ICANS XXI (The ESS target station hot cell facility and associated logistics).

The internal casks and associated lifting devices as well as the mock-up and test stand facility are still in preliminary design. The casks are used for monolith maintenance and for transport of activated components from the monolith to the Active Cells Facility. The mock-up is a steel framework structure designed to support operators in training and system testing. This paper includes a status update on these systems as well as discusses safety classification on cranes and lifting equipment dealing with the radioactive monolith components.

1. Introduction
The Remote Handling Systems (RHS) is a project under the target division at ESS responsible for delivering facilities, systems, structures and components intended for maintaining the target station monolith systems. The main deliverables are the Active Cells Facility (ACF), the Internal Casks and Handling Devices (Casks) and the Mock-up and test Facility (MUTS). All systems will be physically located in the target building (D02) and are shown in Figure 1.

The systems are currently at different stages of design where the structural parts of the ACF is the part that is the most advanced at the moment. The Casks and MUTS systems have undergone Preliminary Design Reviews (PDR). These systems will be posted as possible for in-kind contribution and the detailed design will thus ideally be performed by in-kind partners. UKAEA/RACE at the Culham Science Centre/UK is the in-kind partner for the design of the systems within the ACF.
2. The Active Cells Facility
The construction of the structural parts of the ACF as well as all the cast in items is currently in its final stage. The first 240 m$^3$ of concrete was poured at the 23rd of March, covering the first 400 mm of the basement slab. Another 1100 mm will be casted in 2 stages where cast in items will be installed at the 400 mm level as well as the 1300 mm level.

2.1. Active Cells Facility – Cast in items
All system specific cast in items (not re-bars) are handled in-house ESS. The main items are liner beams, electrical conduits, 10 inch through wall confinement penetrations as well as anchor plates. The anchors are multipurpose for general use or explicitly designed for a specific task. The design of the cast in items have two major design interfaces, the in-kind partner and the construction company Skanska. The intricate interfaces have to accommodate specific requirements in terms of loads, sizes, tolerances and location in conjunction with the structural design including planning and design of the re-bars and casting sequences. In Figure 2, the installation of the electrical conduits is shown, where the bottom of the Ø114 mm pipe is attached to the top of the first 400 mm casting sequence. Figure 3 is showing a CAD image of the finally installed system where hot- and cold-side junction boxes will be installed and cables will be possible to route between in- and outside of the cells avoiding radiation streaming due to its dogleg through the floor.

In order to facilitate the installation of the 10 inch confinement penetrations as well as the liner beams, Skanska have together with sub-contractors designed a system of in wall steel structures. These structures will be able to support the confinement penetrations as well as other casted in items to fulfil the stringent mechanical tolerances that is required. The structure includes spring loaded rods that will push the liner beams against the formworks during casting in order to get a nice stainless steel surface to weld the liner plates to once the structural design is done. This solution has been iterated and refined through several mock-up tests. The principle is shown in Figure 4 and the final casting mock-up is displayed in Figure 5 where the finished surfaces of the liner beams are visible.

Generally, anchors are placed as generic patterns, both in walls and floors, in order to facilitate a maximum flexibility of in-cell layout and system installation. The ACF will not have any windows and therefore the layout is, from a work perspective, not bound to any specific location in the cells.
3. Internal Casks

In order to be able to retrieve and transport the radioactive spent components from the monolith operation to the ACF, a set of shielding systems including casks, covers, floor valves and local shielding will form the logistics for these tasks. The main focuses for the design are worker safety and a technically viable solution. The design of the system is currently in a preliminary state where the main focus has been concentrated on getting all requirements defined. A lot of the requirements are derived from the hazard analysis where lifts of the radioactive components has been one of the main drivers for classification of cranes as one example, where the 100 tons high bay crane is rated as a nuclear crane in accordance with Swedish nuclear regulation in order to avoid hazardous risks of drop loads in and around the high bay area. The cask for the target wheel assembly is shown in Figure 6 as one example of how the casks will be designed. The cask for the moderator and reflector assembly will be designed as a single purpose cask as well, then there will be a multipurpose cask for instrumentation plugs and the proton beam window.

The design of the cask system also has specific challenges with respect to shielding. The main casks are designed with their own internal lifting devices and during the lifts, the position of the radiation hazard is changing in relation to where workers are located. Therefore, all angles have to be investigated for sufficient shielding as well as various shine paths along the lifting path. This is true, both for the handling around the monolith as well as when the casks are docked to the ACF and the components are lowered into the cells.
4. Mock-up and test stands

The MUTS facility will be installed in the back of the transport hall within the target station building. The main functions driving the requirements are focused on the possibility to cold test monolith handling procedures. This include both vertical and horizontal cask operations but it also provides the possibility to cold test components in terms of rotation of the target wheel as one example. As seen in Figure 7, the space allocated is very limited since the waste management have to lift the waste offsite shipment casks from the same area. Also, the high bay crane has a limited coverage towards the short wall in the high bay where the far end of the MUTS only have 50 tons lift capacity.

The primary monolith components facilitated in the stand are the target wheel, the moderator and reflector plug, the proton beam window, the proton beam instrumentation plug and the neutron beam guide inserts. The MUTS facility is currently in a preliminary design state and the aim is that an in-kind partner will be responsible for the detailed design as well as delivery and installation.

Since the construction of the target building is done in conjunction with the component detailed design where the transport hall area of the building is the last part of the facility to be finished, means of installing the MUTS at some other location is currently investigated. This, in order to be able to have the MUTS facility up and running when the monolith components are starting to arrive to ESS. This put other requirements on the construction in terms of being able to disassembly and assembly again in the target building once it is ready and handed over to operations.

5. Conclusion

The various systems within the work package Remote Handling Systems are in various stages of design, stretching from installed at site to preliminary design. Various challenges are addressed spreading from on-site construction interfaces related with installation, to basic design parameters related to requirements of radiation protection around monolith cask operation.

![Figure 6. Target Wheel high bay transport cask.](image-url)

![Figure 7. Mock-up and test stand facility within the D02 building.](image-url)