

CURRENT STATUS OF THE ESS ACTIVE CELLS FACILITY

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ABSTRACT

The European Spallation Source (ESS), Lund, Sweden will be a 5 MW long pulsed neutron spallation research facility with planned first beam on target in 2019. The spallation process induces radiation damage to several large, heavy and complex components that needs to be exchanged and maintained. For the purpose of doing this as well as dealing with the radioactive waste stream, a dedicated hot cell facility or the Active Cells Facility as it is called, will be designed and built for this specific reason.

The design of the Active Cells have to deal with a large variety of requirements in terms of flexibility, life time, high radiation doses, waste logistics etc. On top of that the design team is focusing on including novel technologies for operation making the facility upgradeable to meet future requirements.

Today, the time table points to that first concrete will be poured in early spring 2016 and thus the design and associated reports and documentation of all concrete embedded parts are now being developed.

This paper will be focused on a general update on the current status of the design, augmented reality and virtual reality operation and the associated control systems, schemes for waste management and waste shipment logistics.

1. Introduction

The European Spallation Source (ESS), Lund, Sweden will be a 5 MW neutron spallation research facility. The spallation process, where high-energy protons provided by a linear proton accelerator, produces a large spectrum of particles and ionising radiation. Depending on location and function in production of neutrons, the radiation damage will require maintenance and exchange of machine equipment with intervals from around 6 months to several years.

The spent machine components are ranging between some Sv/h to the kSv/h range contact dose and thus the measures and precautions during handling are crucial. The Active Cells facility will provide a safe way of handling, treating and storing the spent components as well as provide the radioactive waste path to off-site repositories.

The European Spallation Source is built as a green field facility and the design lifetime of the Active Cells Facility is 60 years. Since there is no heritage with associated restrictions in design, the design team at ESS have been trying to challenge common practice of construction of hot cell facilities. Some of these ideas are presented in [1] and [2] but further developed and explained herein.

The first concrete for the Active Cells facility is set to April 2016, basically requiring items and equipment that have to go into the concrete to be delivered around March 2016. The focus of doing detailed design of electrical conduits, stainless steel liner, confinement penetrations, anchor plates etc. is therefore progressing rapidly. Other focus areas are the visualisation system, the interface to the ESS integrated controls system as well as fulfilling regulatory requirements of the structures and installed equipment.

2. Active Cells current layout

The superstructure of the Active Cells facility is frozen in order for the conventional facility to perform detailed design of the concrete parts. The general layout is thus fixed and detailed design of parts going into the concrete have commenced. Further details on the first set of structures going through detailed design are listed in the sub-chapters below. The internal dimensions of the facility are 29,7x13,7x12 [m] (length x height x depth). The layout area nomenclature of the Active Cells facility is shown in Figure 1.

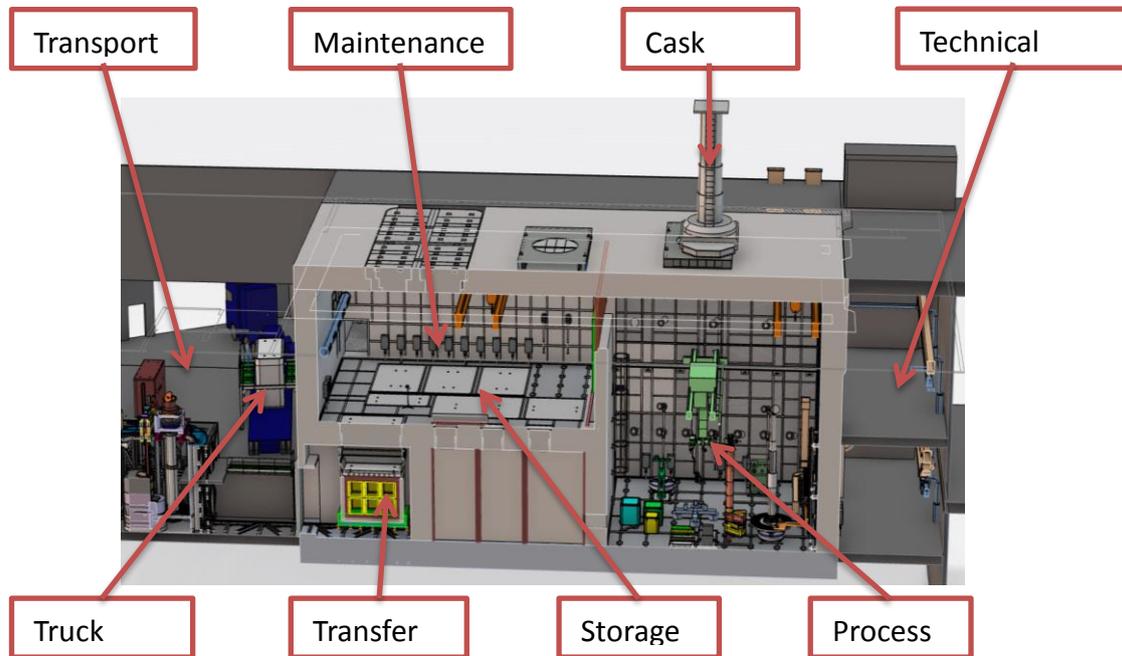


Fig 1. Active Cells facility Layout

The *technical galleries* are human access areas where control room, post irradiation examination cells, machine interfaces, HVAC, airlock, people access points and logistics etc. is located. This is an area that is rated for unlimited access, from a radiological standpoint. The *maintenance cell* is the logistical hub for all material and waste transfer inside the active cells facility, the cell is also used for hands on maintenance of in-cell equipment and decontamination tasks as well as access point to the process cell. The cell is rated for limited access from a radiation perspective but access is directly dependant on what items or task that is performed in the cell. Studies and analysis of the working environment in the maintenance cell shows that the use of ventilated protective suits is likely. The *process cell* will not be accessible by personnel unless the cell is emptied from radiation sources and decontaminated. All dismantling and cutting operations will be performed in this cell. All waste will have the possibility to be interim stored in the *storage pits*. The lids of these pits have to be closed prior to human intervention in the maintenance cell. Off site shipment of waste will be done through the *transfer area* where shipment casks can be introduced via an airlock. The casks are then loaded on a truck in the *transport hall* with the high bay crane with a 95 tons capacity.

2.1 Stainless Steel Liner

Stainless steel liner plates will cover the entire inside of the Active Cells facility. The main purpose is to ensure tightness, reduce wear of the walls and ease decontamination activities. In Figure 2, the outline of the liner components are shown, the components are the embedded parts or liner beams that will be integrated in the concrete structures and the liner plates that will be welded onto the embedded parts once construction has granted access to the area. The plates are 4 [mm] thick on the floor and 2 [mm] on the walls.

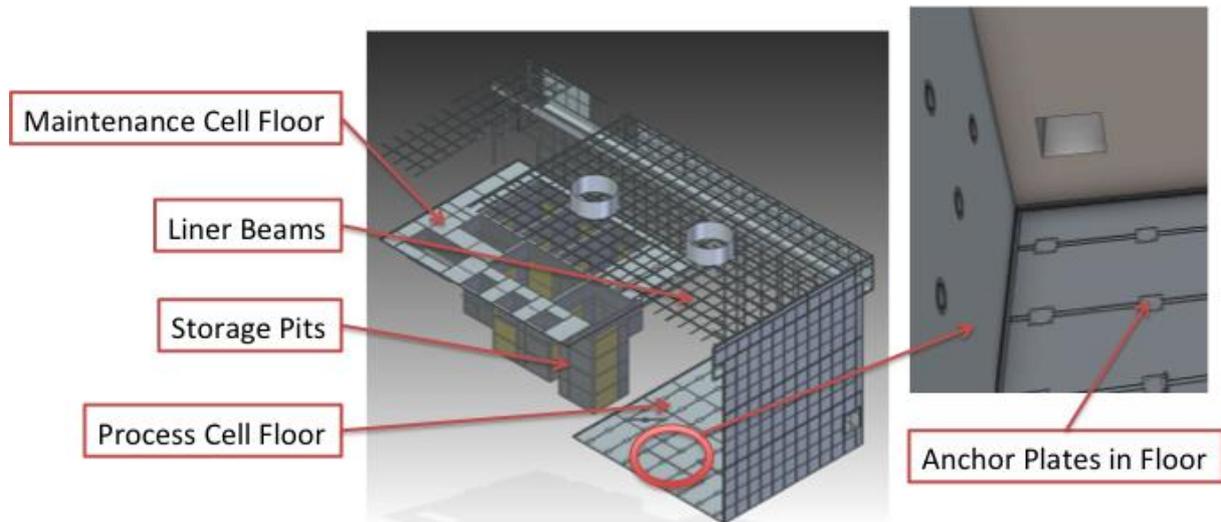


Fig 2. Stainless Steel Liner with details, walls omitted for clarity

The liner beams will be made of 4 mm folded plates with holes along the flanged sides, making sure the concrete to beam interface will be strong enough. The beams are 120 [mm] wide and protrude about 70 [mm] into the concrete. In order to test the mechanical strength of the liner beams, the interaction with the concrete structures at casting as well as how much force different geometries will withstand, beam test coupons have been manufactured, see Figure 3. A view of the beams in the roof of the cells is shown in Figure 4 where the concrete is omitted for clarity.

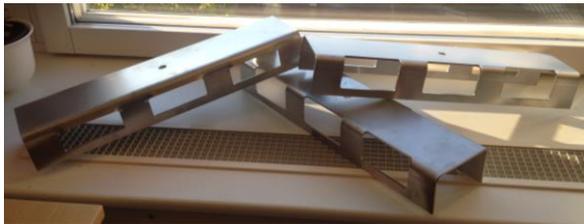


Fig 3. Liner beam test coupons



Fig 4. Example of in-concrete liner beams

For construction of the floor, the initial cast of concrete will be made to 150 [mm] below finished level. The liner beam structures will then be aligned with fixtures pre-fastened in the concrete and then the top 150 mm layer of concrete will be poured. For alignment and positioning reasons, an evenly distributed grid of anchor plates, see Figure 2, will be integrated with the liner beams in the floor.

The storage pits, seen in Figure 2, will be pre-fabricated with the liner beam frames and the liner plates and then used as part of the form for casting concrete between the storage pits. The pits then have to be temporary reinforced and probably filled with sand or water during casting in the interstitial space between the pits.

2.2 Electrical Conduits and Junction Boxes

Since the cells are large and there will be many electrical tools in the cells, some of them with advanced interlocks depending on current operation and on the mode control granted activities, the number of cables that has to be routed from the technical galleries to the interior of the cells is large. The concept used for routing the cables will be through in-floor concrete casted conduits. These are made of stainless steel and have a junction box on both cold and hot side of the walls. The main reason for using this system is to avoid weak shielding areas in the walls and to avoid high cost shielded wall penetration plugs. An early concept study of the junction boxes and associated conduits are shown in Figure 5.

In case of a problem, short cut, damaged junction box, etc., the cold side and boxes in the maintenance cell are accessible hands on but the junction boxes in the process cell will either have to be maintained remotely or the whole junction box including cables will have to be scrapped and a new one installed. In order to ease this process, the process cell junction boxes will be equipped with quick connectors for better remote access. However, this concept is not yet proven and need further studies prior to final decision. In the mean time, there will be more wall penetrations included for design redundancy and choice later in the project. The two junction box types are shown in Figure 6, the orange parts are MCT (Multi Cable Transit) frames ensuring confinement.

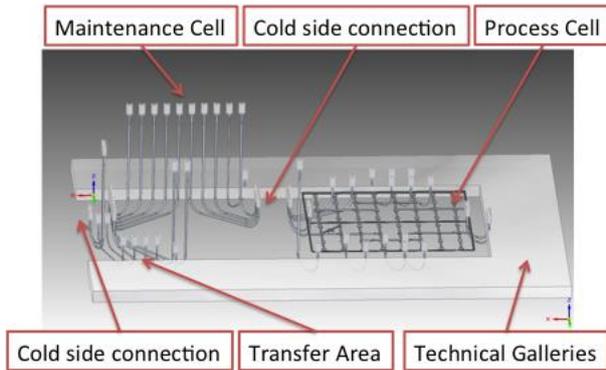


Fig 5. Electrical conduit layout picture

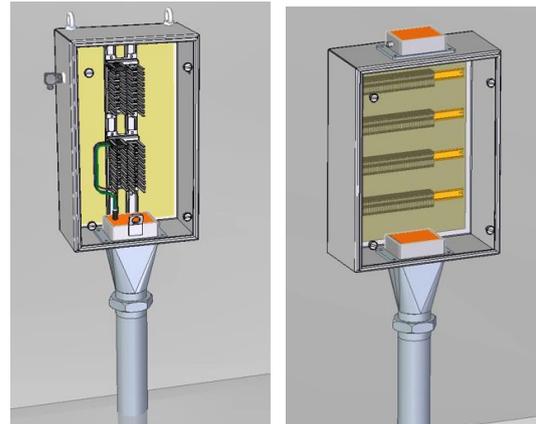


Fig 6. Example of junction boxes, quick connectors to the left and hands on terminals to the right

2.3 Confinement Penetrations

In total there will be around 50 straight pipe penetrations between the technical galleries and the process and maintenance cells. Most of them will be routed to the process cell due to the higher level of remote handling work processes. The total number of penetrations shall ensure enough through wall manipulator coverage, redundancy and options for routing other utilities, power and signal cables. The penetrations are placed with a pattern in the wall focused on equal distribution rather than dedicated floor workstation positions. This will ensure high flexibility of the in-cell operations. The pipe geometry is displayed in Figure 7 and an example of the pipe pattern through the walls is shown in Figure 8.

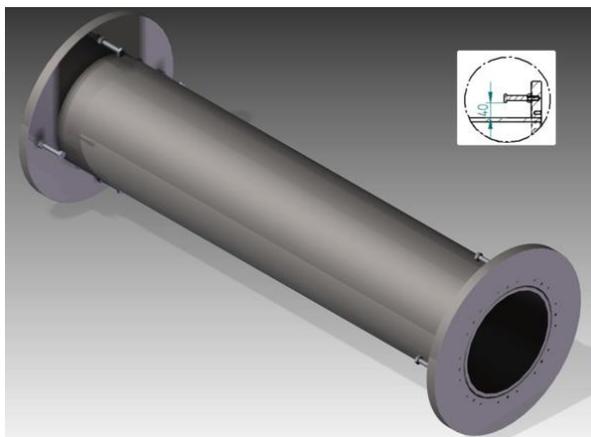


Fig 7. Confinement Penetration Pipe



Fig 8. Even distribution of through wall Penetration Pipes

All the pipes, regardless of final utilization, have the same design. This is done to have the highest level of flexibility once operational since the interface of any item routed through the pipes will be the same.

The negative side effect of the straight pipe design is streaming issues, especially when activated components are lifted inside the cell through the roof from the high bay. Therefore a design restriction of a minimum distance between floor and first row of pipes are set to 2,7 meters. Moreover, the tolerances between pipe and insert is set to a maximum of 1 [mm] radially. Initial MCNP calculations show that the streaming during a lift give acceptable limits in the technical galleries.

3. Waste Logistics

The highly radioactive waste originating from the neutron production in the monolith will be transferred in shielding casks in the high bay, docked to the roof of the Active Cells and then via shielding floor valves be lowered down into the process cell. Depending on what component that is introduced, there will be an in-cell transfer to the appropriate working location via the in-cell over head crane. The waste is treated (cut, separated, demounted, etc.) and different materials and items go in different waste boxes. The boxes are transferred through the intra-bay shielding doors into the maintenance cell part of the cells where the box are decontaminated and then it will be interim stored for an appropriate time depending on activity, shipping details to be finished etc. The box will then with other boxes be placed in a storage container, in the Swedish waste system called a BFA, this is then loaded into a shipment container called an ATB, loaded on a truck and shipped off site. The whole waste process flow is depicted in Figure 9.

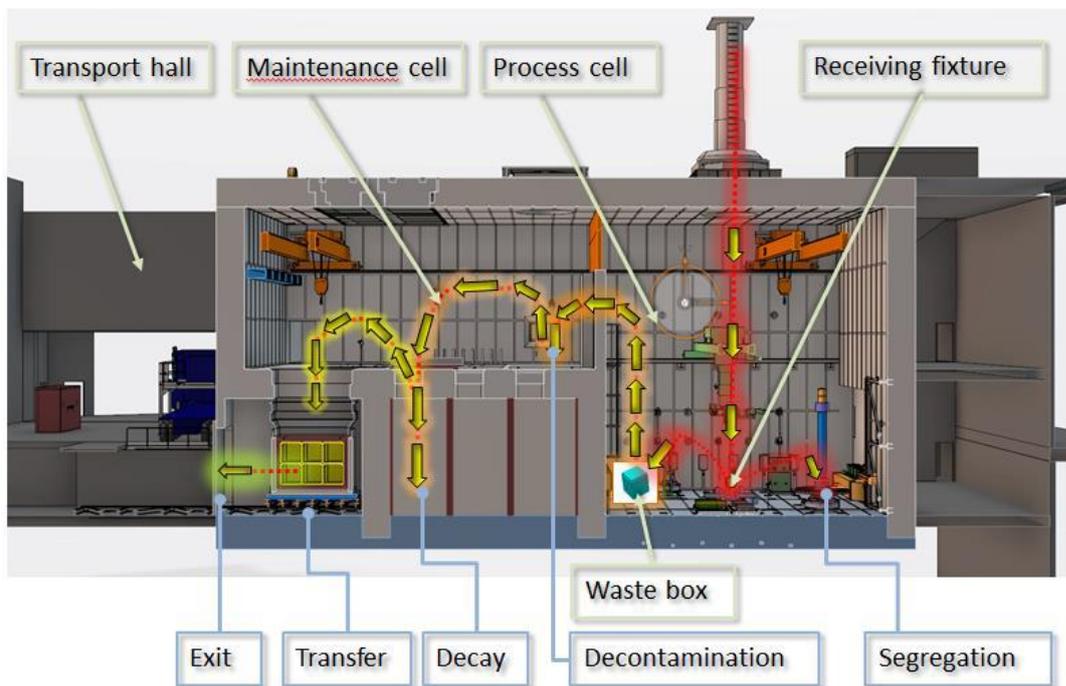


Fig 9. Radioactive waste process flow

There are different types of ATB tanks that could be used and depending on the waste boxes, the type of waste, shipment details, receiving facility acceptance criteria, the logistics can be adopted to fit the needs. In Figure 10, the ATB 1T is shown with a BFA tank and 6 waste boxes. The box dimensions are suited for the BFA tank that have fixed outer dimensions but could have different degree of shielding and thus inner dimensions might change. In Figure 11, the waste boxes are 4 standard moulds with outer dimensions 1,2 x 1,2 x 1,2 [m], these fit into an ATB 4K transport container. Since the standard moulds contain

shielding in them selves (different levels depending on need and type of waste), there is no need for an interstitial BFA tank.

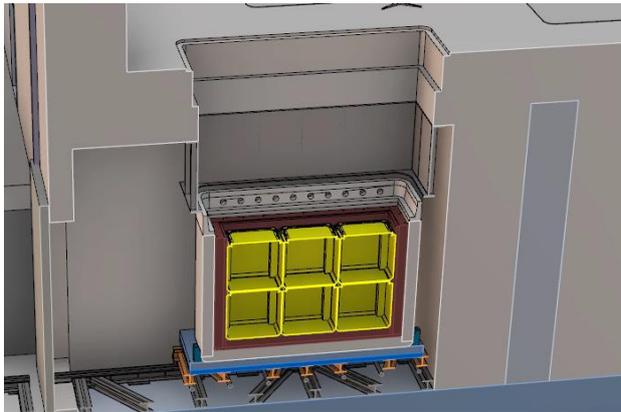


Fig 11. ATB 1T, BFA and Waste boxes

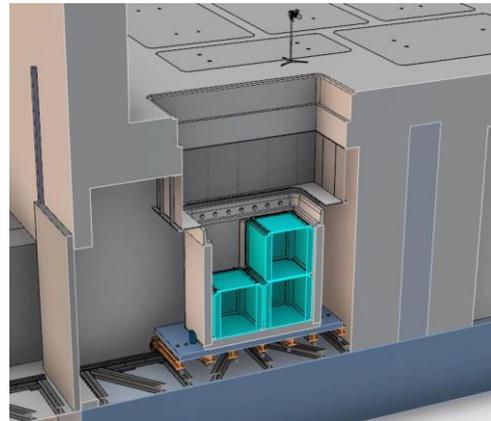


Fig 12. ATB 4K and Standard Moulds

The off site shipment of the ATB containers with waste will be done via truck to a receiving facility. The feasibility study show that it is possible to ship a 140 tons waste load on public road with 10 axes trailer. The total length of the truck and trailer will be around 22 meters. An illustration of the truck with loaded ATB is shown in Figure 13.

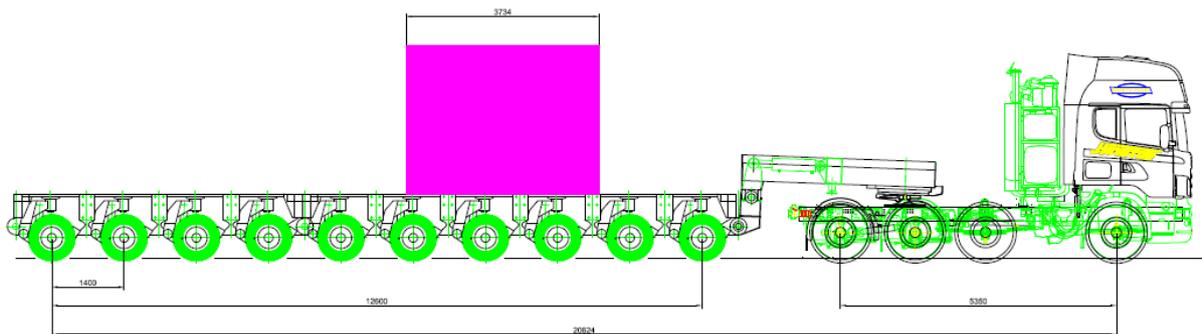


Fig 13. Illustration of transport truck

4. Visualization and Control

The Active Cells facility will not include any shielding glass windows in its design and since the operation will be highly dependent on robotics and remotely controlled equipment, there will be a local control room located in the basement part of the technical galleries. The human machine interfaces have not yet been worked out but the design opens up for future, not yet developed means of operations. The control system will be called ProgrESS and is based on three hot topic-viewing methods, Augmented Reality (AR), Virtual Reality (VR) and Synthetic Viewing. ProgrESS will be a mix of these with the main purpose and focus on safety, efficiency, reliability and availability. In [2] the “Novel Concept for the ESS Target Station Hot Cells” go more into details on what the synergy effects are of not operating through shielding glass windows. The schematic layout of ProgrESS is shown in Figure 14 where the operations mode control is dealt with in the green boxes dependant on the safety signals in red and purple. The equipment control, machine interlocks and general operations in orange and HMI's in light blue.

