The Cask Assembly at ESS

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1. Abstract

The European Spallation Source (ESS) in Lund, Sweden shall be a 5 MW, long pulsed neutron spallation research facility with planned commissioning 2022. The Cask Assembly (CA), shall ensure the safety and protection of workers, property and the environment from the effects of radiation during Target Monolith maintenance and the internal transport of irradiated Monolith Components [1].

The CA shall transport spent components from the Target Monolith through the High-Bay to the Active Cells Facility (ACF) [2], where the irradiated components shall be dismantled, separated and prepared for disposal. The CA shall be lifted by the High-Bay Crane and, using Gamma Gates, it shall dock to the Target Monolith and ACF to provide extended containment. All the cask internal lifting operations must be remote with no man access to ensure worker safety. The CA shall also transport new components from the Mock-Up and Test Stand (MUTS) to the Monolith Target for installation. The Target Station layout is shown in . (Figure 1)

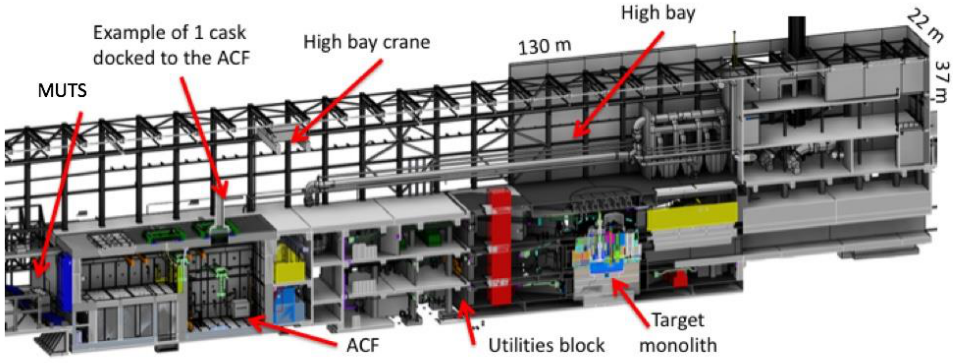

Figure 1. Layout of the ESS Target Station

The CA project interfaces with a number of different areas of ESS, these are at varied levels of maturity. To progress the CA and to assist in the facility design maturity a competitive concept design study was carried out by three suppliers. We at ESS have used this process to understand our suppliers better while involving several highly capable international teams to help us to improve our facility design and refine the CA requirements.

2. 'Monolith Components'

'Monolith Components' that shall be replaced by the CA are: Proton Beam Window (PBW), Moderator Reflector Plug (MRP), Target Wheel (TW), Proton Beam Instrumentation Plug (PBIP) and the Target Monitoring Plug (TMP). To access these components, adjacent removable shielding blocks must be handled and temporarily stored.

The internal remote handling devices must remotely provide adequate precision and accuracy to facilitate installation and removal of these Monolith Components, shown in Figure 2.

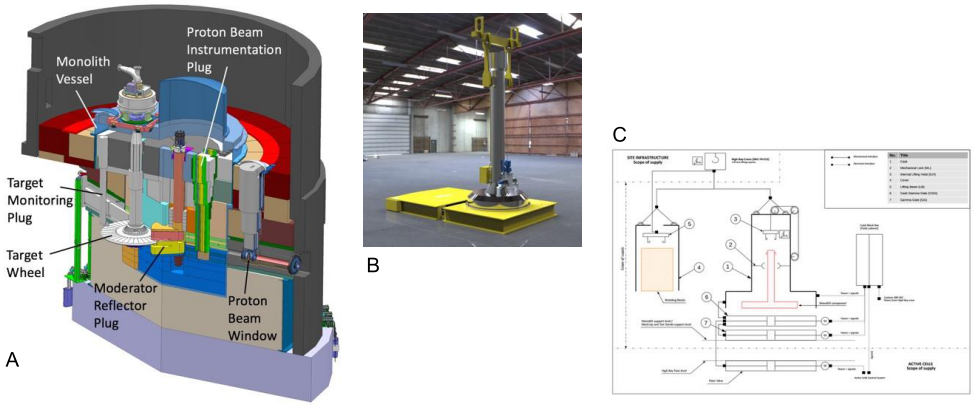

Figure 2. The 'Monolith Components', B. CA concept design, C. Example CA General Arrangement

Table 1. Monolith Components handled by the Cask Assembly

Component handled by the Cask Assembly	**Consumable?** (Y/N)	**Planned interval between replacements** (yrs)	**Mass** ($T_{\pm 10\%}$)	**Max source term*** (μSv/hr)
Moderator Reflector Block Level 6	N	-	14	2.9 e3
Moderator Reflector Block Level 5	N	-	12	2.1 e5
Moderator Cooling Block	N	-	13	7.6 e7
MRP	Y	1	14	7.2 e8
PBIP Shielding Block	N	-	3	4.5 e4
PBIP slices x5	Y	0.5 **	0.5-3	2.0 e7
PBW Upper Shielding Block	N	-	6	9.5 e1
PBW Middle Shielding Block	N	-	6	1.8 e5
PBW Lower Shielding Block	N	-	2	4.6 e6
PBW	Y	0.5	0.5	1.1 e7
TW Block Level 6	N	-	60	4.3 e4
TW Block Level 5 Upper	N	-	30	3.2 e5
TW Block Level 5 Lower	N	-	30	3.0 e6
Rotating Shielding Block	N	-	1	3.0 e5
Target Wheel Cooling Block	N	-	41	6.2 e8
TW	Y	5	9	7.0 e8
TMP	Y	5	11	2.5 e7
TMP Inserts x3	Y	1	0.3	9.8 e2

* After two weeks cool down following plant shutdown
** Every six months a slice shall be replaced, however any one slice may not be replaced for two years

3. Source terms

A detailed study of the Monolith Components source terms was carried out by UKAEA, identifying significantly high gamma levels. MCNP6.1 source definitions were generated using UKAEA's MCR2S code. The results from this study, shown in Table 1, provide a gamma source as whole-body contact dose in μSv/hr. Similar facilities have shown the primary hazard from these components is gamma radiation.

4. Allowable dose

During maintenance activities ESS shall ensure the dose to workers, within any hour, does not exceed 25μSv. The CA is treated as a 'temporary hotspot', the allowable dose, distance from the CA and the allowable worker expose time is presented in Table 1 . Either 19 or 28cm of steel shielding shall be required for the 'hottest' component in Table 1 to satisfy Table 2 or 25 μSv/hr respectively.

Table 2. CA 'temporary hotspot' limitations

Distance (m)	**Allowable dose** (mSv/hr)	**Maximum operator time, in an hour, at this distance**
0.2	2	45 seconds
1	0.5	3 minutes

5. Crane lifting capacity & drop scenarios

If the hottest Monolith Component were exposed without any shielding in the High-Bay there may be a radiation risk for the public. Considering this, it is essential that the integrity of the CA shielding is maintained during any operation, including both anticipated and unanticipated events. One of the risks to the CA shielding integrity is a drop by the High-Bay Crane. Therefore, the High-Bay crane shall be built to reduce the likelihood of a drop to 10e-6 for the maximum certified lift capacity of 95T. This load restriction is a significant constraint for the project and drives a solution with several CA configurations.

6. System development

Adopting a competitive tender philosophy has allowed ESS to refine the system requirements during the development process. Through supplier feedback two Monolith Components have been divided in two in order to reduce lifting mass. In addition, guides and rails have been incorporated into permanent shielding designs to assist in the CA remote deployment.

The project in now progressing into the detailed design phase and is planned to be commissioned by March 2022.

References

1. Dr Carwyn Jones, Magnus Göhran, Lennart Åström, Prof Jon Holt. (2018). ESS Cask Assembly and Systems Engineering Methodology – Proceedings of the Hotlab 2018 Conference in Helsinki.
2. Magnus Göhran, Lennart Åström, Paul Erterius, Eldin Mukovic, Srdjan Vareskic. (2018). The European Spallation Source Active Cells Facility – Challenges in Construction – Proceedings of the Hotlab 2018 Conference in Helsinki.