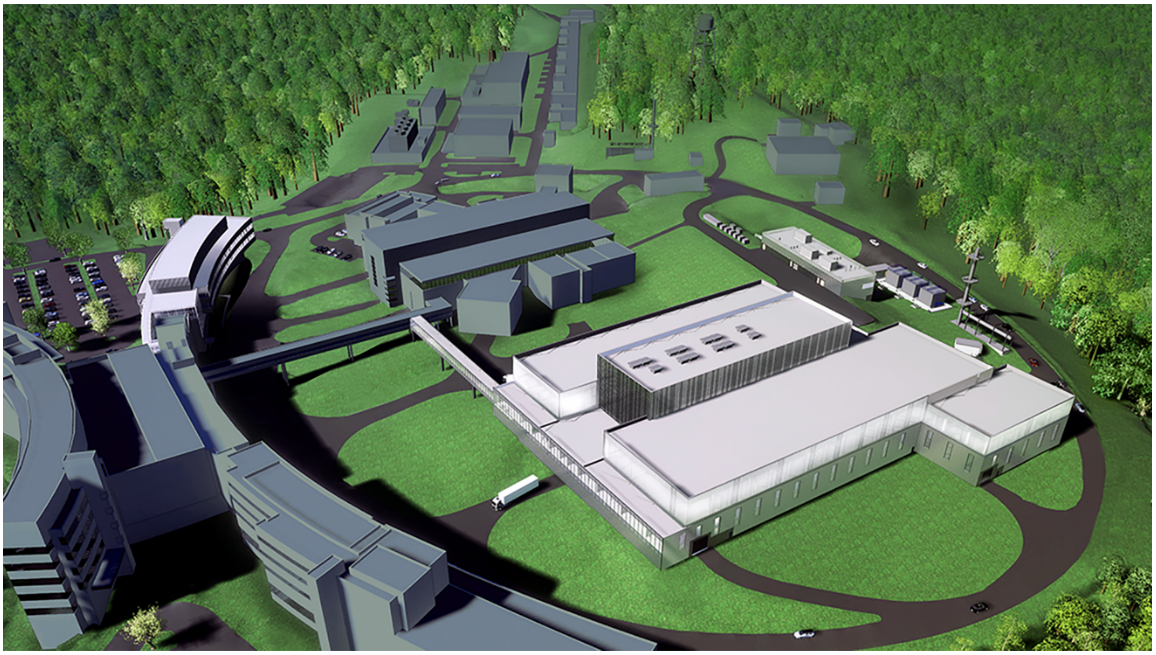
S03040000-DRD10000

Second Target Station Project: Moderator and Reflector Assembly Preliminary Design Review Report



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MODERATOR AND REFLECTOR ASSEMBLY PRELIMINARY DESIGN REVIEW REPORT

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00	Initial Release

Preliminary Design Review of STS Moderator & Reflector Assembly

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Key Points

- The MRA design is ready to proceed to final design review with a clear path for success. The MRA design team has thoroughly explored the most important design aspects and developed methods ensure the MRA will meet all design requirements.
- Beyond meeting requirements, the MRA design team has demonstrated several novel approaches that set a new state of the art for designing neutronics components for both optimum performance and manufacturability.
- The team is commended for excellent work in tracking and maintaining requirements and interfaces as the overall target system design progresses.

Charge 1: Have system requirements been defined, and are they complete and adequate to ensure acceptable system performance?

- Yes, with some risks
- Findings
  - The requirements tracking approach being used by the STS is commended and shows that the team is on track to ensure all requirements will be met and verified.
  - The footprint of the MRA depends upon expectations that other components will not require replacement in the lifetime of the facility. These decisions rely upon radiation exposure limits from the STS Materials Handbook, which has an unclear pedigree. The limits in the Materials Handbook diverge significantly from the limits used at FTS.
  - The KPP objective for peak brightness at 5 Angstrom is set to 2e14 n/cm^2/s/sr/A, which will be easily achieved by both the cylinder and tube moderators as neutronics analyses show.
  - The focal points of the neutron beamlines at the centers of the neutron emission ports preclude any modification of the moderator design.
  - Several requirements were chosen to provide conservative values, which allows design to proceed without requirement for detailed review of specific requirement limits.

Charge 1: Have system requirements been defined, and are they complete and adequate to ensure acceptable system performance?

- Comments
  - Consider evaluating hydrogen density in the tube moderator across each cylindrical section rather than an average throughout.
  - Consider specifying the beryllium material for crystalline grain size and impurity content.
  - For requirements where conservative values were chosen, consider adding notes on how the limit was chosen for future operational troubleshooting.
  - MRA Shipping Requirement 2335 – consider rewording to clarify length of operation separately from decay time (not operation of 1 year or less).
  - MRA requirements 2354, 2893, 2355 – consider rewording to include fabrication of components to the intent of the ASME BPVC.
- Recommendations
  - As early as possible in final design, management should decide on number of beamlines (S.3-R03) update the project requirements.
  - Before vessel systems preliminary design review, Target Systems should ensure material radiation limits used for evaluation of component life have been adequately reviewed.

Charge 2: Is the proposed design expected to meet the functional and performance requirements, and are interfaces properly identified and defined?

- Yes, with areas for improvement in final design
- Findings
  - The open seismic requirements are expected to lead to additional interfaces between the MRA and the surrounding structure.
  - The changing nature of the STS design has led to some lag between written requirements and existing requirements.
  - The team has created more stringent requirements for themselves, such as hydrogen density requirements and deformation limits. While some analyses show these self-imposed limits being challenged, the preliminary design is on track for meeting all specified requirements.
  - Some requirements, such as interfaces with the core vessel lid ports, are not well tracked in requirements lists, but are being addressed by the team.

Charge 2: Is the proposed design expected to meet the functional and performance requirements, and are interfaces properly identified and defined?

- Comments
  - Need to understand the impact of ORNL pressure system safety requirements, and how those will be addressed in design, installation, and operation of STS systems.
  - Address discrepancies in guide entrance distances amongst STS documents.
  - The vessel system interface document is currently at Rev A.
  - The changing height of the MRA may update interfaces with the target wheel segments.
  - Continue to develop and update interface documents as new interfaces are identified
  - Continue to work on pipe bracing – pipes are connected at the top at the flanges and at the bottom at the MRA. Perhaps check pipes (water cooling pipes) for vibration during operation. Long distance between anchor points on a pipe can result in vibrations, but bracing must work with future remote handling.
  - During final design, consider adding alignment/guiding features to the MRA to help installation and removal.
- Recommendations
  - As early as possible in final design, update the project requirements to reflect the acceptable outage length for MRA replacement (S.3-R06 vs S.03.04-2344)

Charge 3: Have appropriate options and alternatives been considered in selecting the design approach?

- Yes.
- Findings
  - The team has made significant improvements to the state of the art of cooperative design of neutronics components.
  - Several design concepts were evaluated, and feedback from the instrument scientists was used to find the best tradeoffs between peak and time-integrated brightness.
  - The extension of the MRA shield block to 1.6 m height is a welcome ALARA measure to lower the dose rates to workers during the change-out scenarios.
  - The neutronics and engineering team work closely together and do a fabulous job in verifying any design change impact to moderator performance and make smart choices.
  - Closing the north-side of the moderators with premoderator could be considered to deliver the best neutron beams to the built-out southside instrument suite.
  - Cooling beryllium by heavy water was considered but rejected because of limited gains to neutron performance.
  - Shrinking the proton beam size to 60 cm^2 shows high gains and could be considered to increase neutron performance further.

Charge 3: Have appropriate options and alternatives been considered in selecting the design approach?

- Comments
  - Consider retaining material samples from the manufactured MRA to use as a compositional reference for evaluation of activation products to inform final disposal path.
- Recommendations
  - None.

Charge 4: Is the proposed design sufficiently mature to proceed to final design?

- Yes
- Findings
  - The team has done significant work optimizing the design for performance, while maintaining manufacturability.
  - The level of detail of analysis, and the focus on the most critical areas are appropriate for the preliminary design level.
  - The MRA and surrounding systems continue to evolve as they progress through design. Interface documents and drawings have been created and are being maintained.

Charge 4: Is the proposed design sufficiently mature to proceed to final design?

- Comments
  - The team has self-identified several areas for improvement in future analysis and design. The team is encouraged to document and track these areas to ensure they are addressed in the final design phase.
  - Beryllium tensile yield strength used (345 – 517 MPa) is high relative to Materion specifications for S-65 beryllium (207 MPa)
  - Studying the impact of moderator misalignment on neutron performance with point-detector estimates may not be the best approach and likely overestimates the misalignment impact. Involving instrument optics simulations may give more and instrument specific insight.
- Recommendations
  - None

Charge 5: Have major project risks and safety hazards been appropriately identified, characterized, and mitigated?

- Yes, but significant work remains for hydrogen components
- Findings
  - Updates to the PHAR have introduced safety requirements for the MRA cryogenic hydrogen components. These requirements are primarily managed under the CMS scope, but MRA scope for seismic analysis is still outstanding.

Charge 5: Have major project risks and safety hazards been appropriately identified, characterized, and mitigated?

- Comments
  - Risk due to delays during fabrication other than damage should be considered. Such as, limited vendor pool, unexpected fabrication challenges.
  - Requirements for the hydrogen piping include various sources (ASME code, PHAR, Pressure system safety) that will require close interface between MRA and CMS scope that could become more challenging if the two systems are split between different engineers.
  - Consider adding a risk that delays to seismic requirements may cause a delay to design completion
  - Consider adding a risk that delays to ASME BPVC equivalent protection guidance may cause a delay to design completion
  - As-early as possible, document approach for equivalent protection to the ASME BPVC for design and fabrication of pressure vessels credited in the PHAR.
- Recommendations
  - As early as possible, issue guidance document for seismic analysis.

Charge 6: Does the project execution according to the acquisition plan and manufacturing plan seem reasonable and adequate?

- Yes
- Findings
  - Excellent work on design for future fabrication.
  - Team has focused on the most critical areas, with less critical areas still having more areas to be addressed in more detail during final design.

Charge 6: Does the project execution according to the acquisition plan and manufacturing plan seem reasonable and adequate?

- Comments
  - During final design, develop a more detailed alignment and measuring plan, in sufficient time to add features or build additional hardware as needed.
  - Consider tracking a list of deliverables to operation, such as measurements and other critical final documentation.
  - Consider documenting and distributing best practices during the project to ensure information useful for future operation and support is not lost.
  - As the design continues, reevaluate the planned split of work between vendors and ORNL staff, and ensure vendor competencies are addressed.
- Recommendations
  - None