S03040000-SR0001

Second Target Station Project: System Requirements Document for Target Systems Moderator Reflector Assembly (MRA)

Jim Janney

July 2026

OAK RIDGE National Laboratory

ORNL IS MANAGED BY UT-BATTELLE LLC FOR THE US DEPARTMENT OF ENERGY

S03040000-SR0001

Second Target Station Project

SYSTEM REQUIREMENTS DOCUMENT FOR TARGET SYSTEMS MODERATOR REFLECTOR ASSEMBLY (MRA)

Jim Janney

July 2026

Prepared by
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, TN 37831
managed by
UT-BATTELLE LLC
for the
US DEPARTMENT OF ENERGY
under contract DE-AC05-00OR22725

Approvals

System Requirements Document for Target Systems Moderator Reflector Assembly (MRA)		ISSUE DATE: 7/31/2026
PREPARED BY Jim Janney	PROJECT Second Target Station	DOCUMENT NUMBER: S03040000-SR0001

	Signature / Date					
	Rev. 00	Date	Rev. 01	Date	Rev. 02	Date
Lead Engineer	Jim Janney	12/1/20	Jim Janney	3/18/2024	Jim Janney 2026.07.31 10:44:23 -04'00'	
Configuration Control Manager	Peter Rosenblad	11/30/20	Daniel Lyngh	3/19/2014		
Quality Assurance						
System Engineering and Integration Lead						
ESH&Q						
SNS						
	Mike Strong	11/30/20				

Revision	Description
00	Initial Release
01	Update for PDR
02	Update for FDR

1. SCOPE

This document serves to establish the full set of requirements for the design of the Target Systems Moderator Reflector Assembly (MRA) for the Second Target Station.

2. DESIGN REQUIREMENTS

The following table is an export from the Moderator Reflector Assembly tracker on Codebeamer at the time of the Final Design Review. Codebeamer is the STS project requirements tracking tool that is used to track and link requirements. The requirements with a white background are primary MRA requirements, which are decomposed from Target Systems requirements, and the requirements with a grey background are derived MRA requirements which are derived from primary MRA requirements. HAR Links have been added to denote requirements which fulfill requirements from the STS Hazard Analysis Report. The Item ID is a Codebeamer ID unique to each requirement.

Summary	Description	Decomposed From	HAR Links	Item ID
MRA Neutron Brightness Requirement	The MRA shall deliver 18 neutron beams with the characteristics and locations described in the MRA-Instrument Systems Interface Sheet, S01020500-IS0023. The peak brightness of all neutron beams shall be greater than 2x10^14n/cm^2/sr/Å/s at the neutron wavelength 5Å.	[S.03-1029] - Peak Brightness,[S.03-1030] - Number of Beamlines,[S.03-1031] - Consider Background Effects		2887
MRA Moderator Hydrogen Density Requirement	The hydrogen in both moderators shall have a minimum average density of 72.0 kg/m^3.	[S.03.04-2887] - MRA Neutron Brightness Requirement		2888
MRA Moderator Hydrogen Maximum Temperature Requirement	The hydrogen temperature shall at no point in the moderators exceed 32 K.	[S.03.04-2887] - MRA Neutron Brightness Requirement		2889
MRA Moderator Alignment Requirement	The MRA shall position the moderator viewed faces within +/- 1 mm of their ideal locations during installation.	[S.03.04-2887] - MRA Neutron Brightness Requirement		2323
MRA Moderator Operational Displacement Requirement	The MRA moderators shall have a displacement of 0.3 mm or less relative to the MRA mounting points from installation to 700 kW operation.	[S.03.04-2887] - MRA Neutron Brightness Requirement		2892
MRA Proton Beam Port Size Requirement	The MRA proton beam port shall be 262.8 mm wide by 80.8 mm tall or greater in order to allow for >99.9% of the nominal proton beam profile to pass through to the target.	[S.03-1028] - Accept Beam from Accelerator		2321
MRA Temperature Requirement	The MRA shall be capable of maintaining temperature of the assembly such that structural integrity is unaffected at 700 kW beam power.	[S.03-1028] - Accept Beam from Accelerator		2324
MRA Aluminum Temperature Requirement	The MRA aluminum 6061-T6 structures shall have a maximum operating temperature of 100 C.	[S.03.04-2324] - MRA Temperature Requirement		2325

MRA Stainless Steel Temperature Requirement	The MRA stainless steel structures shall have a maximum operating temperature of 200 C.	[S.03.04-2324] - MRA Temperature Requirement		2326
MRA Beryllium Temperature Requirement	The MRA beryllium shall have a maximum operating temperature of 100 C.	[S.03.04-2324] - MRA Temperature Requirement		2327
MRA Water Temperature Requirement	The MRA cooling water shall have a maximum temperature of 100 C.	[S.03.04-2324] - MRA Temperature Requirement		2328
MRA Temperature Monitoring Requirement	The MRA shall include thermocouples for monitoring the temperature of the MRA through the integrated control system per S01020500-IST10126.	[S.03-1042] - Accommodate timing & monitoring		2336
MRA Lifetime Requirement	The MRA design shall allow for a lifetime of at least 5 years of operation.	[S.03-1032] - Operational Life		2337
MRA Material Lifetime Requirement	The MRA materials shall allow for a lifetime of at least 5 years.	[S.03.04-2337] - MRA Lifetime Requirement		2338
MRA Cyclic Loading Requirement	The MRA shall be designed for a lifetime of 5 years (25000 hours of 700 kW beam power operation) or more with respect to cyclic loading. The hydrogen boundaries are expected to experience 50 full pressure cycles during commissioning and 10 full pressure cycles per year during operation. Hydrogen pressure is expected to fluctuate 2 bar or less during beam trips and ramps. The water boundaries are expected to experience 20 pump start cycles during commissioning and 4 pump start cycles per year during operation. A pump start cycle is expected to produce an MRA water pressure change of 1 bar or less. No full pressure cycles are expected for the water boundaries. 10000 beam trips are expected to occur each year.	[S.03.04-2337] - MRA Lifetime Requirement		2339

MRA Availability Requirement	The MRA design shall allow for greater than 95% availability for greater than 5000 hours of proton beam on target per year with accommodation for maintenance intervals in accordance with the STS operating schedule.	[S.03-1033] - Yearly Operating Hours,[S.03-1034] - Availability,[S.03-3009] - Maintenance & Lifetime Criteria		2344
MRA Maintenance Requirement	The MRA shall be designed to require no maintenance during its lifetime.	[S.03.04-2344] - MRA Availability Requirement		2345
MRA Joining Requirement	The MRA design shall use all welded construction (including friction welds and explosion bonds) on all pressure boundaries.	[S.03.04-2344] - MRA Availability Requirement		2346
MRA Replacement Requirement	The MRA shall be capable of being replaced in a 1400 hour maintenance outage.	[S.03.04-2344] - MRA Availability Requirement		2347
MRA Leak Rate Requirement	The MRA shall maintain leak rates less than what would cause degradation of the core vessel environment or the insulating vacuum surrounding the hydrogen boundary.	[S.03-1034] - Availability		10927
MRA Hydrogen Leak Rate Requirement	All MRA hydrogen boundaries shall have a leak rate of 1 x 10 ^ -9 mbar-l/s or less.	[S.03.04-10927] - MRA Leak Rate Requirement		2351
MRA Water Leak Rate Requirement	All MRA water boundaries shall have a leak rate of 1 x 10 ^ -6 mbar-l/s or less.	[S.03.04-10927] - MRA Leak Rate Requirement		2350
MRA Vacuum Leak Rate Requirement	All MRA vacuum boundaries shall have a leak rate of 1 x 10 ^ -9 mbar-l/s or less.	[S.03.04-10927] - MRA Leak Rate Requirement		2352
MRA Structural Integrity Requirement	The MRA shall maintain structural integrity under all expected loading conditions.	[S.03-1034] - Availability,[S.03-1035] - Safe Operation		2348

MRA Hydrogen Transfer Line Requirement	The MRA hydrogen transfer lines shall be designed and fabricated to 2019 ASME B31.12. Applied seismic loads shall be derived from the NPH BOD.	[S.03.04-2348] - MRA Structural Integrity Requirement	[CDF-9951] - credited DF28,[CDF-9941] - credited DF18,[CAIC-10066] - DF Critical to Event Evaluations 37	2349
MRA Water Piping Requirement	The MRA water piping shall be designed and fabricated to 2020 ASME B31.3. Applied seismic loads shall be derived from the NPH BOD.	[S.03.04-2348] - MRA Structural Integrity Requirement		2353
MRA Hydrogen Vessel Requirement	The MRA hydrogen vessels shall be designed to the intent of the 2023 ASME BPVC. Applied seismic loads shall be derived from the NPH BOD.	[S.03.04-2348] - MRA Structural Integrity Requirement	[CDF-9941] - credited DF18,[CAIC-10066] - DF Critical to Event Evaluations 37	2354
MRA Vacuum Vessel Requirement	The MRA vacuum vessels shall be designed to the intent of the 2023 ASME BPVC. Applied seismic loads shall be derived from the NPH BOD.	[S.03.04-2348] - MRA Structural Integrity Requirement		2893
MRA Reflector Vessel Requirement	The MRA reflector vessels shall be designed to the intent of the 2023 ASME BPVC. Applied seismic loads shall be derived from the NPH BOD.	[S.03.04-2348] - MRA Structural Integrity Requirement		2355
MRA Backbone Requirement	The MRA Backbone shall be designed to the intent of the 2023 ASME BPVC. Applied seismic loads shall be derived from the NPH BOD.	[S.03.04-2348] - MRA Structural Integrity Requirement		10921
MRA Fastener Requirement	The fasteners employed within the MRA shall have a factor of safety of 3 or greater against yielding for all expected loading conditions including lifting and seismic. Applied seismic loads shall be derived from the NPH BOD.	[S.03.04-2348] - MRA Structural Integrity Requirement		11057
MRA-CMS Interface Requirements	Requirements derived from the MRA-CMS Interface Sheet, S01020500-IST10148	[S.03-1029] - Peak Brightness,[S.03-1035] - Safe Operation		2320

MRA Hydrogen Loop Pressure Drop Requirement	The MRA hydrogen loop pressure drop shall be less than 0.15 bar @ 0.5 l/s and 20 K.	[S.03.04-2320] - MRA-CMS Interface Requirements		2356
MRA Hydrogen Boundary Pressure Requirement	The MRA hydrogen boundary MAWP shall be 19 bara.	[S.03.04-2320] - MRA-CMS Interface Requirements		2357
MRA Vacuum Boundary Pressure Requirement	The MRA vacuum boundary MAWP shall be 2 bara.	[S.03.04-2320] - MRA-CMS Interface Requirements		2358
MRA Vacuum Space Requirement	The MRA vacuum space shall be designed to provide insulating vacuum surrounding all MRA hydrogen boundaries. The vacuum space shall be designed for vacuum service.	[S.03.04-2320] - MRA-CMS Interface Requirements	[CAIC-10078] - DF Critical to Event Evaluations 49	2359
MRA Vacuum Venting Requirement	The MRA vacuum space shall be designed to support venting of hydrogen leaks without exceeding the MAWP.	[S.03.04-2320] - MRA-CMS Interface Requirements	[CAIC-10079] - DF Critical to Event Evaluations 50	3591
MRA Hydrogen Venting Requirement	The MRA hydrogen lines shall be designed to support venting of hydrogen after loss of transfer line vacuum without exceeding the MAWP.	[S.03.04-2320] - MRA-CMS Interface Requirements		3592
MRA-Process Systems Interface Requirements	Requirements derived from the MRA-Process Systems Interface Sheet, S01020500-IST10186	[S.03-1028] - Accept Beam from Accelerator		2360
MRA Water Boundary Pressure Requirement	The MRA water boundaries shall have a MAWP of 5 bara.	[S.03.04-2360] - MRA-Process Systems Interface Requirements		2361
MRA Upper Premoderator Pressure Drop Requirement	The MRA upper premoderator water loop shall have a pressure drop of less than 15 psi at 7.5 gpm and 32.2 C inlet temperature	[S.03.04-2360] - MRA-Process Systems Interface Requirements		2362

MRA Lower Premoderator Pressure Drop Requirement	The MRA lower premoderator water loop shall have a pressure drop of less than 15 psi at 7.5 gpm and 32.2 C inlet temperature	[S.03.04-2360] - MRA-Process Systems Interface Requirements		2363
MRA Upper Reflector Pressure Drop Requirement	The MRA upper reflector water loop shall have a pressure drop of less than 15 psi at 7.5 gpm and 32.2 C inlet temperature	[S.03.04-2360] - MRA-Process Systems Interface Requirements		2364
MRA Lower Reflector Pressure Drop Requirement	The MRA lower reflector water loop shall have a pressure drop of less than 15 psi at 7.5 gpm and 32.2 C inlet temperature	[S.03.04-2360] - MRA-Process Systems Interface Requirements		2365
MRA Backbone Pressure Drop Requirement	The MRA backbone water loop shall have a pressure drop of less than 15 psi at 15 gpm and 32.2 C inlet temperature	[S.03.04-2360] - MRA-Process Systems Interface Requirements		2366
MRA-AIC Interface Requirement	The MRA design shall provide a clear path through the MRA for the optical path from the TVP mirror to the target assembly face as shown in S03050230_L-M8U-8800-A001-SKEL.PRT as specified in the MRA-AIC Interface Sheet, S03000000-IST10000.	[S.03-1041] - Measure beam profile & position		2371
MRA-Target Assembly-Core Vessel Clearance Requirements	The MRA shall not contact the target assembly and shall not contact the core vessel shielding, except for the alignment features and the seismic restraint, by meeting the requirements of the MRA-Target Assembly-Core Vessel Clearance Budget Document.	[S.03-1035] - Safe Operation,[S.03-1034] - Availability, [S.03-1478] - Hydrogen Boundary interactions	[CDF-9931] - credited DF8	2373
MRA Boundary Requirement	The MRA nominal boundary shall match the boundary defined in the MRA-Target Assembly-Core Vessel Clearance Budget Document.	[S.03.04-2373] - MRA-Target Assembly-Core Vessel Clearance Requirements,[S.03-1478] - Hydrogen Boundary interactions	[CDF-9931] - credited DF8	2374

MRA Profile Tolerance Requirement	The MRA shall have an overall profile tolerance of +/- 1mm to the ideal boundary after installation.	[S.03-1478] - Hydrogen Boundary interactions,[S.03.04-2373] - MRA-Target Assembly-Core Vessel Clearance Requirements	[CDF-9931] - credited DF8	2995
MRA Deflections Requirement	The MRA outside surfaces shall not deflect more than +/- 1.5mm from their installed locations under any expected loading conditions.	[S.03-1478] - Hydrogen Boundary interactions,[S.03.04-2373] - MRA-Target Assembly-Core Vessel Clearance Requirements	[CDF-9931] - credited DF8	2994
MRA Shielding Requirement	The MRA design shall support the Target Systems Monolith meeting the Target Systems Radiation Shielding Requirement. Note: The MRA design must be carefully coordinated with surrounding structures to minimize the impact of streaming gaps.	[S.03-1036] - Radiation Safety		3593
MRA Remote Handling Requirement	The MRA design shall include features to allow for remote handling and replacement	[S.03-1037] - Replacement and Disposal Path		2329
MRA Lifting Stud Requirement	The MRA shall include a 1.5"-8 UN threaded stud located over the assembly CG.	[S.03.04-2329] - MRA Remote Handling Requirement		2330
MRA Pipe Cutting Requirement	The MRA piping shall be designed for cutting above the upper shield block.	[S.03.04-2329] - MRA Remote Handling Requirement		2331
MRA Blowdown Requirement	The MRA shall be capable of blowdown of water passages such that the subsequent water level is at or below the top of the MRA shield block.	[S.03.04-2329] - MRA Remote Handling Requirement		3588
MRA Removal Requirement	The MRA shall be capable of vertical removal from core vessel after the removal of 3 target segments.	[S.03.04-2329] - MRA Remote Handling Requirement		3589

MRA Installation Requirement	The MRA shall be capable of vertical installation after the removal of 3 target segments.	[S.03.04-2329] - MRA Remote Handling Requirement		3590
MRA Utilities Dose Rate Requirement	The dose rates at 30 cm from the MRA hydrogen transfer line connection and water line connections shall be 100 mrem/hour or less after MRA operation and decay time of 8 hours to allow for hands on replacement of these connections with the target station in nominal operating configuration with the exception of the removal of the Core Vessel MRA hatch.	[S.03.04-2329] - MRA Remote Handling Requirement		10944
MRA Disposal Requirement	The MRA shall be capable of shipping to and disposal at a waste facility at the end of life.	[S.03-1037] - Replacement and Disposal Path		2332
MRA Size Requirement	The MRA shall fit within a liner designed to fit in the TN-RAM shipping cask after removal of piping above the upper shield block.	[S.03.04-2332] - MRA Disposal Requirement		2333
MRA Mass Requirement	The mass of the MRA shall be less than 2400 kg after removal of piping above the upper shield block and subsequent drying of water passages.	[S.03.04-2332] - MRA Disposal Requirement		2334
MRA Shipping Requirement	The MRA shall meet the radiological requirements for shipping in the TN-RAM cask after operation of 6 years and decay time of 2 years or less.	[S.03.04-2332] - MRA Disposal Requirement		2335
MRA Disposal Classification Requirement	The MRA shall meet the waste acceptance criteria for Nevada National Security Site after operation of 6 years and decay time of 2 years or less.	[S.03.04-2332] - MRA Disposal Requirement		2322
MRA Assembly Structure Requirement	The hydrogen vessels shall be located within the vacuum vessels, which are located in the central region of the reflector vessels and surrounded by premoderator water and beryllium, providing 2 layers of aluminum and the beryllium reflector around each hydrogen vessel to prevent potential contact.	[S.03-1035] - Safe Operation	[CAIC-10082] - DF Critical to Event Evaluations 53	10931