

SECOND TARGET STATION (STS) PROJECT

Instrument Systems Requirements Document



May 2021

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INSTRUMENT SYSTEMS REQUIREMENTS DOCUMENT

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Instrument Systems Requirements Document

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ACRONYMS

KPP	Key Performance Parameter
PPEP	Preliminary Project Execution Plan
PPU	Proton Power Upgrade
SNS	Spallation Neutron Source
STS	Second Target Station
RCRA	Resource Conservation and Recovery Act
TTOP	Transition to Operations Plan
WBS	Work Breakdown Structure

DEFINITIONS

Shall, must, will, may, and should are used to define each individual requirement. The definitions of these terms are as follows:

- *Shall* – is a requirement that is binding and must be implemented
- *Must* – is an absolute, binding alternative to “shall” or “requirement”
- *Will* – is used to inform intent or declaration of purpose
 - This is not a requirement; the author must use the word ‘shall’ to indicate that a requirement is binding and must be implemented
- *May* – is used to indicate a desire or goal of a requirement
 - This can also be interpreted ‘as nice to have’ and is not binding
- *Should* – is used to indicate a desire or goal of a requirement
 - This can also be interpreted ‘as nice to have’ and is not binding

“Not” is used in combination with the above terms to indicate the opposite; that is, “shall not” and “must not” describe prohibited

CD-2

DOE Critical Decision 2 – Approve Performance Baseline

CD-4

DOE Critical Decision 4 – Approve Start of Operations or Project Completion

1. INTRODUCTION

This Instrument Systems Requirements Document defines the requirements for WBS level 2 Instrument Systems. These requirements derive from the *S01010100-SR0001 Second Target Station (STS) Project Global Requirements Document*. These requirements establish the basis for WBS level 3 requirements established by lead engineer and lead scientist for each of the instruments, by the lead engineer for the bunker and technical lead for scientific software.

2. SCOPE

STS Instrument Systems includes the design, construction, installation, system testing, and early commissioning of the neutron scattering instruments constructed within the STS Project. Neutron scattering instruments include:

1. Neutron optics that transport neutrons emitted from the moderator face to the sample position, shape the neutron beam, and, in some cases, polarize or analyze the polarization state of the neutron.
2. Neutron choppers that transmit selected neutron wavelengths and, in some cases, sharpen the neutron pulse.
3. Bulk shielding along the neutron beamline and caves around the end stations containing the sample areas and surrounding detectors to lower instrument backgrounds and reduce personnel dose rates. Other shielding is used internal to the instrument specifically for background reduction.
4. Neutron detectors that monitor the incident neutron beam and detect neutrons scattered by the sample.
5. Moving elements including detector and neutron optics movement, shutters, sample positioning and sample changing robots.
6. Instrument specific components such as vacuum vessels and their associated vacuum systems.
7. Infrastructure and utilities including electrical distribution, piping distribution fire suppression system, mezzanines, instrument control cabins, HVAC and Secondary Confinement Exhaust where required.

Instrument Systems will also provide the infrastructure necessary to ensure early science success of the constructed instruments which includes equipment in laboratory spaces for sample preparation/characterization/storage, scientific software for instrument calibration, (automated) data reduction and analysis, and initial sample environment equipment. Instrument Systems scope also includes in-monolith components and two near-monolith integrated shielding volumes (bunkers) to support the initial project-constructed instruments as well as support the eventual installation of the remaining beamlines.

3. REQUIREMENTS

The Instrument Systems requirements are listed in Table 1 below. Traceability (column 3 in Table 1) is referenced to project-level global requirements in Table 1 of *S01010100-SR0001 Second Target Station (STS) Project Global Requirements Document*.

Table 1. STS Instrument Systems Requirements.

ID	Requirement	Traceability
S.4-R01	<p>Instrument Systems shall provide 8 neutron instruments with world-leading science capabilities using cold neutrons with more than 10x gain relative to comparable First Target Station instruments.</p> <p><i>Note: The STS is designed to enable time-resolved measurements of kinetic processes and beyond-equilibrium matter, more intense neutron beams with smaller cross-sections, and simultaneous measurements over large ranges of length and energy scales. Where comparable, STS instruments shall provide improvements in science capabilities relative to their First Target Station counterparts by enabling >10x faster measurements, measurements of >10x smaller sample volumes, or accessing >10x larger range of length or energy scales simultaneously. Gains in these science capabilities can be achieved either singly or in combination through higher neutron source intensity or brightness, improvements in neutron transport, greater efficiency in measuring scattered neutrons, establishing new limits for extreme sample conditions, or reducing sample sizes.</i></p>	R4, R5
S.4-R02	<p>Instrument Systems equipment shall be designed to operate for a proton beam power of 0.7 MW at 15 Hz repetition rate.</p> <p><i>Note: The effects of a proton beam power increase from 0.7MW to 1.4MW on design and performance must be evaluated for all elements of the Instrument Systems that are intended to be permanently installed, i.e. those that are not expected to be removed or replaced for the lifetime of the facility, such as the Beamline Shielding, Monolith Inserts, and Bunker Shielding. The source of the power increase is not determined.</i></p>	R1,R2, R7, Section 5 of Global Requirements Document
S.4-R03	<p>Instrument Systems components shall be designed for a lifetime of at least 10 years.</p> <p><i>Note: Experience at the SNS First Target Station instruments has shown that instruments remain operational for at least 10 years. Typically, on about that time scale neutron instruments may require a significant upgrade. The STS facility is being designed to support >5000 hours per year of neutron production.</i></p>	R7, R8

ID	Requirement	Traceability
S.4-R04	<p>Individual instruments shall be designed to support $\geq 95\%$ availability of that instrument during beam operations.</p> <p><i>Note: Instruments require a high level of availability to support both time-sensitive measurements (e.g. sample ageing, stroboscopic and time-resolved measurements) and a user program with non-ORNL participants having dedicated times allotted for experiments. Also, many instrument systems such as choppers and optical systems remain in operational mode even when instrument shutters are closed during operations to facilitate sample changes. Such instrument equipment must be capable of operating throughout the 5000 hours of yearly planned STS facility operation.</i></p>	R8, R9
S.4-R05	<p>Instruments shall be capable of operating independently of one another without negatively impacting the performance of other instruments.</p> <p><i>Note: To maximize science productivity and operational flexibility, instruments must be capable of independent operation from both a safety perspective and the perspective of negatively impacting the performance of other instruments (e.g. changing neutron backgrounds or magnetic interference).</i></p>	R4, R6
S.4-R06	<p>Instruments Systems equipment shall be designed to be removable. The use of RCRA-listed materials and materials that activate with long-lived isotopes shall be minimized.</p> <p><i>Note: Flexibility for future instrument upgrades or replacement require that equipment, including shielding, be reconfigurable or replaceable.</i></p>	R7, (TBD for decommissioning)
S.4-R07	<p>Instruments shall be capable of remote operation.</p> <p><i>Note: While it is not reasonable to expect that challenging experiments will be done remotely (e.g. installing or using a non-standard or complex piece of sample environment equipment), instrument designs shall support off-site control of a series of standard data collection measurements.</i></p>	R4, R10
S.4-R08	<p>Instruments must be designed to operate safely and efficiently within the context of a user program.</p> <p><i>Note: The expectation is that these instruments will support science proposed by the user community. Often, non-ORNL researchers will be physically present and trained to operate the instrument.</i></p>	R2,R4, R10, R11
S.4-R09	<p>Instruments shall be designed to accept the neutron pulses from the moderator viewed by their specific beam port.</p> <p><i>Note: Detailed design of the instrument optics, especially within the monolith, is tightly integrated into a specific moderator design. Beamlines ST01, ST06, ST11, ST12, ST17, and ST22 view the tube moderator; the others view the cylinder moderator.</i></p>	R6

ID	Requirement	Traceability
S.4-R10	<p>Instrument Systems shall construct two near-monolith, integrated shielding volumes (bunkers) that will support an eventual 22 neutron beamlines.</p> <p><i>Note: Bunkers must provide adequate shielding to allow personnel to access the instrument halls near the bunker and the high bay in the Target Building during beam on. Removable shielding must provide the equivalent protection as the fixed shielding surrounding it.</i></p>	R2,R5, R6, R7, R8, R9, R11, (TBD for decommissioning)
S.4-R11	<p>The bunkers shall isolate the Target atmosphere from the instrument halls and end stations.</p> <p><i>Note: The Target Building ventilation system space, which includes the bunkers, is separated from the Instrument Halls, and the bunker serves as part of that boundary.</i></p>	R11
S.4-R12	<p>Instrument Systems' in-monolith equipment shall be designed for life-of-the-facility maintainability.</p> <p><i>Note: Such equipment will have a calculated lifetime of 40 years or greater but will be replaceable if beamline instrument needs change.</i></p>	R2,R7, R8, R9, R11, (TBD for decommissioning)
S.4-R13	<p>Instrument Systems must provide at least one monolith insert which can support a downward-directed neutron beam.</p> <p><i>Note: This requirement provides flexibility for future instruments and could be modified for additional custom beamports.</i></p>	R6
S.4-R14	<p>Instruments must be able to meet and maintain the alignment requirements required by their performance specifications for the lifetime of the instrument.</p> <p><i>Note: For some advanced neutron optic designs incorporating Kirkpatrick-Baez mirrors, installation accuracy requirements exceed the capabilities of current Survey & Alignment technologies and will likely require remotely adjustable optic supports. Maintaining installed optic conditions over time may require monitoring and/or adjustment or realignment capabilities.</i></p>	R4, R8, R9
S.4-R15	<p>Instrument Systems equipment shall be designed following all applicable standards for personnel safety.</p> <p><i>Note: Safety hazards will be evaluated within the framework of a formal hazards analysis identifying consequences, likelihood and proposed mitigation of hazardous events.</i></p>	R11

ID	Requirement	Traceability
S.4-R16	<p>Instrument Systems design shall limit radiation exposure in areas around the Instrument Systems portion of the STS that are accessible to personnel during beam-on and beam-off operations to less than 0.25 mrem/h in accordance with the STS Radiation Policy.</p> <p><i>Note: During beam-on operations, radiation levels in certain Instrument Systems areas are expected to be greater than this limit, but those areas would not be accessible while the beam is on.</i></p>	R11