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Experimental Facilities Division Installation, Commissioning, And Operations Plan (ICOP)

A U.S. Department of Energy Multilaboratory Project

SPALLATION NEUTRON SOURCE

Argonne National Laboratory • Brookhaven National Laboratory • Thomas Jefferson National Accelerator Facility • Lawrence Berkeley National Laboratory • Los Alamos National Laboratory • Oak Ridge National Laboratory

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EXPERIMENTAL FACILITIES DIVSIION INSTALLATION, COMMISSIONING, AND OPERATIONS PLAN

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Experimental Facilities Division Installation, Commissioning, and Operations Plan

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ACRONYMS

AE	architect/engineer
ARR	accelerator readiness review
ADS	Accelerator Systems Division
ASE	accelerator safety envelope
ASME	American Society of Mechanical Engineers
CD-4	critical decision-4
CF	Conventional Facilities
CLO	Central Laboratory Office (Building)
CM	construction manager
DOE	U.S. Department of Energy
ES&H	environment, safety, and health
FSAR	final safety analysis report
FTE	full-time equivalent
GC	general contractor
HVAC	heating, ventilating, and air conditioning
I&C	instrumentation and controls
IC	instrumentation contractor
IAT	instrument advisory team
IDT	instrument development team
IOC	input/output controls
MCC	motor control centers
ORNL	Oak Ridge National Laboratory
ORR	operational readiness review
PCES	primary confinement exhaust system
JPLC	programmable logic controller
PPS	Personnel Protection System
QA	quality assurance
RID	ring injection dump
RTBT	ring-to-target beam transport
SAD	safety assessment document
SANS	small-angle neutron scattering
SAR	safety analysis report
SC	safety class
SNR	startup notification report
SNS	Spallation Neutron Source
SOD	Site Operations Division
SS	safety significant
SSC	structures, systems, and components
SvT	Sverdrup
TSR	technical safety requirement
UPS	uninterruptible power supply
WBS	work breakdown structure
VFD	variable frequency drive
XFD	Experimental Facilities Division

1. INTRODUCTION

This report provides the Experimental Facilities Division (XFD) plan for achieving full-power operations of the Spallation Neutron Source (SNS) Target Facility. Commissioning of the target facility will begin in FY 06 and is planned as the culmination of a series of accelerator commissioning modules, starting with the front end.

This plan focuses on XFD efforts and addresses necessary interfaces with other groups within SNS and Oak Ridge National Laboratory (ORNL). Target Systems and Instrument Systems are both discussed. Necessary baseline utilities are assumed to be in place to support systems testing and integrated systems testing. It is also assumed that the accelerator ring-to-target beam transfer (RTBT) line will have been successfully commissioned through to the RTBT beam dump before target commissioning is initiated. Commissioning of the RTBT extension to the actual target interface will be completed concurrently with target commissioning. Accelerator commissioning is addressed in the SNS Accelerator Systems Commissioning Program Plan prepared by the Accelerator Systems Division (ASD).

To simplify the drive to full-power operations, the target will initially be operated as a "radiological facility" for the purpose of low-power testing. The target will be commissioned following an Accelerator Readiness Review (ARR) conducted under accelerator safety order, DOE Order 420.2A, *Safety of Accelerator Facilities*. During low-power operations, the target proton bombardment will be limited to maintain radionuclide inventories within the radiological facility classification.

During the-low power operations phase, data will be collected, performance will be assessed, and valuable operational experience will be gained. Concurrent with low-power operations, an operational readiness review (ORR), under DOE Order 425.1B, *Startup and Restart of Nuclear Facilities,* will be initiated to obtain approval for normal full-power operations. Information collected and experience gained during low-power operations will facilitate the ORR. Radionuclide inventories associated with full-power operations will exceed the radiological facility classification, requiring a hazard category 2 designation.

Installation of Target Systems monolith and hot cell equipment is addressed in Chapter 2. As components and systems are installed, they will be thoroughly tested, both individually and as integrated systems, as addressed in Chapters 3 and 4. As testing nears completion, the target ARR will be initiated with the goal of commissioning the target for low-power operations. The plan for successful completion of the target ARR is addressed in Chapter 5.

The next step in the process will be to have the target commissioned. Information obtained during target commissioning will be used to satisfy the project acceptance tests milestone, which will in turn provide the basis for the U.S. Department of Energy (DOE) to reach Critical Decision 4 (CD-4). Target commissioning and attainment of CD-4 is addressed in Chapter 6.

Chapter 7 addresses plans for low power operations as a radiological facility. During this phase, target operations will be limited and radionuclide inventories will be carefully tracked to ensure compliance with the radiological facility classification. Low-power operations will provide the opportunity to collect valuable information on system performance and to gain operating experience.

After low-power operations commence, the ORR will be initiated to obtain approvals to proceed to normal high-power operations. The plan for successfully completing the ORR is described in Chapter 8. Plans for reaching the desired high-power operations after successful completion of the ORR are described in Chapter 9.

Figure 1-1 shows the overall chronology of events necessary for achieving full-power operations. The schedule presented is consistent with both the Integrated Project Schedule and the Project Commissioning Strategy (as presented in the May 2001 DOE Review).

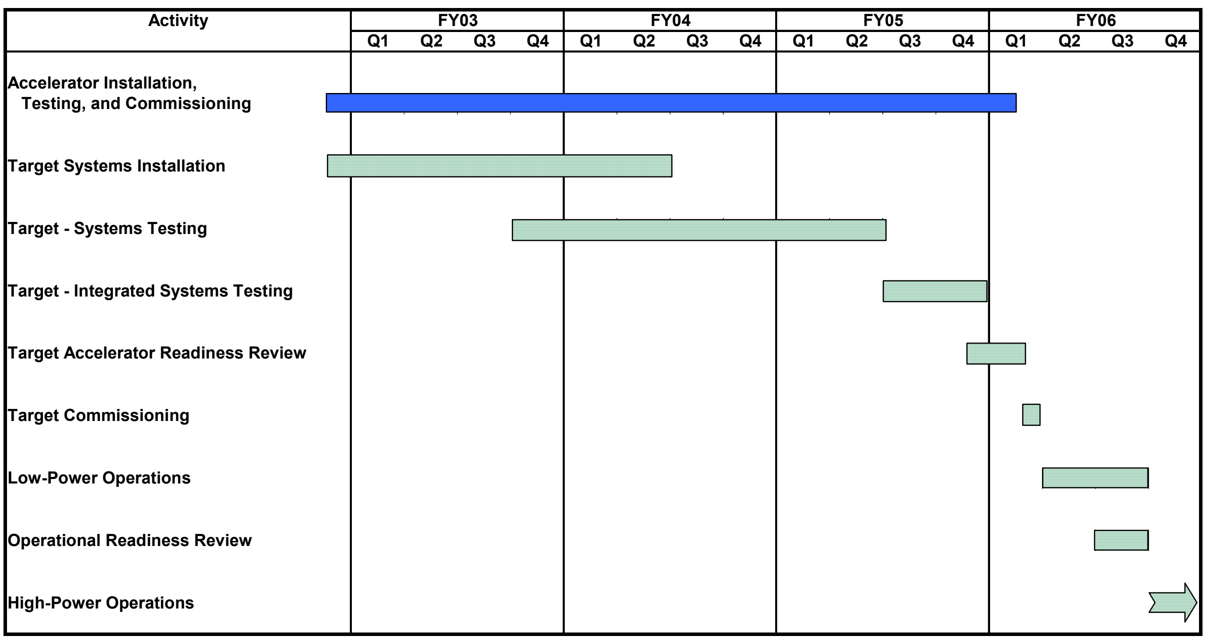


Fig. 1-1. Schedule for achieving full-power operations.

Instrument Systems will progress under a separate review and approval process that is mostly independent of the target commissioning process. At least one instrument (possibly a temporary instrument) must be installed, tested, reviewed, and approved for use in conjunction with target commissioning. Plans for installation, testing, readiness review, and commissioning are presented in Chapters 10 through 14. Instruments that are not needed for completion of target commissioning can be brought on-line after commissioning, and a separate readiness review will be held for each.

The Appendix addresses the interfaces between Target Systems and Instrument Systems. Interfaces between Target Systems and Conventional Facilities (CF) and between Target Systems and Accelerator Systems will be addressed in a later revision to this document.

This plan should be considered a "living document" and should be revised and updated periodically to incorporate comments and new information as it becomes available.

2. INSTALLATION

2.1 PURPOSE

The purpose of the installation planning described in this chapter is to ensure that the major installation activities necessary to complete target and support systems installation have been identified. Where applicable, the sequence of installation activities is specified. Careful planning and coordination of installation activities will be required to ensure that schedule and budgetary requirements are met. The target monolith, target assemblies, moderator systems, utilities, remote handling systems, instrumentation and controls, beam dumps, and conventional facilities are addressed.

2.2 SCHEDULE

Target Systems has several components required to be available in the December 2001 to January 2002 time scale. These are the bulk shield baseplate and liner, the two drain lines for the bulk shielding and core vessel, and the four water loop drain tanks located in the basement. The majority of the installation is linked to two main ready-for-equipment dates in the Integrated Project Schedule–ready for bulk shield installation (March 2003) and ready for hot cell equipment installation (July 2003). The installation runs for approximately one year in parallel with completion of the Target Building.

2.3 CRITERIA FOR SUCCESS

Detailed installation plans will specify methods of installation, tolerances, tests, and required inspections. Tests and inspections will be in accordance with the Target Systems Quality Assurance (QA) plan and will be documented and approved by the appropriate quality assurance representative and appropriate design organization representatives.

2.4 METHOD OF ACCOMPLISHMENT

The Target Building general contractor will perform the majority of the installation work for Target Systems. Exceptions to this include those components that will be replaced remotely in the future using specialized remote-handling equipment. For these components, plans are for SNS technicians toperform the operations. For some specialized work, an outside equipment vendor will either perform the work or provide on-site technical support. The installation work has been divided into seven main tasks, which follow.

1. Monolith–Nearly all components within the 400-in. diameter of the iron biological shielding such as the core vessel, bulk shielding, and neutron beam shutters.
2. Target assemblies–Mercury loop components and associated iron shielding located within the hot cell.
3. Moderator systems–Helium refrigeration system and hydrogen loop components.
4. Utilities–Three light water and one heavy water cooling loop; helium, nitrogen, and vacuum systems; and utilities for the 200-kW ring injection dump (RID).
5. Remote-handling systems–Crane, manipulators, and other specialized equipment.
6. Instrumentation and controls (I&C)–Safety class target protection system, safety significant systems, and all general I&C.
7. Beam dumps–The bulk shielding and beam stops for the three dumps.

2.4.1 Monolith

Assembly of these components is a complex operation and must be integrated with the installation of CF and placement of concrete. Detailed installation sequence planning has been started. The general sequence is as follows:

1. Bulk shield liner
2. Chopper region steel columns
3. High-density concrete collar
4. Core vessel support cylinder and lower shielding
5. Shutter guide rails and interstitial shielding
6. Core vessel inserts
7. Shutter gates, top blocks, and drives
8. Piping pan, utility connections, and shielding
9. Shine shield after testing

Figure 2.1 shows the monolith region after the start of step 4, which begins in March 2003.

Figure 2.2 shows the configuration after additional shielding, the lower outer support cylinder, and the middle section of the core vessel is installed. This section of the vessel is designed to be less then 50 tons and is installed through an open section of the roof.

After the middle section is installed, additional bulk shielding, vessel system shielding, the upper support cylinder, shutter guide rails, and shutter shielding is installed. Figure 2.3 shows the assembly ready for installation of the core vessel inserts.

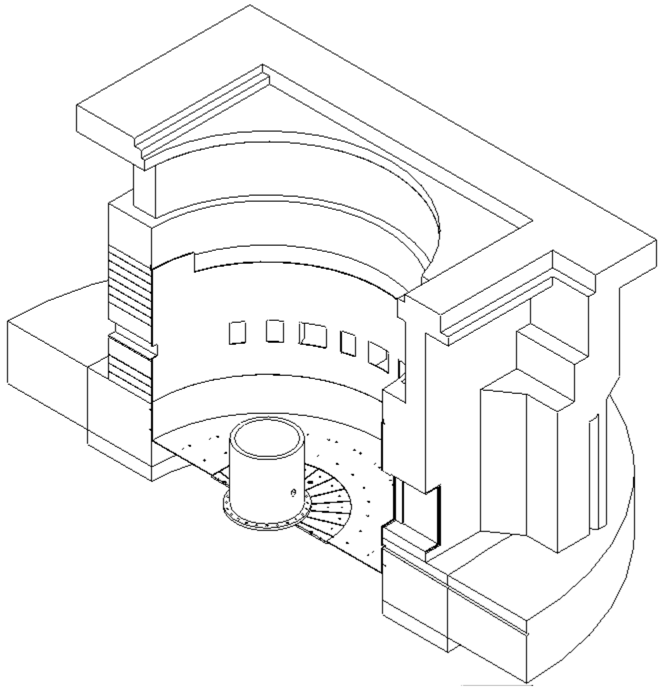


Fig. 2.1. Start of bulk shielding installation.

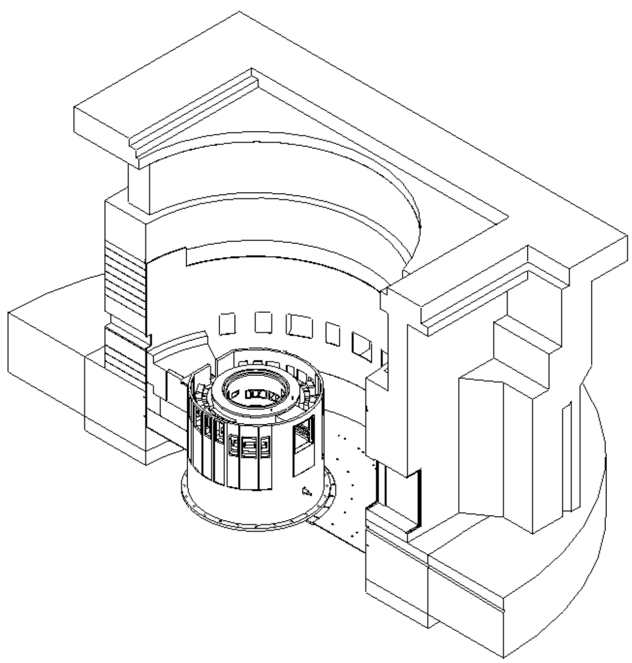


Fig. 2.2. 50-ton core vessel middle section, installed.

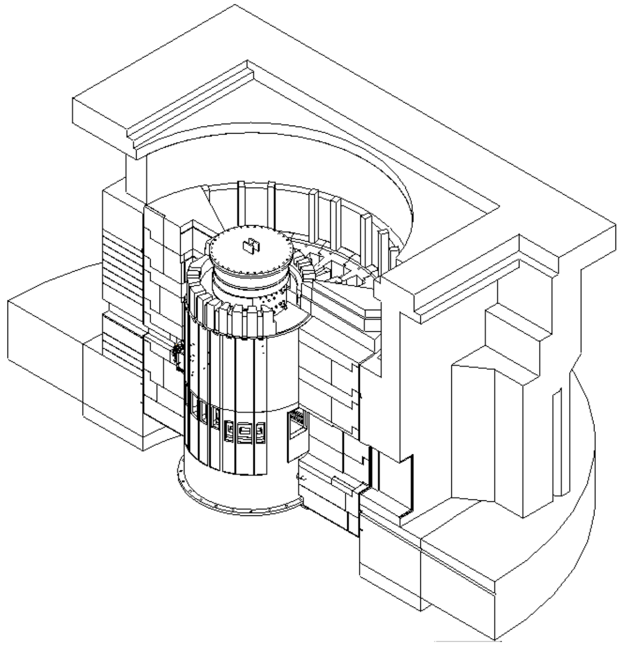


Fig. 2.3. Monolith without top blocks.

2.4.2 Target Assemblies

Installation of target system components in the hot cell begins after the cell is lined and the remote-handling crane is installed. This is scheduled for August 2003. It starts with the process system including mercury piping, the heat exchanger, pump, and process shielding. After the core vessel is installed in the monolith, the liner between the hot cell and the core vessel can be completed and rails to hold the carriage can be installed. The carriage is then built up, the drive installed, and after the remote-handling telemanipulator is available, the target module will be attached to the front of the carriage assembly. SNS technicians will perform this last operation.

This work can be subdivided into three major subtasks: (1) installation of the target cart, (2) installation of the process equipment/piping, and (3) the final alignment and mating of the piping in the cart and process loop. Work on the target cart requires activities in the hot cell and in the tunnel between the hot cell and monolith structure, while work on the process equipment takes place exclusively in the hot cell. The mating interface of the pipes for these two subsystems is in the hot cell.

The major equipment items to be installed under each subtask are listed subsequently in the recommended order that they are to be installed. Simultaneous work on the first two subtasks is possible, subject to work site scheduling and access limitations. The first two subtasks must be completed before the third is started.

Target Cart Assembly

- Tunnel cart rail supports and shielding
- Hot cell cart rail supports
- Target cart rails
- Cart drive rack assembly
- Cart base frame
- Cart piping
- Cart drive mechanisms
- Car shield blocks

Process Equipment

- Collection basin
- Storage tank
- Heat exchanger and supports
- Mercury pump
- Piping supports
- Mercury loop piping
- Utilities (water, gas, vacuum) piping and pipe supports

Final Alignment and Assembly

- Align flange connections between the mercury process loop and the target carriage
- Align flange connections between the utility piping and the hot cell penetrations
- Install shielding over and around the mercury and water process piping

The schedules for installing this equipment are to be coordinated with other related construction activities, namely, those of 1.6.6 Utilities, 1.6.7 Remote Handling, and 1.6.8 I&C.

2.4.3 Moderator Systems

This task includes installation of the 7.5-kW helium refrigerator system equipment and the hydrogen system equipment. The refrigerator components will be installed in the Target Building and in the Compressor Building; the hydrogen components will be installed in the Hydrogen Utility Room atop the RTBT tunnel.

The cold box (10 tons) will be placed on the RTBT shielding before the Target Building roof is finished using an external yard crane.

Helium piping will be welded and inspected according to the American Society of Mechanical Engineers (ASME) codes. The refrigerator vendor will perform equipment/instrument functionality tests after the installations are complete. Successful passing of these tests is required before the installations are considered completed and ready for turnover to SNS.

Equipment associated with moderator systems includes:

Helium Refrigerator System	Hydrogen System
Cold box	Heat exchanger module
Compressor	Pump module
Oil removal system	Gas handling module
Motor control center	Purge module
Helium piping	Storage vessel
Helium buffer tank	

2.4.4 Utilities

The Target Building general contractor (GC) will perform the target and beam dump utilities installation. The labor, materials, tools, equipment, and services furnished by the GC will be in strict accordance with the specifications and drawings provided in the WBS 1.6.6 construction package. The scope includes installation of cooling water, helium/nitrogen distribution, and vacuum systems. These installations will be coordinated with WBS 1.6.8, Instruments and Controls. Most of the equipment will be installed in the Target Building with the remainder installed in the Ring Injection Building.

This task includes the installation of government-furnished equipment (e.g., tanks, heat exchangers, ion exchange columns, filters, pumps, valves, condensers, collection pots, pipe spools, and helium panels). Special handling requirements will be identified.

Ensuring that the radioactive cooling water and water collection systems are fully drainable is a critical aspect of design and installation. Installation will require accurate sloping and/or alignment of tank nozzles and pipe spools that penetrate concrete. Construction sequencing and fixturing methods that facilitate accurate alignment will be employed. Where floors are sloped, tanks will be shimmed level. Anchor bolt locations for government-furnished equipment will depend on vendor information to be provided by the construction manager after equipment design approval.

Because of the nature of the technical components being served by the Utility Systems, cleanliness during construction and installation is critical. Many technical components are fabricated with narrow openings that may be obstructed by small particulates. Special care must be taken during all phases of construction to ensure that the installation process does not compromise technical component functionality.

The installer will make provisions for lifting the various components (up to 8 tons for certain ion-exchange columns) since the target utilities installations will be completed before the Target Building crane is available for use. Similar lifting is required for components in the ring injection beam dumps.

Examinations, inspections, and tests will be performed as specified in the construction package specifications. Welding and weld examinations and inspections shall be in accordance with the applicable specification sections and Division 18100A, *"General Welding Requirements for Target Building and Beam Dump Systems,"* of the construction packages being prepared by Knight/Jacobs. The successful passing of all tests, examinations, and inspections is required before the installations are considered completed and ready for turnover to SNS.

2.4.5 Remote-Handling Systems

The sequence of activities required for installation of remote-handling equipment in the target (hot) cell include the following:

- install the crane rails for the bridge crane,
- install the 7 1/2-ton crane,
- install the rails for the telemanipulator bridge transporter,
- install the transporter,
- install the remote-handling control room cabinets and related cabling, and
- install the video control consoles and related cabling.

The installer shall provide the labor, construction consumables, and the means for lifting since the building cranes will not be available to install most of this equipment. The heaviest lift will be the crane, weighing approximately 10 tons. The equipment outlined previously will be furnished by the SNS project, including the related wiring and cabling. The installer will route and pull the wiring and cabling provided by SNS and will make all terminal connections in the consoles and cabinets. SNS will provide detailed installation plans and on-site technical support from the manufacturers of the equipment.

There are no special assembly/installation tests to be performed by the installer, except to follow the manufacturer's installation instructions for the crane and telemanipulator. Integrated systems tests will be implemented by these equipment suppliers (for the crane, telemanipulator, and video systems) before the installations are considered completed and ready for turnover to SNS.

2.4.6 Instrumentation and Controls

A qualified instrumentation contractor (IC) selected by the SNS project will install the Target Systems instrumentation for utilities, the mercury loop, and the shutters. The GC will be directed by SNS to use the selected IC as a lower-tier subcontractor. The selection process for the IC will include unit pricing for installing instrumentation.

Target Systems will write task orders to the IC for the installation of various instrumentation components. SNS will procure instrumentation through Sverdrup (SvT), who will provide the instrumentation components to the IC.

The instrumentation installer will be responsible for mounting instrumentation on the process lines, wiring from the process elements to the transmitters, wiring from the transmitters to the cabinets, terminating the wires in the cabinets, and pulling and terminating Control Net and Device Net cables between cabinets and the motor control centers (MCC). The instrumentation installer will route and install inside cables to the instrumentation and between cabinets, test cable continuity to confirm proper termination, and fabricate pipe racks for mounting instrument transmitters. Drawings will be provided that show dimensions of the pipe racks and the locations of instrumentation on the pipe racks. Instrumentation air lines will be installed between solenoid valves and valve operators and between positioners and valve actuators. The instrumentation air lines will be field-routed in accordance with a general routing drawing. Conduit will be installed from instrumentation to penetrations inside the utility vaults, in the shutter drive room, and in the service gallery. Conduit in radiation areas will be coated with epoxy paint. Instrumentation and cabinets will be provided to the installer. A separate piping contractor will install process connections (i.e., wells) for instrumentation connections. The subcontractor will not be required to field weld anything other than pipe racks for mounting transmitters. The installer will purchase the specified cables. The instrumentation subcontractor will install and wire the variable frequency drive (VFD) for the mercury pump motor. The drive will be furnished by SNS.

The GC will route and terminate uninterruptible power supply (UPS) and auxiliary power cables to the programmable logic controllers (PLCs) and the input/output controls (IOC-EPICS) cabinets from the power panels. The motor power cables will terminate at the motor end. Under the CF contract with the GC, the GC will be responsible for routing electric power cables from MCCs to the motors; the power cables will be left coiled for later termination. Both the instrumentation installer and GC will develop cable pull schedules that will be reviewed and approved by the construction manager (CM) before cable installation. SvT will fabricate PLC and IOC cabinets and deliver them to the GC. The GC will install these cabinets and will route outside cables in the cable ducts.

Instrumentation installation includes the following activities:

1. Install target utility instrumentation on the process system in the utility vaults in the Target Building basement; inside the monolith at the inner inserts; and in the gas/liquid separator cavity, service gallery, hot cell, and helium panels in several locations in the Target Building.
2. Install mercury loop instrumentation on the process system in the hot cell.
3. Install target shielding instrumentation at the top of the shield stack in the monolith.

4. Install PLC/IOC cabinets in the Target Building control room, the basement near the utility vaults, the service gallery, and the high bay.
5. Install target protection system cabinets in the Target Building control room and the Central Laboratory/Office (CLO) Building target control room.
6. Pull outside cables from the Target Building to the CLO, to the RTBT Service Building, and to the Front-End Building.
7. Pull inside cables from the PLC cabinets in the Target Building to the Target Building control room, from power panels to the PLC cabinets, and from PLC cabinets to the MCCs.
8. Fabricate pipe racks for mounting instrumentation transmitters in the target basement, service gallery, and the high bay.
9. Install instrumentation air lines in the basement vaults and the hot cell.
10. Install conduit inside the utility vaults, in the shutter drive room, and in the service gallery.
11. Install the VFD for the mercury pump and pull and terminate power cables for the cabinet.
12. Install the nuclear facility safety significant cabinets in the Target Building control room and in the CLO target control room.

2.4.7 Beam Dumps

Installation for the ring injection, ring extraction, and linac dump consists of placing each array of 10-ton shielding blocks and the beam stops and enclosures. This will be done in conjunction with ring construction.

2.4.8 Conventional Facilities

CF will provide the Target Building structure and some of the infrastructure required to operate the target systems and neutron-scattering instruments. This includes providing the experimental facilities for the instruments, and meeting their space and utility requirements.

The Target Building consists of two functional areas: (1) the nonnuclear facility, which includes the experiment hall and associated neutron-scattering instruments and (2) the nuclear facility, which contains the target and mercury process loop, high bay, bulk shielding, maintenance hot cell complex, utility systems, and the waste-handling systems. For the nonnuclear facility areas, CF will provide the space and utility requirements for the scattering instruments. Within the nuclear facility portion of the Target Building, CF will provide proton beam line shielding and a hot cell complex used for the target systems. Additionally, the electrical; cooling; waste; and heating, ventilating, and air conditioning (HVAC) systems used to support the proton target, neutron moderators, and experimental facilities in an appropriately shielded and serviceable environment will be provided by CF.

2.5 RESOURCES REQUIRED

The GC will furnish the Davis-Bacon craft support required. Title III design support will be provided by XFD target design engineers. Installation of equipment using remote-handling devices will be done by SNS XFD technicians to gain experience for operations.

CF engineers will provide oversight of the CF installation, testing, and inspection program. Architect-engineer (AE)/CM personnel will provide project inspection of all subcontract and vendor installation, testing, and examinations required by the GC in checkout of CF. The vendors supplying the equipment will perform equipment testing.

3. SYSTEMS TESTING

3.1 PURPOSE

After installation, a series of systems tests will be conducted for each level 3 work breakdown structure (WBS) element under Target Systems (WBS 1.6) to confirm that components are correctly fabricated, assembled, and installed and that all equipment and components meet specified operational requirements. Systems Tests for a specific level 3 WBS element are independent of other level 3 WBS elements within Target Systems or any element within any other level 2 WBS system, such as Ring and Transfer Systems (1.5), Instrument Systems (1.7), CF (1.8), or Integrated Control Systems (1.9). Additionally, safety-significant and safety-class systems will be tested to demonstrate that they can perform their credited safety missions.

CF will complete systems tests on CF equipment but will not complete integrated systems testing before Target Systems testing is completed.

3.2 SCHEDULE

The schedule for Target Systems Tests is summarized in Fig. 3-1. This summary is taken from the SNS baseline detailed schedule for the Target Systems subproject (Ref. 3-1). In general, the systems tests commence with the end of installation for each system or assembly of components. The first element to undergo systems tests will be the beam dumps (WBS 1.6.9) in August 2003, and the final element will be remote handling (WBS 1.6.7) in March 2005. Following completion of the systems tests, integrated systemst Tests (Chapter 4) will be conducted.

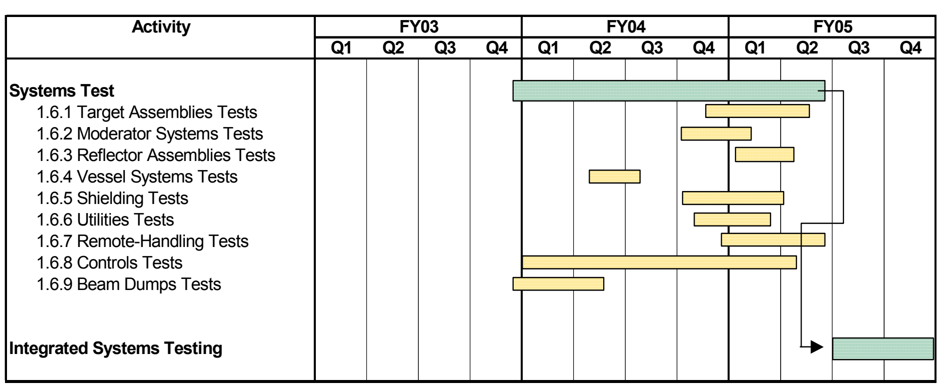


Fig. 3-1. Summary schedule for Target Systems tests.

CF equipment testing, installation testing, software testing, controls testing, and system balancing will occur during the construction contract period scheduled to be completed about December 2004. CF and Target Systems will coordinate test activities.

3.3 CRITERIA FOR SUCCESS/DELIVERABLES

Target Systems tests will be performed in accordance with written procedures, and the results will be documented. Procedures will include criteria or specified operating characteristics that must be met before completion of this phase of work. A listing of the systems tests for Target Systems level 3 WBS elements is provided in Table 3-1. The criteria are based on the list of parameters measured or features demonstrated, shown in Table 3-1. Target Systems tests that play a role in verifying a safety-significant or safety-class capability are also indicated in Table 3-1.

Examples of the types of parameters that will be measured or the features that will be demonstrated include:

- Performance characteristics and features of safety-significant or safety-class systems that have been credited in the safety analysis report for the target nuclear facility.
- Leak rates for vessels, enclosures, or fluid lines under pressurized and/or vacuum conditions.
- Flow rates and pressure drops for mercury and some portions of water flow systems.
- Demonstration of the operation of instrumentation, including software testing.
- Demonstration of the operation of valves, controls, mechanical, or hydraulic drive systems and remote handling of manipulators and tools.

The deliverable item from this phase of the project will be the documentation package containing the test procedures and test results.

Table 3-1. Systems tests for level 3 WBS elements under Target Systems

Level 3 WBS	Test description	Start	Finish	Parameters measured or features demonstrated
1.6.1 Target Assemblies		**8/23/04**	**2/22/05**	
	Target module leak tests at vacuum and max pressure			Leak rate in mercury vessel & water shroud
	Target plug leak tests at vacuum and max pressure			Leak rate
	Mercury loop leak and flow tests at vacuum and max pressure			Leaks, pressure drops, flow rates
	Instrumentation and controls checkout tests			Demonstrate/calibrate loop instrumentation
	Functionality test of target transport drive system			Traveling speed, positioning accuracy, & emergency stops
	Filling and draining of mercury process loop from storage tank			Demonstration of fill and drain and measurement of fill and drain times
	Flow to spill collection tank			Flow and residual fluid remaining [*Safety Significant (SS) mission]
1.6.2 Moderator Systems		**7/5/04**	**11/8/04**	
	Leak test H_2O & H_2 loops w/o moderator assemblies			Leak rates
	Flow tests for cryogenic loop w/o moderator assemblies			Flow rates, pressure drops
	Cryogenic moderator helium inerting system (SS)			SS mission: provide helium barrier, alarm annunciation if barrier not in place
	Heat load tests on cryogenic loop w/o moderator assemblies			Flow rates, pressure drops, and temperatures
1.6.3 Reflector Assemblies		**10/11/04**	**1/14/05**	
	Leak test water loops within reflector plugs			Leak rates
	Instrumentation and controls checkout tests			Demonstrate/calibrate loop instrumentation
1.6.4 Vessel Systems		**2/3/04**	**5/4/04**	
	Leak check core vessel drain line			Field welds
	Leak check core vessel			field welds between lower section and chimney
	Pressure test proton beam window after installation			Leak rate
	Core vessel confinement of spilled mercury (SS)			SS missions: confinement of spilled mercury and detection/annunciation of mercury spill inside core vessel (or in drain line)
	Overall vessel vacuum/helium inert environment			Leak rate
1.6.5 Shielding		**7/6/04**	**1/4/05**	
	Gas and vacuum leak tests on shells and liners			Leak rate
	Water leak tests on cooled components			Leak rates
1.6.6 Utility System		**8/6/04**	**2/14/05**	
	Water leak testing			Pressure decay
	Water tank calibrations			Volume as f(level)
	Water pump checks			Power, proper rotation, alignment/runout, vibration
	Vacuum system leak tests			Leak rates
	Pump down tests			Measure ultimate pressure
	Helium and nitrogen systems leak test			Leak rates
	Helium and nitrogen pressure regulation & distribution tests			Operability of valves and controls
1.6.7 Remote-Handling System		**1/17/03**	**3/22/05**	
	Hot cell manipulator function (6 systems)			Specified operating characteristics
	Hot cell closed circuit television (CCTV) Function (2 systems)			Specified operating characteristics
	Hot cell bridge crane function			Specified operating characteristics
	Hot cell gantry robot function			Specified operating characteristics
	Target module handling tool function			Specified operating characteristics
	Hot cell waste handling tool function (6 systems)			Specified operating characteristics
	Proton beam removal and installation			Specified operating characteristics
	Inner plug removal and installation			Specified operating characteristics
	Portable manipulator function			Specified operating characteristics
	Core vessel helium inerting system (SS)			SS mission for both helium and vacuum inerting modes: maintain inert atmosphere in core vessel, alarm annunciation when atmosphere not inerted
	Proton beam window and target plug seal pressurization systems (SS)			SS mission: maintain inert pressurized inflatable seals to support maintenance of core vessel inert atmosphere, alarm annunciation when seals not pressurized. Determine vacuum-off seal retention time for development of emergency procedures.
	Control system functional tests			Specified operating characteristics

1.6.8 Controls		**10/1/03**	**2/7/05**	
	Cable checkout			Connections
	Checkout tests for all Target Systems I&C			Software and logic tests
1.6.9 Beam Dumps		**9/12/03**	**2/24/04**	
	Test for leaks in ring injection dump (RID) beam stop			Leak rate
	Instrumentation and Controls checkout tests for RID			Demonstration and calibration of loop instrumentation

CF testing will be performed in accordance with approved plans and procedures specifying the testing. Results will be documented and records maintained per QA requirements. CF tests that play a role in verifying an SS or safety class (SC) capability are shown in Table 3-2.

Table 3-2. CF tests involving safety-related systems

Level 3 WBS	Test description	Start	Finish	Parameters measured or features demonstrated
1.8.x Conventional Facilities SS Components and Structures		**8/23/04**	**2/22/05**	
	Fires suppression system in hot cell (SS)			SS mission: automatic initiation of fog system at set point level
	Smoke detection system (SS mission)			SS mission: detection of smoke escaping from cell during off-normal PCES configuration(s)
	High bay crane (SS)			SS mission: TBD characteristics demonstrated
	Primary confinement exhaust system (PCES) (SS)			SS missions: inlet back-draft damper characteristics. Cell inflow and capture velocity adequate for normal and off-normal (or maintenance) configurations unless SS annunciator actuating, sounding evacuation alarm. Charcoal filters flow and mercury retention characteristics
	Hot cell stainless steel liner (SC)			SC mission: prevent escape of spilled mercury from the hot cell
	Bulk shield drain line termination (SC)			Safety class mission: prevent leakage of mercury collected in the fireproof, PC-3 seismic qualified drain cavity

3.4 METHOD OF ACCOMPLISHMENT

The Level 3 WBS Task Leaders for Target Systems will have primary responsibility for conducting Target Systems tests. The Task Leaders will also be responsible for preparing test procedures and documenting test results. To the degree that they are available, technicians and craft labor from the Nuclear Facility Operations Staff will be utilized. Using these staff members to support the Systems Tests is highly desirable to facilitate the transition to operations.

As discussed in Chapter 5, operation of the target with high proton beam power will quickly lead to buildup of radionuclide inventory within the target, and a corresponding designation of the target and supporting equipment and structures as a "nuclear facility." Safe operation during high power beam operation depends upon the credited safety-related (SC and/or SS) systems, structures, and components being able to perform their credited safety missions. Many of the safety significant and safety class systems will require testing during installation and testing in order to demonstrate that they can perform their credited safety missions. This testing, which is required to be completed prior to the readiness review for full power operation (Chapter 8), will be performed either as part of Systems Testing or Integrated Testing (Chapter 4), as appropriate for each system. Tests that play a role in verifying a SS or SC mission capability are indicated in Tables 3-1 and 3-2.

3.5 RESOURCES REQUIRED

An estimate of the resources required to conduct Target Systems tests was developed as part of the SNS baseline cost estimate for each level 3 WBS element of Target Systems (Ref. 3-1). These resources include engineering support, technician and craft labor support, and materials. The peak level of technician/craft staffing occurs in the first quarter of FY 2005 and is about 10 full time equivalents (FTEs). To the degree that they are available, technicians and craft labor from the Nuclear Facility Operations staff will be used. Using these staff members to support the systems tests is highly desirable to facilitate the transition to operations. In addition to the resources directly identified for systems tests, engineering support for these tests is included in a separate Title III support category for some level 3 WBS elements.

3.6 REFERENCES

3-1. SNS Project Schedule, Version SNS 8, Detailed Schedule, Target Systems, September 2001.

4. INTEGRATED SYSTEMS TESTS

4.1 PURPOSE

After completion of the systems tests on each level 3 WBS element under Target Systems (WBS 1.6), integrated systems tests will be conducted. These tests will confirm that systems are working in an integrated fashion to achieve the required performance levels. Integrated systems tests will verify that interfaces between level 3 WBS elements within Target Systems and interfaces between Target Systems and other level 2 WBS systems, such as Ring and Transfer Systems (1.5), Instrument Systems (1.7), CF (1.8), or Integrated Control Systems (1.9), are in place and functioning properly.

A listing of the integrated systems tests for Target Systems level 3 WBS elements is shown in Table 4-1. This table also identifies the parameters or features that will be demonstrated for each test.

Table 4-1. Integrated systems tests for Target Systems

WBS Element		Test description	Start	Finish	Parameters measured or features demonstrated
1.6.10	**Technical Support**				
1.6.10.4	**Integrated Systems Tests**		**4/5/2005**	**9/30/2005**	
		Seal between target assembly and core vessel			Leak rate
		Target module remote handling			Ability to perform key operations remotely
		Leak test of water lines and welded flange connections on core vessel			Leak test with and without water pressure in lines
		Funtionality of shutters			time, distance, controls
		Shielding effectiveness using gamma source			Dose rate
		Water flow distribution for all loops			Flow splits, pressure drops, I&C, functionality of water processing units
		Vacuum system			Vacuum to each component & interface with contaminated off-gas system
		Helium and nitrogen systems			Distribution of helium or nitrogen & interface to contaminated off-gas
		TPS & Nuclear Facility SS system			Cabling, logic, and instruments
		Target module remote handling			Remote performance of key operations
		Proton beam removal and installation			Operating time requirement
		Waste container handling cycle			Operating time requirement
		Target module disassembly			Operating time requirement
		Shutter removal and installation			Operating time requirement
		Inner plug removal and installation			Operating time requirement
		Portable manipulator positioning and integration			Operating time requirement
		Water filter removal and installation			Specified operating characteristics
		Ion exchange unit removal and installation			Specified operating characteristics
		Beam stop (RID) removal and installation			Specified operating characteristics
		Remote handling control system functional tests			Specified operating characteristics
		Control system links to other control systems			Specified operating characteristics

CF integrated system testing occurs after completion of preoperational testing. It verifies that systems operate as designed and in conjunction with other systems. An integrated system test plan will be generated and the Site Operations Division (SOD) will conduct the testing with assistance from the AE/CM. CF testing will not involve hydrogen, chemicals, or radioactive materials.

4.2 SCHEDULE

The schedule for the Target Systems integrated systems tests is identified in the summary schedule shown in Fig. 3-1. The information in this summary schedule is taken from the baseline detailed schedule for the Target Systems subproject (Ref. 3-1). The Integrated Systems Tests, which are isolated as a separate level 4 WBS element (WBS 1.6.10.4), commence with the completion of all Systems Tests. Target Systems Integrated Systems Tests start at the beginning of April 2005 and extend for six months. Following completion of the Integrated Systems Tests, the Target Accelerator Readiness Review (Chapter 5) for Target Systems will be conducted.

Conventional Facility Integrated System Testing begins near the end of CF construction and continues during Target Systems testing. Conventional Facilities and Target Systems will coordinate test activities.

4.3 CRITERIA FOR SUCCESS/DELIVERABLES

Integrated systems tests will be performed in accordance with written procedures, and the results will be documented. These procedures will include criteria or specified operating characteristics that must be met before completion of this phase of work. The criteria will be based on the parameters measured or features demonstrated listed in Table 4-1. Examples of the types of parameters that will be measured or features that will be demonstrated include the following:

- Performance characteristics and features of SS or SC systems that have been credited in the safety analysis report for the target nuclear facility.
- Water and vacuum leak rates.
- Water flow distribution, flow rates, pressure drops, and controls for all loops.
- Operation and performance of vacuum and gas distribution systems.
- Operation of the shutters and their controls.
- Ability to perform key operations using remote-handling equipment.
- Operating time requirements for remote-handling operations.
- Functional CF utilities and systems.

The deliverable items from this phase of the project will include a documentation package containing the test procedures and test results, as well as operating procedures (standard operating procedures, off-normal operating procedures, and maintenance procedures).

4.4 METHOD OF ACCOMPLISHMENT

The lead engineer, with support from the level 3 WBS task leaders for Target Systems will have primary responsibility for conducting these tests. The task leaders for interfacing level 3 elements will be responsible for preparing the test procedure and documenting the test results. To the degree that they are available, technicians and crafts from the Nuclear Facility Operations staff will be used to conduct these tests. Using these staff members to support the integrated systems tests is highly desirable to facilitate the transition to operations. The operating procedures will be developed by a cooperative effort between the Target Systems engineering staff and the Nuclear Facility Operations staff.

CF will be responsible for conducting CF integrated system testing and will coordinate with Target Systems and Instrument Systems as required.

4.5 RESOURCES REQUIRED

An estimate of the resources required to conduct these tests was developed as part of the SNS baseline cost estimate for Target Systems. These resources include engineering support, technician and craft labor support, and materials. The technician and craft support staffing needed to support integrated systems testing is 13 FTEs. To the degree thatthey are available, technicians and craft labor from the XFD Operations staff will be used. Using these individuals to support integrated systems testing is highly desirable to facilitate transition to operations.

Resources required to conduct the CF tests are included in FTEs allocated to SOD. Plans are to use engineers who will be part of the SOD so that they will be familiar with Target Building operations.

5. TARGET ACCELERATOR READINESS REVIEW

Before target commissioning and low-power operation, operation of the target and neutron experiment facilities in the Target Building will be evaluated to determine their readiness for this final stage of the SNS commissioning process. Since the Target Commissioning Review will be conducted under the accelerator safety order (DOE Order 420.2A), it will be referred to as the Target Accelerator Readiness Review (Target ARR). Operations will be limited during the target commissioning and low-power operations phase to ensure that radionuclide inventories do not exceed the limits for designation as a radiological facility. Subsequent high-power operations will require an ORR per DOE Order 425.1B for the target nuclear facility within the Target Building.

Table 5.1 summarizes the readiness jurisdiction in the Target Building. The neutron instruments and instrument hall and the accelerator RTBT line that extends into the Target Building will be considered part of the "accelerator" facility, the safety of which is ensured under DOE Order 420.2A.

5.1 PURPOSE

The purpose of the Target ARR is to verify the readiness to proceed with target commissioning and subsequent low-power operation, the last phase of commissioning of the SNS. The Target ARR should confirm, to the extent necessary, that

- construction is sufficiently complete,
- the necessary construction tests have been performed and accepted,
- the required safety-related systems are installed and operational,
- the relevant procedures have been approved,
- appropriate personnel have been assigned and adequately trained, and
- target commissioning and low-power operations are ready to proceed safely.

To ensure the success of the 425.1B-required ORR that must be completed before high-power target facility operation, the decision has been made that the Target ARR should meet the review content and criteria of a 425.1B ORR to the extent possible. This goal of documenting the review to the nuclear facility readiness format is applicable to the parts of the Target Building that will become an HC-2 nuclear facility during routine operation. In a similar vein, operations within parts of the facility that will become the target nuclear facility will, to the extent possible, be conducted within the technical safety requirements (TSRs) developed in conjunction with the target nuclear facility final safety analysis report (FSAR).

Table 5.2 provides a comparison of the 420.2A ARR criteria and the 425.1B ORR, which are similar. Addressing ORR requirements to the extent practicable, as part of the Target ARR, will support preparation for the ORR.

5.2 SCHEDULE

To meet the SNS internal schedule, the Target ARR must be finished by December 1, 2005. The ARR is expected to require four months, so it must begin no later than July 31, 2005.

To expedite the overall SNS schedule, the Target ARR will be divided into two phases: (1) Team Organization and Planning and (2) Basic Review. Phase one will begin approximately four to six weeks before the second phase. During this part of the review, the ARR team will organize itself and gather documentation to study and prepare for the second phase. In the second phase, the team will conduct the interactive portion of the review. Two prerequisites must be completed before beginning the second phase of the Target ARR:

- The target nuclear facility FSAR and TSRs must be completed by July 31, 2005 (because of the management decision that the commissioning and low power operations will be conducted under the TSRs to the extent practicable).
- Target management certifies on or before August 8, 2005, that the target facility is ready to begin commissioning.

5.3 CRITERIA FOR SUCCESS / DELIVERABLES

The detailed criteria for success will be established in the Target ARR Preparation Plan to be developed. The plan will provide a detailed matrix of criteria, requirements, and deliverables. The plan will clearly define the success criteria for each readiness criterion and will allow line management sufficient time to ensure that the facility is ready to be commissioned before the Target ARR is conducted. The plan will be based, in general, on the guidance of the draft *Accelerator Safety Implementation Guide for DOE Order 420.2A, Safety of Accelerator Facilities* (August 2001). The plan will include a matrix of criteria in the following four categories:

- Documentation
- Equipment
- Training
- Personnel

Table 5.2 lists the general criteria from which specific, detailed acceptance criteria and deliverables definitions will be developed.

5.4 METHOD OF ACCOMPLISHMENT

The Target ARR will be conducted in a manner similar to that of the other accelerator ARRs (front end, linac, ring, etc.) that will be completed before the Target ARR begins. In fact, the generic readiness assessment areas that will already have been evaluated in the various accelerator ARR segments will considerably aid the target commissioning ARR. For example, the generic training, radiation protection, configuration control, and work control areas of readiness will be directly applicable to supply the same need for the Target Building.

As with any readiness review, preparation will be the key to success. Target operations will begin working toward commissioning preparation during preparation of the detailed Target ARR Preparation Plan. The plan will define the milestones to be completed and the evidence files to be documented before the commissioning review.

Selection of personnel for the Target ARR will be important to ensure a complete and thorough review. It would be desirable to use part or all of the ARR team from the linac, ring, and RTBT (Phase A) ARRs. A few additional types of expertise will be needed for the target commissioning ARR. Individuals familiar with operation of neutron targets, hot cells, and neutron instruments will be needed. In addition, although the target will not be a nuclear facility during commissioning and low-power operation, the ARR team should be supplemented by one or two individuals experienced in the implementation of DOE Order 425.1B.

5.5 RESOURCES REQUIRED

An independent team of subject matter experts will conduct the readiness review. Their time and travel expenses must be covered in the budget for readiness reviews. SNS operational; design; quality; environmental, safety, and health (ES&H), and other staff must stand ready to provide information to the ARR committee.

Table 5-1 Readiness jurisdiction for the Target Building
(DOE Order 420.2A, *Safety of Accelerator Facilities* or
DOE Order 425.1B, *Startup and Restart of Nuclear Facilities*)

Part of Target Building[a]	Target Commissioning	Target Routine Operation
RTBT in Target Building	420.2A	420.2A
Target bulk shielding monolith shutters	420.2A	420.2A
Mercury process system, hot cell equipment, related support systems, and I&C, including Target Protection System	420.2A	425.1B – Nuclear facility
Cooling systems in basement	420.2A	425.1B – Nuclear facility
Core vessel equipment	420.2A	425.1B – Nuclear facility
Neutron beam lines	420.2A	420.2A
Personnel protection system	420.2A	420.2A
Neutron instrument enclosures	420.2A	420.2A

[a] The target nuclear facility includes the mercury target and surrounding core vessel, the hot cell, and its supporting facilities in the basement and high bay. The balance of the Target Building (e.g. the neutron instruments and the part of the accelerator RTBT line that extends into the Target Building) is by definition part of the accelerator facility.

Table 5-2. Comparison of ARR (Order 420.2A) and ORR (Order 425.1B) criteria

Category	ARR Criteria (paragraph numbers from the DOE Order 420.2A draft guidance issued 8/2001)	ORR Criteria (paragraph numbers from DOE Order 425.1B, Attachment 1 Contractor Requirements Document)
Documents	III.C.1.a An Accelerator Safety Envelope (ASE) has been developed in accordance with DOE Order 420.2A.	2.d (7) Facility Safety documentation is in place and has been implemented that describes the "safety envelope" of the facility. The safety documentation should characterize the hazards/risks associated with the facility and should identify preventive and mitigating measures (systems, procedures, administrative controls, etc.) that protect workers and the public from those hazards/risks. Safety structures, systems, and components (SSCs) are defined and a system to maintain control over their design and modification is established.
Documents	III.C.1.b. The ASE has been reviewed by an independent safety review system internal to the contractor's organization. The results of that review have been received by contractor management and considered.	2.d (7) See above for text.
Documents	III.C.1.c. DOE has approved the ASE for the proposed activity or, as a minimum, has received the proposed ASE for approval.	2.d (7) See above for text.
Documents	III.C.1.d. The procedures addressing ASE required equipment and systems specify the minimum necessary system components and monitoring devices to allow operation. In the event these minimums are not met, actions are specified.	2.d (7) See above for text.
Documents	III.C.2.a A Safety Assessment Document (SAD) (or its equivalent) exists, has been reviewed by the contractor's internal independent safety review system, and management has adequately addressed the comments and recommendations resulting from that review.	2.d (7) See above for text.
Documents	III.C.2.b Contractor management has documented its conclusion that the activity analyzed in the SAD is an accurate evaluation of the ES&H consequences of undertaking the activity, and that the mitigated risks of the activity to employees, the public, and the environment are acceptably low.	2.d (9) The facility systems and procedures, as affected by facility modifications, are consistent with the description of the facility, procedures, and accident analysis included in the safety basis.
Documents	III.C.3.a. Procedures necessary for safe operation of	2.d (10) Adequate and correct procedures

Category	ARR Criteria (paragraph numbers from the DOE Order 420.2A draft guidance issued 8/2001)	ORR Criteria (paragraph numbers from DOE Order 425.1B, Attachment 1 Contractor Requirements Document)
	the activity have been developed, reviewed, verified (by performance where applicable), and approved.	and safety limits are in place for operating the process systems and utility systems that include revisions for modifications that have been made to the facility.
Documents	III.C.3.b. A procedure control system has been established which defines the processes for procedure preparation, review, approval, verification, distribution, and training.	2.d (1) Line management has established programs to ensure safe accomplishment of work (the authorization authority should identify in the plan of action those specific infrastructure programs of interest for the startup or restart.) Personnel exhibit an awareness of public and worker safety, health, and environmental protection requirements and, through their actions demonstrate a high-priority commitment to comply with these requirements.
Documents	III.C.3.c. Maintenance activities involving the safety aspects of the activity being reviewed have been identified and maintenance procedures for these activities have been developed, reviewed, verified, and approved.	2.d (1) See above for text of this paragraph.
Documents	III.C.3.d. There is a system for assuring that procedures for safety-related operations and maintenance are kept current.	2.d (1) See above for text of this paragraph.
Documents	III.C.3.e. Procedures to deal with off-normal and emergency situations have been prepared and are approved for use.	2.d (11) A routine drill program and emergency operations drill program, including program records, have been established and implemented.
Documents	III.C.4.a. Facility management has required a review to be made of the activity's conformance to applicable ES&H requirements.	2.d (14) Formal agreements between the operating contractor and DOE have been established via the contract or other enforceable mechanism to govern the safe operations of the facility. A systematic review of the facility's conformance to these requirements has been performed. These requirements have been implemented in the facility, or compensatory measures are in place and formally agreed to during the period of implementation. DOE approves the compensatory measures and the implementation period.
Documents	III.C.4.b. Nonconformances have been identified and schedules and resources for achieving compliance have been established and approved by the appropriate level of management.	2.d (15) A feedback and improvement process has been established to identify, evaluate, and resolve deficiencies and recommendations made by oversight groups, official review teams, audit organizations, and the operating contractor (e.g., DOE Policy 450.5 *Line*

Category	ARR Criteria (paragraph numbers from the DOE Order 420.2A draft guidance issued 8/2001)	ORR Criteria (paragraph numbers from DOE Order 425.1B, Attachment 1 Contractor Requirements Document)
		Environmental, Safety, and Health Oversight).
Documents	III.C.4.c. There is a process for reviewing changes to the proposed activity for impacts on hardware, procedures, training, and unreviewed safety issues.	
Documents	III.C.4.d. Processes exist for evaluating the readiness of radiological control measures and other ES&H items applicable to the proposed activity.	
Documents	III.C.5.a. A process exists to identify, evaluate, and resolve findings made by internal and external oversight and audit groups.	2.d (15) A feedback and improvement process has been established to identify, evaluate, and resolve deficiencies and recommendations made by oversight groups, official review teams, audit organizations, and the operating contractor (e.g., DOE Policy 450.5 *Line Environmental, Safety, and Health Oversight*).
Documents	III.C.5.b. Previous findings made by internal and external oversight and audit groups, including prior Accelerator Readiness Reviews of the accelerator, which are relevant to the activity under review, have been satisfactorily completed or have corrective actions underway. ("Observations" do not require action on the part of the contractor.)	
Hardware	III.D.1.a. Equipment and systems having safety importance meet criteria described in the SAD and have been appropriately tested. This includes, but is not limited to: - Shielding - Electrical system isolation - Protection against credible fires - Protection from oxygen-deficient environments - Cryogen storage, transfer, and use - Beam transport - High-power beam dumps - Personnel protection systems, including secured area interlock system - Fixed and portable radiation monitoring equipment - Other instrumentation for monitoring equipment - Other instrumentation for monitoring safety and health conditions	

Category	ARR Criteria (paragraph numbers from the DOE Order 420.2A draft guidance issued 8/2001)	ORR Criteria (paragraph numbers from DOE Order 425.1B, Attachment 1 Contractor Requirements Document)
	- Systems for controlling environmental, safety, and health parameters	
Hardware	III.D.1.b. The results of testing conducted to confirm the readiness of hardware to undertake the activity safely have been documented, evaluated to ensure adequacy, and meet quality assurance requirements.	
Hardware	III.D.2.a. A program is in place to periodically reconfirm the status and operability of hardware systems having safety importance.	2.d (8) A program is in place to confirm and periodically reconfirm the condition and operability of safety SSCs. This includes examinations of records of tests and calibration of these systems. The material condition of all safety, process, and utility systems will support the safe conduct of work.
Hardware	III.D.2.b. The performance of the physical systems that provide assurance of the viability of the ASE and that maintain the activity within the Operations Envelopes (when used), have been verified, and records of appropriate tests and calibrations of these systems exist and are current.	2.d (12) An adequate startup or restart program has been developed that includes plans for graded operations and testing after startup or resumption to simultaneously confirm operability of equipment, the viability of procedures, and the performance and knowledge of the operators. The plans should indicate validation processes for equipment, procedures, and operators after startup or resumption of operations including any required restrictions and additional oversight.
Personnel	III.E.1.a. Training and qualifications programs have been established for general safety orientation, accelerator operations personnel, maintenance and support personnel, experimenters using the facility, and emergency responders. These training and qualification programs are documented and encompass the range of duties required to be performed in accordance with the SAD.	2.d (3) The selection, training, and qualification programs for operations and operations support personnel have been established, documented, and implemented. The selection process and applicable position-specific training for managers ensure competence commensurate with responsibilities. (The training and qualification program encompasses the range of duties and activities required to be performed.)
Personnel	III.E.1.b. A process to evaluate training program effectiveness on a periodic basis has been established and documented and specifically includes the following considerations: [1] Classroom and individualized instruction are appropriate for the facility, and facility management periodically evaluates instructor performance.	2.d (4) Level of knowledge of managers, operations, and operations support personnel is adequate based on reviews of examinations and examination results and selected interviews of managers, operating, and operations support personnel.

Category	ARR Criteria (paragraph numbers from the DOE Order 420.2A draft guidance issued 8/2001)	ORR Criteria (paragraph numbers from DOE Order 425.1B, Attachment 1 Contractor Requirements Document)
	[2] A systematic evaluation of training program effectiveness, including feedback from job performance, is used to ensure the training program conveys all the required skills and knowledge. [3] The personnel protection training program is specific to the facility's hazards and provides the knowledge and skills necessary for individuals to perform their assigned job functions while avoiding exposure to specific facility hazards such as high voltage, cryogens, and oxygen deficient environments, and minimizing their exposure to radiation and chemicals. [4] Training and qualification of personnel has been achieved.	
Personnel	III.E.2.a. The numbers of trained and qualified operations, maintenance and support persons meet SAD or ASE requirements.	2.d (2) Functions, assignments, responsibilities, and reporting relationships [including those between the line operating organization and Environment, Safety and Health (ES&H) support organizations] are clearly defined, understood, and effectively implemented with line management responsibility for control of safety. 2.d (6) Sufficient numbers of qualified personnel are available to conduct and support operations. Adequate facilities and equipment are available to ensure operational support services are adequate for operations. (Such support services include operations, training, maintenance, waste management, environmental protection, industrial safety and hygiene, radiological protection and health physics, emergency preparedness, fire protection, quality assurance, criticality safety, and engineering).
Personnel	III.E.2.b. Individual assignments, responsibilities, authorities, and reporting relationships are defined, documented, and included in training.	2.d (1) Line management has established programs to ensure safe accomplishment of work (the authorization authority should identify in the plan of action those specific infrastructure programs of interest for the startup or restart). Personnel exhibit an awareness of public and worker safety, health, and environmental protection requirements and, through their actions, demonstrate a high-priority commitment to

Category	ARR Criteria (paragraph numbers from the DOE Order 420.2A draft guidance issued 8/2001)	ORR Criteria (paragraph numbers from DOE Order 425.1B, Attachment 1 Contractor Requirements Document)
		comply with these requirements.
Personnel	III.E.2.c. Qualifications or exceptions to specified areas of training, based upon education or experience and have been granted and documented by a designated contractor manager.	2.d (4) Level of knowledge of managers, operations, and operations support personnel is adequate based on reviews of examinations and examination results and selected interviews of managers, operating, and operations support personnel.
Limited applicability to a new facility.		2.d (5) Modifications to the facility have been reviewed for potential impacts on training and qualification. Training has been performed to incorporate all aspects of these changes.
Not applicable to a research machine: SNS Work Smart Standards will not include DOE Order 5480.19, *Conduct of Operations*.		2.d (13) The formality and discipline of operations is adequate to conduct work safely, and programs are in place to maintain this formality and discipline (e.g., DOE Order 5480.19).

6.0 TARGET COMMISSIONING / CD4

6.1 PURPOSE

The purpose of the target commissioning phase is to demonstrate operability of the SNS facility to DOE. Information obtained in target commissioning will be used to satisfy the project acceptance tests milestone, which will provide the basis for DOE to reach CD-4. CD-4 is a level 0 milestone, which designates that the project has been completed. For Target Systems, the pertinent CD-4 criterion is that SNS produces moderated neutrons at or above a determined flux per incident proton.

6.2 SCHEDULE

Target commissioning is expected to require one month. The project is obligated to complete target commissioning by June 2006, but the internal SNS goal is to finish this activity by December 31, 2005. Therefore, to meet the internal schedule, commissioning should begin December 1, 2005.

Before initiating target commissioning, both the target and accelerator must be ready to begin integrated operation. Readiness of these systems will be determined by successful completion of two independent activities: (1) the Target ARR and (2) the initial RTBT commissioning (addressed in the ASD Commissioning Plan). Successful completion of the Target ARR will demonstrate that both the XFD systems and staff are prepared for the target to receive the high-energy proton beam.

Commissioning of the initial RTBT will be the final in a series of accelerator segments to be commissioned before the beam is transported to the target. Upon completion of the Target ARR and with the approval of SNS management, all prerequisites to final RTBT and target commissioning will have been met and target commissioning can begin. Target and final RTBT commissioning will be done concurrently. This project phase will constitute the first fully integrated operation of the SNS as a combined accelerator/target facility. Integrated operations will require careful coordination between target and accelerator personnel. A detailed integrated commissioning plan will be developed that ensures a coordinated team approach to completing required target/RTBT commissioning activities.

6.3 CRITERIA FOR SUCCESS/DELIVERABLES

One DOE level 0 milestone and two DOE level 1A milestones are associated with target commissioning. Initiation of target commissioning meets the level 1A milestone "Start Target Commissioning." Completion of this milestone is defined as the issuance of a memorandum, with supporting technical documentation to the project office. Completion of commissioning provides the last component of the level 1A "Project

Acceptance Tests" milestone. The criteria for the performance test is to demonstrate that a pulse of 1×10^{13} protons can be transported to the target and that there is an integrated neutron flux of 5×10^{-3} neutrons per steradian solid angle per incident proton measured viewing a moderator face. Completion of the "project acceptance tests" is a prerequisite for CD-4. CD-4 is defined as a secretarial decision memorandum from DOE confirming the completion of the milestone.

In addition to the basic physical measurements needed to confirm that performance meets CD-4 criteria, other measurements and observations will be made during target commissioning. Even though these will not be formal commitments or deliverables, a considerable amount of valuable information can be gained during initial operations with regard to areas such as preliminary shielding assessments and target systems behavior.

6.4 Method of Accomplishment

As stated previously, for target commissioning to begin, systems for both the target and accelerator must be fully operational, and operations staffs must be ready.

Operation of the Target Systems will be conducted under the FSAR. Although the facility is being designed to ultimately operate as a hazard category 2 nuclear facility, for target commissioning the facility will be operated as radiological facility. Even though the XFD target and support systems will initially be approved for operation as a radiological facility, it is intended that all safety related structures, systems, and components (SSCs) necessary for a category 2 nuclear facility will be in place and fully functional at this time. The accelerator safety envelope developed for target commissioning and low-power operations will specify how operations will be restricted to keep the facility within the radiological facility category.

All testing will be performed according to approved plans. The highest-level plan will be a written Target Commissioning Plan describing the activities throughout the entire phase. The next and most detailed plans are test plans. Specific tests or groups of tests will be performed according to a written plan. Test plans will describe how the accelerator beam and target systems will be operated and what data will be collected. The plans will include a proposed time line for each test. If multiple tests occur simultaneously, the interactions and interfaces will be described.

For the first operations, it is expected that the proton beam will be at full acceleration voltage but with a low intensity and low pulse rate frequency. The first beam may be delivered on a pulse-on-demand basis. With each pulse, target parameters, neutron production measurements, and radiation measurements can be observed. Beam on target can be suspended as necessary in response to unexpected conditions.

Striking the target with high-energy protons for target commissioning will provide the first opportunity to assess the adequacy of radiation shielding. Radiological surveys of areas in and around the Target Building will be conducted. It will be important to determine both prompt radiation and residual radiation. Prompt radiation is directly associated with each pulse and residual radiation is caused by the build up of radioactive isotopes. Most residual radiation will be associated with the target. Even though the target commissioning phase will be short in duration and will be done with proton pulses and duty cycles much less than maximum, the radioactive isotope inventory in the mercury will be substantial. Radiation levels from the mercury target material may become large enough to begin to identify shielding deficiencies if they exist.

Radiation instruments will be in place to remotely measure radiation levels around the target. Detailed radiation surveys with hand-held instruments will be conducted. The first areas to be measured will be those that are to be occupied during commissioning operations. When it is determined to be safe for personnel to be in place, personnel may then occupy the areas. If shielding problems are discovered, operations will be adjusted as appropriate to provide protection for personnel.

The radiation survey process will continue beyond the target commissioning phase through operating phases. As the proton current to the target increases and as the radioactive inventory increases, both prompt and residual dose rates will increase to maximum levels. Shielding will be evaluated throughout these phases.

It is essential that direct communications exist between the accelerator and experimental facility groups. The protocols for beam operation will be determined and documented before the initiation of testing. Operational protocols will be strictly followed. For commissioning activities it is also essential that there is direct communications between health physics personnel measuring radiation fields and the control room operators.

The neutronic effectiveness of the target, moderator, and reflector assembly will be verified by measuring the brightness of a moderator face using standard neutron beam monitor detectors in one of the neutron beam lines. Time-of-flight detectors will be calibrated using simultaneous foil activation measurements. The results will indicate the energy-dependent spectral brightness of the moderator over the energy range accessible to the neutron-scattering instruments. To satisfy the requirements associated with CD-4, we plan to demonstrate that the spectral brightness meets or exceeds the spectral brightness associated with a 1-eV moderator coupling of 5×10^{-4} neutrons per steradian per electron volt per proton incident upon the target and a Maxwellian flux distribution with a thermal ratio of 0.5 at a spectral temperature appropriate to the moderator.

6.5 RESOURCES REQUIRED

Target commissioning will require a fully integrated effort from SNS personnel. Accelerator Systems, Site Operations, ES&H, and Experimental Facilities will function together to safely produce spallation neutrons. XFD control room operators will be on 24-hour shift coverage, as needed to support tests, measurements, and commissioning activities.

7.0 LOW POWER OPERATIONS

7.1 PURPOSE

The purpose of this phase is to operate the facility at low power to gain operational data and operating experience. Information collected during low-power operations will be used to facilitate the ORR and to assess the performance of various systems and operating procedures. The ORR will be facilitated by the opportunity to evaluate information and experience based on genuine operations, rather than predicted operational scenarios. Operating at low power will provide the opportunity to gain valuable experience before the SNS becomes a nuclear facility.

7.2 SCHEDULE

Low-power operations will occur after successful completion of target commissioning and DOE rendering CD-4. Based on the internal SNS goal of finishing target commissioning in December 2005, low-power operation will begin early in January 2006.

Low-power operations are expected to continue for six months and will end with successful completion of the ORR. The ORR (addressed in Chapter 8) will be conducted during the latter portion of the low-power operations phase and must be completed before high-power operations.

7.3 CRITERIA FOR SUCCESS/DELIVERABLES

The following four criteria for success have been identified for the low-power operations phase:

1. SNS is operated at low power in a safe and efficient manner in compliance with applicable requirements.
2. Appropriate operational and experimental data are collected to facilitate the successful completion of the ORR.
3. Appropriate operational and experimental data are collected to assist in the preliminary performance testing of the accelerator, target, instrument, shielding, dose rates, etc.
4. Operational experience is gained to facilitate a smooth transition to high-power operations.

Ultimately, successful completion of the ORR (Chapter 8) will be the formal deliverable. Conducting operations at low power will provide valuable information to facilitate the readiness review process and preliminary systems assessments. Such information will concern both the performance of the experimental facilities systems and the effectiveness of the operations personnel and strategies. Routine and preventive maintenance activities will begin. Such activities will demonstrate that the infrastructure and discipline are in place to maintain configuration control, manage work activities, conduct proper waste handling, provide contamination control, and manage other essential program elements that will be evaluated in the ORR.

Other areas for which there are no formal deliverables but for which operational experience and information is necessary to bring the SNS to full power operations are discussed subsequently.

7.3.1 Accelerator Operations

Operational knowledge and experience will be gained with the accelerator systems during this period. Although beam will have been delivered to the target in the target commissioning phase, in this phase additional work will be done with the integrated accelerator system. Throughout this phase, the average proton power to the target will remain well below the 1.4-MW nameplate rating, but the energy of individual proton pulses striking the target could approach the maximum of 25 kJ/pulse. The primary limit to beam operation to the target is to keep the production of radioisotopes below the inventory threshold for hazard category 3.

Period of low-power operations will be devoted to establishing a more complete understanding of the accelerator systems without using the target. In these studies the beam will be directed to one of the linac, injection, or extraction dumps. Accelerator operation will deal primarily with beam tuning and loss minimization efforts. Some work will be done at low intensity on beam losses, but some short periods of high beam power will be required to measure small beam losses.

7.3.2 Target Measurements

Because of the low-power nature of this operating phase, it is unlikely that the power-handling systems can be tested; however, measurements of the impact of the pressure wave induced in the mercury during each pulse can be made. The initial target module will be instrumented with a set of fiber-optic strain gauges that will provide valuable information that can be compared with design analysis predictions. These data can be used to update fatigue lifetime predictions and could lead to target module design improvements.

Operations during this phase will also be used to verify the following to the extent possible with low-power operation:

- shielding effectiveness;
- performance of the beam diagnostics module used to protect the target from overly focused beam profiles;
- release of radiolysis products (oxygen and hydrogen) from the primary water loops to either confirm that the delay and release system will be adequate at full power or to identify needed upgrades as early as possible;

- parameters such as flows and temperatures for the mercury, water, and supercritical hydrogen loops; and
- neutron production performance of the moderators.

7.3.3 Instrument Commissioning

Commissioning activities for some of the instruments will begin during the low-power operation phase. Each instrument will proceed through commissioning at its own pace as appropriate (see Chapters 10 through 14). Commissioning for each instrument will begin with verification of correct instrument operation with beam. This includes tests with known scattering samples to ascertain that time-of-flight timing of neutrons is working correctly. Further tests with known scattering samples will be used to verify instrument resolution. Periods of no beam between such tests will be useful to allow for analysis of the test results and to carry out any instrument modification needed to remedy unsatisfactory results.

Once these basic instrument functions are established, we will begin the optimization of detector shielding to minimize instrument backgrounds. This shielding optimization can begin during low-power operation but will require a period of high-power operation to complete.

The instrument commissioning activities indicated here do not require low-power operations but can make efficient use of this mode of operation.

7.4 Method of Accomplishment

Operation of the facility will be performed under the requirements approved in the ARR. This safety envelope will maintain the facility classification below the hazard category 3 nuclear facility threshold. The radioactive inventory will be required to remain below the hazard category 3 threshold until the facility is approved in the ORR for operation as a nuclear facility. After successful completion of the ORR (see Chapter 8), the SNS will begin the ascent to full power.

Each group within SNS (Accelerator Systems, Target Systems, Instrument Systems, CF, etc.) will participate in the development of a prioritized list of test activities that require beam-on-target operations during the low-power operations phase. The anticipated target bombardment parameters (proton beam current, pulse rate frequency, and time on target) will be specified for each activity. The target bombardment parameters will be used to calculate the induced radioactivity associated with each desired test.

The radionuclide inventory will be limited during the low-power operations phase to maintain the radiological facilities classification. Consequently, target operations will be limited. Careful planning will be required to accommodate as many low-power testing activities as possible. Desired test activities will be screened to ensure that limits on the radionuclide inventory are not exceeded. A detailed scheduling analysis will be performed that takes into account the priority of each activity. The scheduling objective will be to ensure that the necessary activities are completed while maintaining inventories within the radiological facility category. With proper planning, it should be possible to conduct several tests concurrently, saving valuable beam time for other activities.

The radionuclide inventory in the mercury stream will be calculated using proven computational methodologies demonstrated to adequately predict isotope levels in comparable facilities and experiments. The calculations will follow buildup, depletion, and decay curves for the full radionuclide inventory as a function of proton beam history. This procedure will permit assessment of the radionuclide inventory at any time during low-power operations. We will further be able to predict the inventory at any time for a variety of proton beam scenarios in the short-term future, allowing us to best modify the operational strategy as necessary to meet unforeseen facility testing requirements.

As with the target commissioning activities, there will be a major effort to survey areas during operation. As stated earlier, characterization of radiation fields, both with beam on and off, will continue through the operation phases. These measurements will maintain high priority as proton beam power and duty cycles increase. If higher than anticipated radiation is detected, operations may be adjusted and shielding modified as necessary.

The XFD control room operators will operate the target systems. This group will consist of one lead technician and five technicians. Each will be trained and qualified to hazard category 2 nuclear facility standards.

Most operations will be single shift, but both ASD operations and XFD operations will provide 24-hour control room coverage during beam operations. Some operations could require multiple shifts to complete measurements, but such operations will be the exception rather than the rule.

During beam operation, an operations technician will be on duty 24 hours a day. This operations technician will function as the shift supervisor for the experimental facility. Much of the technician's time will be spent in the control room, but rounds to inspect and observe operation will also be conducted. To do this the operator will leave the control room for time periods not expected to exceed 30 minutes. The target systems are designed to operate safely without human intervention, which includes going to a safe state in the event of an abnormality. All control room operations will be in accordance with approved procedures.

An approved waste-handling plan and approved waste handling procedures will be in place before beginning this phase of operations. No major component changeouts are expected during this phase, but routine and preventive maintenance activities will begin. It is anticipated that these activities will produce some radioactive waste requiring waste handling and disposition. Approved procedures will be followed in dealing with the wastes generated.

The facility will remain a radiological facility and will be operated within the safety envelope defined by the accelerator safety envelope for commissioning and approved in the Target ARR. The operational infrastructure and operational discipline pertinent to the target nuclear facility will be conducted, to the extent practical, to the level required for a hazard category 2 nuclear facility. Conducting target nuclear facility operations with this increased level of rigor will assist in completing the ORR and will ease the operational transition from a radiological facility to a nuclear facility.

7.5 RESOURCES REQUIRED

Low-power operations will require fully staffed operations groups for the SOD, ASD, and XFD. The XFD operations staff will consist of 6 control room operations technicians, 6 nuclear facility technicians, 13 support crafts, a waste-handling engineer, and 2 group managers. The SNS ES&H office will supply 6 health physics personnel, as well as any additional ES&H. The entire target engineering staff will be available to support operational needs throughout this period, but five to seven engineers will be directly assigned to assist in the low-power operations effort.

8.0 OPERATIONAL READINESS REVIEW

8.1 PURPOSE

The ORR provides an independent verification that the target nuclear facility is ready to operate safely, as described in the FSAR and within the envelope set forth in the TSRs.

8.2 SCHEDULE

The ORR will occur during the low-power operations phase and should be initiated within three months after CD-4. The SNS project is to transmit a startup notification report (SNR) at least 12 months before the initiation of the ORR. Additionally, target nuclear facility management will certify that the facility is ready to operate safely at full beam power before initiation of the ORR.

The ORR is expected to require three months to complete. The process of completing CD-4 and initiating low-power operations before the ORR will be beneficial because it will provide operational data and experience that will be available to address ORR questions about operating characteristics. Upon completion of the ORR, the facility will transition to full-power operations.

8.3 CRITERIA FOR SUCCESS/DELIVERABLES

The criteria for success for the ORR will be to conduct and successfully complete the ORR on schedule (July 2006) with all necessary approvals obtained to proceed to normal full-power operations. Deliverables will include a documentation package assembled to support the ORR.

An ORR preparation plan will be developed based on DOE Order 425.1B. The document will include a matrix of criteria in the following categories:

- Documentation
- Equipment
- Training
- Personnel

The purpose of the matrix will be to establish specific, detailed acceptance criteria and deliverables definitions to ensure clear understanding of how the requirements of DOE Order 425.1B will be satisfied.

8.4 METHOD OF ACCOMPLISHMENT

The Target ORR will be conducted in the manner required by DOE Order 425.1B. Additional guidance for the ORR is contained in DOE-STD-3006-2000, *Planning and Conduct of Operational Readiness Reviews (ORR).* The ORR entails a contractor review and a DOE review. The final approval, after the DOE review, will be made by a designee of the secretary of energy. The SNS project proposes that the designee be the head of the SNS project within DOE-ORO.

As with any readiness review, preparation will be the key to success. Work will begin toward ORR preparation with the ARR Preparation Plan. This document will define the milestones to be completed and the evidence files to be documented before the commissioning review.

A detailed matrix of criteria, requirements, and deliverables should be prepared approximately three years before the ORR is to begin. This matrix should clearly define success criteria for the ORR. The matrix will build on requirements identified in the ARR Preparation Plan (see Chapter 5).

Selection of personnel for the ORR will be important to ensure a complete and thorough review. For the contractor review, plans are to retain at least two members team that perform the Target ARR: one accelerator specialist and one individual with both accelerator and neutron instrument knowledge. This will help ensure that interfaces with the target nuclear facility are treated appropriately. For the same reason, the DOE review team should have one or more individuals with significant accelerator experience.

8.5 RESOURCES REQUIRED

An independent team of subject matter experts will conduct the readiness review. Their time and travel expenses must be covered in the budget for readiness reviews. SNS operational, design, quality, ES&H, and other staff must stand ready to provide information to the ORR committee.

9.0 HIGH-POWER OPERATION

9.1 PURPOSE

The phase described in this chapter covers the transition from low- to full-power operations with high availability. During the transition to full-power, the facility will be producing neutrons for scientific research but the number of instruments and the number of users will be substantially less than expected for the mature facility.

9.2 SCHEDULE

This transitional phase will begin upon successful completion of the ORR and will extend until reaching full-power operations, with the ultimate goal of operating 5000 hours per year with an availability of 90%. It is anticipated that the transition to full power will require approximately one year. Attaining the availability goal is expected to require another two years.

9.3 CRITERIA FOR SUCCESS/DELIVERABLES

The criteria for success will be attainment of full-power operations for 5000 hours per year at an availability of 90%. There will be a major effort to continually improve annual operational hours and availability. Reaching the stated goal is expected to require additional time after reaching full power.

A key metric for the SNS facility will be how well the user community is served. About 500 users are expected in the first full year of operation. The number of users will grow as availability increases and as the number of instruments available increases. When the facility is mature with a full suite of instruments, the number of users is expected to approach 2,000 annually.

The number of instruments available when SNS reaches full-power operation is not a stated metric at this time. The goal is to have as many instruments as possible, but the actual number will depend on funding from both DOE and other sources. Current planning has five instruments operating, with five more being installed within one year of attaining full power. On average, one and one-half new instruments will come on-line every year until there is a full suite of 24 instruments. After that, the existing instruments will be renovated, replaced, or modified at approximately the same rate through the life of the facility.

9.4 METHOD OF ACCOMPLISHMENT

Following completion of the ORR, the facility will operate as a hazard category 2 nuclear facility. The beam power and duty cycle will no longer be limited to maintain the radioactive inventory below category 3 levels. Operation of the facility will be governed by an FSAR, with the associated TSRs defining the safety envelope for full-power operation.

Proceeding to full-power operation will be accomplished in a stepwise fashion. The accelerator beam power and/or duty cycle will be increased by a predetermined amount. After each stepped increase, the performance of the accelerator and target systems will be observed and evaluated. If performance is outside acceptable limits, appropriate modifications will be made as necessary before continuing the power and duty cycle ramp. When it is determined that performance of all necessary systems is within acceptable limits, the power and/or duty cycle will be increased. This cycle will be repeated until full power is reached.

In general, the ramp in power is expected to proceed relatively quickly to the mid-power range and then more slowly as full power is approached. For the target systems, the thermal performance of the mercury system, moderators, and utility cooling systems will not be measurable until the proton beam power approaches the 10% range. Modeling confirmation and verification will be better accomplished with power levels of 50% or greater.

Achieving the goal of operating for 5000 hours per year and at 90% availability will require additional effort after reaching full power. Improvement of the operating hours and availability factor will be accomplished through a strategy of multiple efforts. The following strategic areas will be evaluated to identify ways to improve performance.

9.4.1 Systems Hardening

Hardening of the systems to improve both performance and lifetimes can be accomplished through design changes and equipment modifications. Design modifications may be obvious improvements based on observed system performance or may require additional research, development, and analysis.

9.4.2 Systems Maintenance

Improvements in routine and preventive maintenance efforts will help to keep equipment in service and allow the components and systems to operate longer and at higher performance.

9.4.3 Operating Procedures

Operating strategies may be improved to increase availability. These strategies could include changes in the startup or shutdown procedures, changes in operating limits, modifying operating interfaces, etc.

9.4.4 Operator Training

As operating experience is gained, operator training will be assessed for areas of improvement.

9.4.5 Operating and Maintenance Planning and Strategies

Planning system downtimes will help minimize the time required and maximize the results of the work done. For example, a target replacement is expected to require one week. Planning for a target changeout will include preparing a detailed schedule; coordinating the responsible parties; and staging of tools, replacement components, and waste-handling and disposition equipment. Experience gained performing downtime maintenance should lead to improvements.

9.4.6 Spare Parts Inventory

An appropriate inventory of spare parts is critical to minimize downtime during both unexpected repairs as well as planned replacements. This inventory can be reassessed as operational experience is gained to ensure availability of needed components.

9.4.7 Maintenance Personnel and Procedures

Trained maintenance personnel using high-quality maintenance procedures are essential to reducing downtime. Skilled maintenance personnel will suggest areas where design modifications could improve maintenance activities.

The preceding list is not intended to be exhaustive. Improvement of operating hours and availability will be accomplished by addressing every area that causes proton production to cease or that requires time to reestablish production.

9.5 RESOURCES REQUIRED

The high-power operations phase requires a fully staffed ASD, SOD, and XFD operations staff. The recent FY2007 budgetary plan submitted to DOE reflects the resources necessary to operate a fully functioning SNS facility for the first year of steady operation. For subsequent years, most of the operational staff and budget should remain constant (when adjusted by inflation), but instrument and user staff and budget will increase as the number of operating instruments and users grow. This growth is described in the FY 2007 Operating Budget for the Spallation Neutron Source (Ref. 9-1).

9.6 REFERENCES

9-1. *FY 2007 Operating Budget for the Spallation Neutron Source*, Labortory, SNS 0000000-TD0001-R003, UT-Battelle, LLC, Oak Ridge National Laboratory, October 2001.

10. INSTRUMENT INSTALLATION

10.1 PURPOSE

This installation plan is intended to cover the instruments included in the line item funding for the SNS. Currently, there are five instruments included in the line item baseline, as shown in Fig. 10-1. Three of these instruments are planned to be installed as part of the baseline, and two are planned to be installed if supplemental funds become available. The baseline instruments are as follows:

- Backscattering spectrometer (WBS 1.7.4), funded
- Magnetism reflectometer (WBS 1.7.5), funded
- Liquids reflectometer (WBS 1.7.6), funded
- Small-angle neutron scattering (SANS) diffractometer (WBS 1.7.8), requires supplemental funds
- Powder diffractometer (WBS 1.7.10), requires supplemental funds

There are at least two instrument development team (IDT) instruments that may be installed concurrently with the line item instruments that are not covered by this plan.

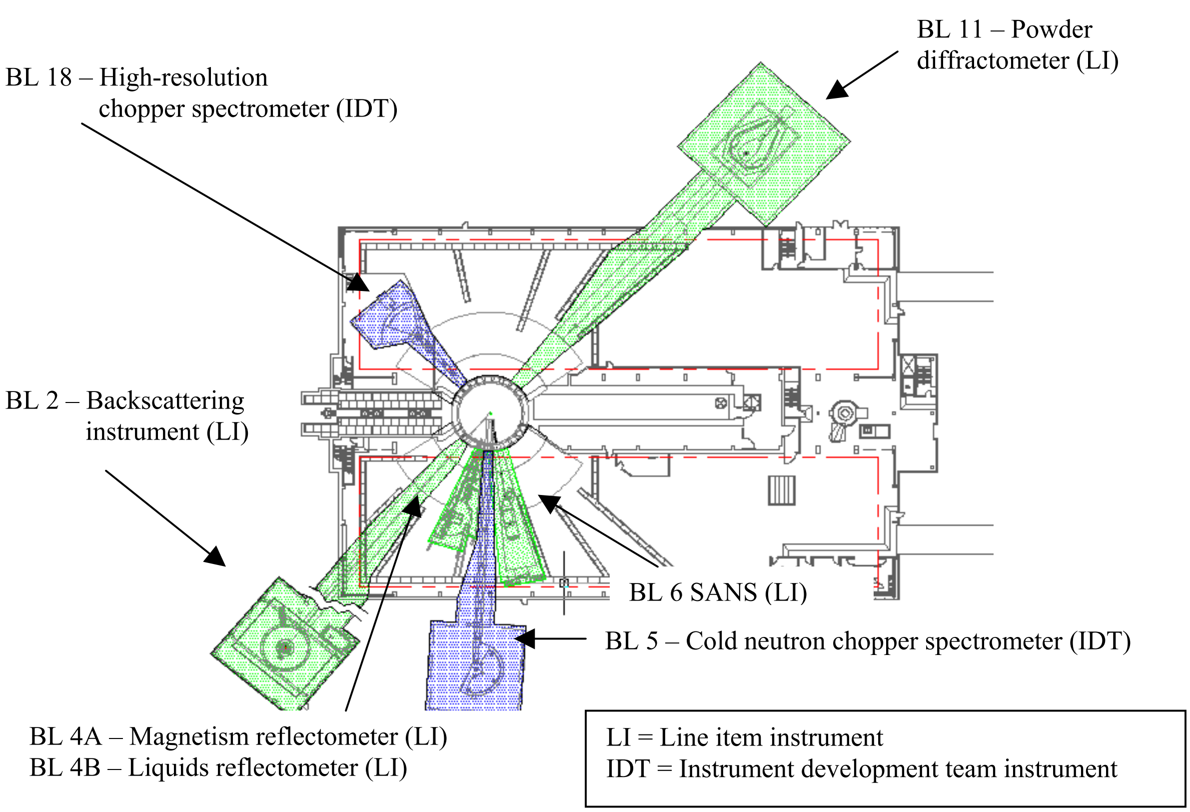


Fig. 10-1. Instrument layout in the Target Building

10.2 SCHEDULE

The schedule for instruments is being created and maintained using Primavera Project Planner (P3) software. Included in the schedule are task identifier, description, start date, duration, predecessors, and successors for every task. In addition, important links have been established with portions of the project external to instruments. See The Appendix for examples of interface links and responsibilities. An example of these types of links is as follows:

1. Target Building floor completed and bottom portion of target monolith shielding installed. This precedes the installation of the 35-in.-high raised ledge of high-density concrete and the installation of the poured-in-place shielding for the backscattering instrument and the powder diffractometer.
2. Target Building enclosure installed.
3. Target vessel installed and ready for core vessel insert installation.
4. Core vessel utility cabinets installed.
5. Central portion of the shutters for beam ports 1A&1B, 4A&4B, 8A&8B, 11A&11B, 14A&14B, and 16A&16B.
6. Target monolith shielding ready for shutter installation.
7. Backscattering instrument installation (except for poured-in-place shielding):
    a. *Start instrument installation, June 8, 2004.*
    b. *Finish installation, February 21, 2006.*
8. Magnetism and liquids reflectometer installation:
    a. *Start instrument installation, June 8, 2004.*
    b. *Finish installation, February 24, 2006.*
9. Start powder diffractometer installation:
    a. *Start instrument installation, June 8, 2004 (depends on funds availability).*
    b. *Finish installation, January 16, 2006 (depends on funds availability).*
10. Start SANS installation *(depends on funds availability).*
11. Low-power operations will occur after successful completion of target commissioning and DOE rendering CD-4. Based on the internal SNS goal of finishing target commissioning in December 2005, low-power operation will begin early in January 2006. Instrument installation activities will be occurring during this activity, will continue past the start of low-power operations, and will extend past the end of the line item project.

10.3 METRIC/CRITERIA FOR SUCCESS/DELIVERABLES

1. **Acceptance testing:** Acceptance testing will be conducted to verify installation.
2. **Functional testing:** Functional testing will be conducted to verify operational performance.

3. An instrument will be considered to be “installed” if all of the components necessary to satisfy the instrument readiness review process (see Chapter 13) have been installed.

10.4 METHOD OF ACCOMPLISHMENT

Instrument installation activities are categorized as target area installation activities and instrument-specific installation activities. The target area installation activities include installation of all portions of the instruments from the target station liner flanges inward toward the moderators. They also include installation of core vessel and shutter inserts for all uninstrumented beamlines. Instrument-specific installation activities include the portions of the instrument from the liner flange outward.

10.4.1 Target Area Installation Activity Sequence

See The Appendix for installation interfaces.

1. With the target liner and core vessel in place, establish a nominal centerline for each beam line with core vessel insert support flange as reference point.
2. Install core vessel inserts. Install core vessel insert after bulk shielding is installed in the liner and before installation of the shutters. Install core vessel inserts using remote insertion fixture – Target Group.
3. Stage remainder of instrument shielding near beam line and wait for settling.
4. Recheck the beam centerline using a reference on the core vessel insert and take into account any deviations.
5. Install shutter inserts into shutters using shutter insert insertion fixture – Target Group.
6. Install shutters into target station – Target Group.
7. Install configurable shielding between shutter and liner wall.
8. Install plate flanges (with beam port opening) on liner flanges.
9. Install instrument components as indicated below.

10.4.2 Instrument-Specific Installation Activities

Instrument-specific installation activities begin at the liner flange and continue outward from the liner. The following sections present the instrument-specific installation activities for the five line item funded–instruments.

10.4.2.1 Instrument 1 — Backscattering Spectrometer (WBS 1.7.4)

The start date for installation of the backscattering instrument is July 2, 2004, which is the day now scheduled as the start of beneficial occupancy. However, some of the shielding, which is poured in place, will be installed with the building and does not appear in this schedule. Also, the inserts required for the shutter and between the shutter and moderator will be installed in October 2003 and also do not appear in this schedule.

Installation activities will take place concurrently. The size of this instrument makes it feasible to assemble both ends of the instrument at the same time. (*This would include not only the instrument itself, but initially, the straight line portion of the shielding in the beam line building — its base, guides, chopper, and overlying shielding. None of this impacts the instrument hall crane schedule, and manpower scheduling, is a more likely issue. The main interface will be with the alignment group.)*

Forklifts, etc., will be a viable option for the instrument, since it will be one of the first to be installed. Forklifts will not be viable for latter instruments after the floor becomes obstructed with beam line shielding.

1. **Presurvey target and building:** The installation contractor will make an initial survey of the moderator and core vessel flange to identify their locations. Temporary bench Mmarks will be installed.

2. **Stage Beamline Components:** Stage shielding, choppers, guide, and supports near beamline as shown in Fig. 10-2, Step 1.

10.4.2.1.1 Sample end of instrument

1. **Instrument enclosure:** Construct instrument enclosure (scattering chamber). *(Installation of the scattering chamber and the sample chamber will have an interface with the alignment group. This will have to be aligned with respect to the beamline,)*
2. **Instrument control/office:** Construct instrument control room/office. concurrently with some of the other following activities.
3. **Sample vessel:** Install and align sample vessel.
4. **Detectors:** Install detectors.
5. **Radial collimator:** Install radial collimator.
6. **Cold beryllium filter:** Install cold beryllium filter.
7. **Crystal analyzers:** Install and align crystal analyzers *(The crystal analyzers, radial collimator, and beryllium filter will require alignment, but this is entirely internal to the instrument itself. It is assumed that someone from the alignment group would be available for these tasks. Final alignments will be completed after neutrons are available).*
8. **Utilities:** Install utilities.
9. **Personal protection system (PPS):** Install PPS equipment.

The completion date for this portion of the installation is February 21, 2006.

10.4.2.1.2 Target end of instrument

1. **Front end shielding:** Configurable shielding is installed in the chopper cavity area.
2. **Bandwidth choppers:** Install bandwidth choppers as shown in Fig. 10-2, Step 3.
3. **Utilities:** Install utilities.

4. **Guide:** Install guide as shown in Fig. 10-2, Step 4.
5. **Shielding:** Install beam line shielding. *(Front-end and midline shielding installation is expected to run from June 8 – September 10, 2004. The main interface and dependency is crane access. The schedule is predicated on unencumbered crane access. There may be a minor interface with the alignment group in that they will need to periodically double check beam-line alignment as the shielding goes on to ensure no significant deviations).*
   a. Install first course of shielding as shown in Fig. 10-2, Step 5.
   b. Install side shielding as shown in Fig. 10-2, Steps 6 & 7.
   c. Install top shielding as shown in Fig. 10-2, Steps 8 & 9.

The completion date for this portion of the installation is August 31, 2005.

10.4.2.2 Instrument 2—Magnetism Reflectometer (WBS 1.7.5)

1. **Install optics into inserts:** The optical guide sections will be installed into the core vessel and shutter inserts. These guide sections will also be aligned within the inserts. Subcontractor and/or laboratory personnel may do this. This activity precedes the core vessel and shutter insert installation.
2. **Pre-survey Target and Building:** The Installation Contractor will make an initial survey of the Moderator and Core Vessel Flange to identify their locations. Temporary Bench Marks will be installed.
3. **Pour below guide shielding:** The installation contractor or subcontractor will pour the bottom portion of the magnetism reflectometer shielding in place.
4. **Final survey target & building:** After the bottom portion of the magnetism reflectometer shielding is poured in place, a final survey will be preformed and the temporary bench marks permanently secured.
5. **Configurable shielding:** Configurable shielding will be installed in the chopper cavity area. This shielding conforms to the close-in reflectometer optics.
6. **Close-in shielding:** Lower and close-in shielding will be installed.
7. **Chopper supports:** The Chopper supports will then be installed and aligned.
8. **Bottom front shields:** The bottom row of front shielding blocks that rest on the poured shielding will then be installed.
9. **Guide assembly:** The guide assembly consists of the guide support structure and guide enclosure sections. This assembly and its supports will be installed and aligned.
10. **Choppers:** The choppers will be installed and aligned starting with the one adjacent to the target liner and working outward. This will also include routing of the cooling lines to the chopper cooler location.
11. **Middle front shields:** The middle row of front shielding blocks that rest on the bottom row will be installed.
12. **Top front shields:** The top sections of front shielding blocks will be installed.
13. **Hutch walls and roof:** The hutch assembly will be worked simultaneously for both the liquids reflectometer and the magnetism reflectometer. The sidewalls

will be installed first so that the hutch contents can be installed through the open rear wall area. The roof will also be added at this time. Sample area components can be installed after the rear wall is installed.

14. **Sample assemblies:** Sample area components (optical benches, optics, goniometer, rotating stage, and sample holders) will e installed.
15. **Detector assembly:** Detector components will be installed (shielded detector enclosure, detector assemblies, and analyzers).
16. **Complete hutch assembly:** Once all of the components are assembled in the hutch area, the rear wall with the door is installed.
17. **Chopper cooler:** The chopper cooler will then be installed.
18. **Building utilities:** Final building utilities will be connected.
19. **PPS and Process Control System**: The PPS and the Process Control System will be installed.
20. **Acceptance testing:** Acceptance sesting will be conducted to verify installation.
21. **Functional testing:** Functional testing will be conducted to verify operational performance.

10.4.2.3 Instrument 3—Liquids Reflectometer (WBS 1.7.6)

1. **Install optics into inserts:** The optical guide sections will be installed in to the core vessel and shutter inserts. These guide sections will also be aligned within the inserts. Subcontractor and/or laboratory personnel may do this. This activity precedes core vessel and shutter insert installation.
2. **Presurvey target and building:** The installation contractor will make an initial survey of the moderator and core vessel flange to identify their locations. temporary bench marks will be installed.
3. **Pour below guide shielding:** The installation contractor or subcontractor will pour the bottom portion of the liquids reflectometer shielding in place.
4. **Final survey target and building:** After the bottom portion of the liquids reflectometer shielding is poured in place, a final survey will be preformed and the temporary bench marks permanently secured.
5. **Configurable shielding:** Configurable shielding is installed in the chopper cavity area. This shielding conforms to the close-in reflectometer optics.
6. **Close-in shielding:** Lower and close-in shielding will be installed.
7. **Chopper supports:** The chopper supports will then be installed and aligned.
8. **Bottom front shields:** The bottom row of front shielding blocks that rest on the poured shielding will then be installed.
9. **Guide assembly:** The guide assembly consists of the guide support structure and guide enclosure sections. This assembly and its supports will be installed and aligned.
10. **Choppers:** The choppers will be installed and aligned starting with the one adjacent to the target liner and working outward. This will also include routing of the cooling lines to the chopper cooler location.
11. **Middle front shields:** The middle row of front shielding blocks that rest on bottom row will be installed.

12. **Top front shields:** The top sections of front shielding blocks will be installed.
13. **Hutch walls and roof:** The hutch assembly will worked for both the liquids reflectometer and the magnetism reflectometer. The sidewalls will be installed first so that the hutch contents can be installed through the open rear wall area. The roof will also be added at this time. Sample area components can be installed after the rear wall is installed.
14. **Sample assemblies:** Sample area components (optical benches, optics, goniometer, rotating stage, and sample holders) will be installed.
15. **Detector assembly:** Detector components will be installed (shielded detector enclosure, detector assemblies, and analyzers).
16. **Complete hutch assembly:** Once all of the components are assembled in the hutch area, the rear wall with the door will be installed.
17. **Chopper cooler:** The chopper cooler will then be installed.
18. **Building utilities:** Final building utilities will be connected.
19. **PPS and Process Control System**: The PPS and Process Control System will be installed.
20. **Acceptance testing:** Acceptance testing will be conducted to verify installation.
21. **Functional testing:** Functional testing will be conducted to verify operational performance.

10.4.2.4 Instrument 4—SANS Diffractometer (WBS 1.7.8)

1. **Install optics into inserts:** The optical guide sections will be installed in to the core vessel and shutter inserts. These guide sections will also be aligned within the inserts. Subcontractor and/or laboratory personnel may do this.
2. **Presurvey target and building:** The installation contractor will make an initial survey of the moderator and core vessel flange to identify their locations. Temporary bench marks will be installed.
3. **Pour below guide shielding:** The installation contractor or subcontractor will pour the bottom portion of the SANS shielding in place.
4. **Final survey target and building:** After the bottom portion of the SANS shielding is poured in place, a final survey will be preformed and the temporary bench marks permanently secured.
5. **Chopper supports:** The chopper supports will then be installed and aligned.
6. **Bottom shields:** The bottom row of shielding blocks that rest on the poured shielding will then be installed.
7. **Guide assembly:** The guide assembly consists of the guide support structure, guide enclosure sections, and carousel assembly. This assembly and its supports will be installed and aligned.
8. **Choppers:** The choppers will be installed and aligned starting with the one adjacent to the liner and working outward. This will also include routing of the cooling lines to the chopper cooler location.
9. **Middle shields:** The middle row of shielding blocks that rest on bottom roll will be installed.
10. **Top shields:** The top row of shielding blocks will be installed.

11. **Sample table:** The sample table will be installed and aligned.
12. **High angle detector assembly:** The high angle detector assembly will be delivered from the fabricator as an assembly. This assembly will be equipped with survey fiducials. These fiducials will be used to install and align the high angle detector as a single unit.
13. **SANS tank assembly:** The SANS tank will be delivered from the fabricator as an assembly and will include the detector carriage. This assembly will be equipped with survey fiducials. These fiducials will be used to install and align the SANS tank as a single unit.
14. **Low-angle detector:** The low-angle detector will be installed after the SANS tank is installed and aligned.
15. **Beam stop:** The main beam stop will be installed immediately after the SANS tank is installed.
16. **Enclosure shielding:** The shielding around the SANS tank and large-area detector will then be installed.
17. **Platform and hutch:** The operator platform and hutch will then be installed. This includes the appropriate control panels.
18. **Chopper cooler:** The chopper cooler will then be installed.
19. **Building utilities:** Final building utilities will be connected.
20. **PPS and Process Control System**: The PPS and Process Control System will be installed.
21. **Acceptance testing:** Acceptance testing will be conducted to verify installation.
22. **Functional testing:** Functional testing will be conducted to verify operational performance.

10.4.2.5 Instrument 5—Powder Diffractometer (WBS 1.7.10)

The start date for installation for the powder diffractometer is June 8, 2004, the day now scheduled as the start of beneficial occupancy. Portions of the shielding, which are poured in place, will be installed with the building and do not appear in this schedule. Also, the inserts required for the shutter and between the shutter and moderator will be installed in October 2003 and also do not appear in this schedule.

Installation activities will take place concurrently. The size of this instrument makes installation at both ends of the instrument feasible.

Start date –July 2, 2004

1. **Presurvey target and building:** The installation contractor will make an initial survey of the moderator and core vessel flange to identify their locations. Temporary bench marks will be installed.
2. **Stage beam line components:** Stage shielding, choppers, guide, and supports near beam line, as shown in Fig. 10-2, Step 1.

10.4.2.5.1 Sample end of instrument

1. **Instrument enclosure:** Construct instrument enclosure.
2. **Shield base:** Pour shielding base (section not poured as part of the CF contract).
3. **Mezzanine:** Construct steel platform (mezzanine).
4. **Beamstop:** Install beamstop.
5. **Detector frames:** Install detector frame assemblies.
6. **Utilities:** Install utilities.
7. **Carousel:** Install interchangeable guide assembly.
8. **Sample vessel:** Install sample vessel.
9. **PPS:** Install PPS equipment.
10. **Collimators:** Install collimators.
11. **Detectors:** Install detectors.
12. **Hutches:** Install instrument hutches.

The completion date for this portion of the installation is September 24, 2004.

10.4.2.5.2 Target end of instrument

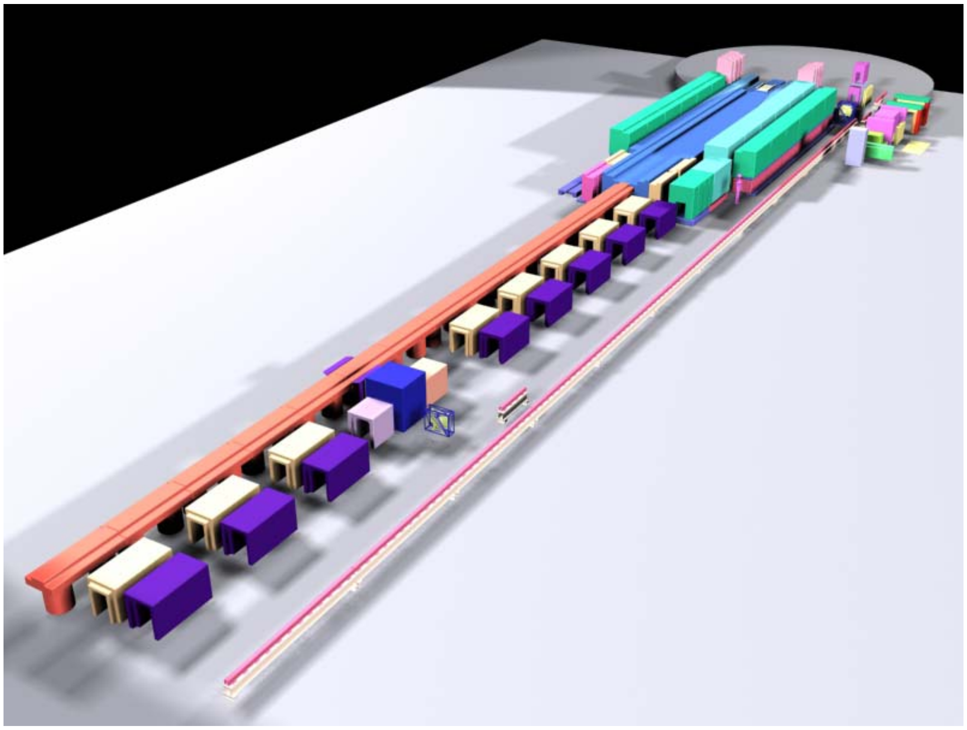
1. **Guide supports:** Install guide support posts.
2. **Front-end shielding:** Configurable shielding is installed in the chopper cavity area. This shielding conforms to the close-in powder diffractometer optics.
3. **T_0 chopper:** Install T_0 chopper.
4. **Bandwidth chopper support:** Install bandwidth chopper support posts.
5. **Bandwidth choppers:** Install bandwidth choppers as shown in Fig. 10-2, Step 3.
6. **Utilities:** Install utilities.
7. **Guide:** Install guide as shown in Fig. 10-2, Step 4.
8. **Shielding:** Install beam line shielding.
    a. Install first course of shielding as shown in Fig. 10-2, Step 5.
    b. Install side shielding as shown in Fig. 10-2, Steps 6 and 7.
    c. Install top shielding as shown in Fig. 10-2, Steps 8 and 9.

The completion date for this portion of the installation is June 30, 2005.

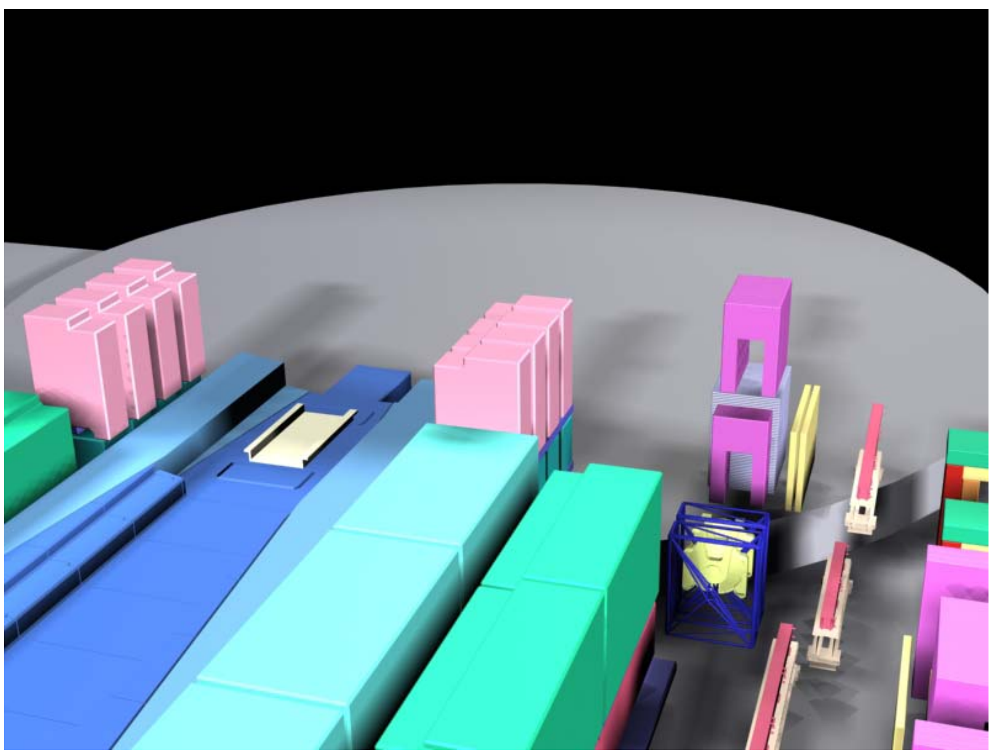
On or about May 25, 2005, the testing of the control system, PPS equipment, and user interface will begin. The expected duration of this testing phase is 200 days, making the final completion date March 10, 2006.

10.5 RESOURCES REQUIRED

Installation of this instrument will be performed by both Davis-Bacon trade labor and by ORNL technicians. Responsibility for coordinating installation lies with the instrument scientist. Figure 10.3 shows the installation schedules.

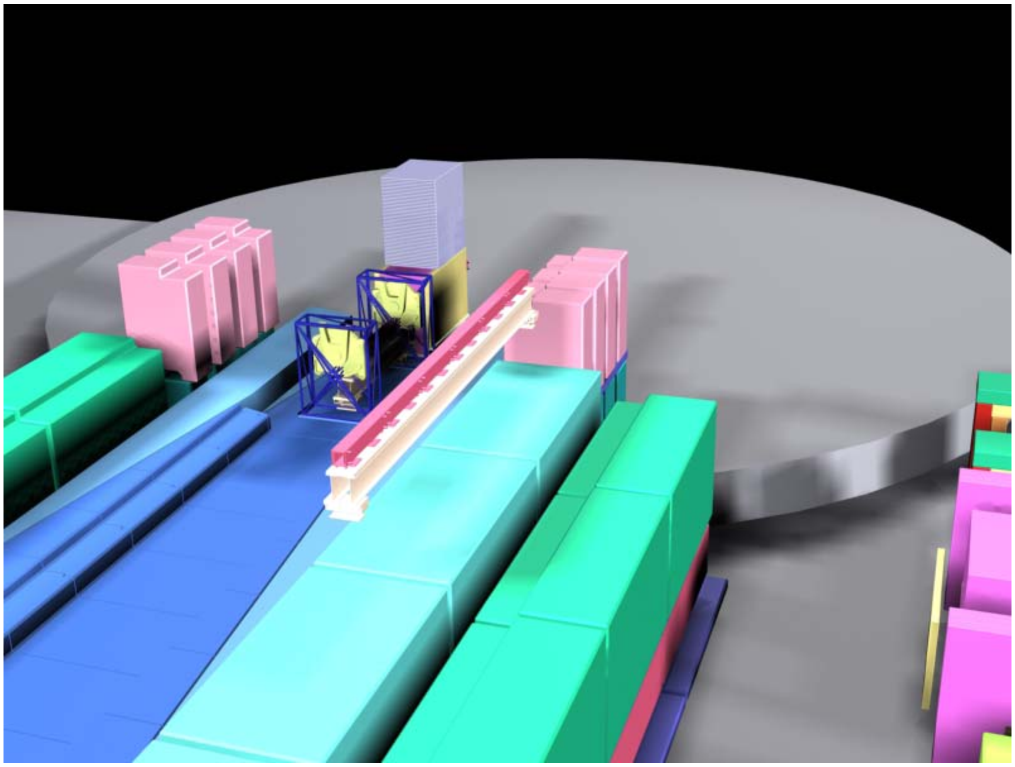


Step 1. Staging of choppers, guide and shielding.

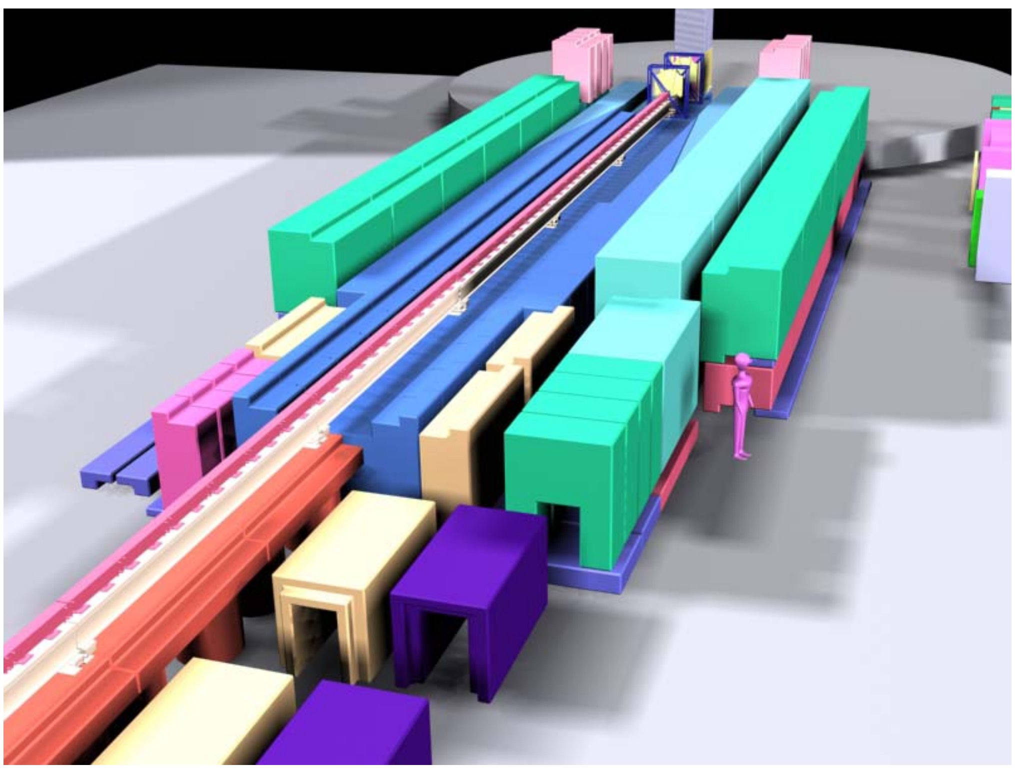


Step 2. Close-up shielding and optics base preparation.

Fig. 10-2. Typical long beamline central shield installation.

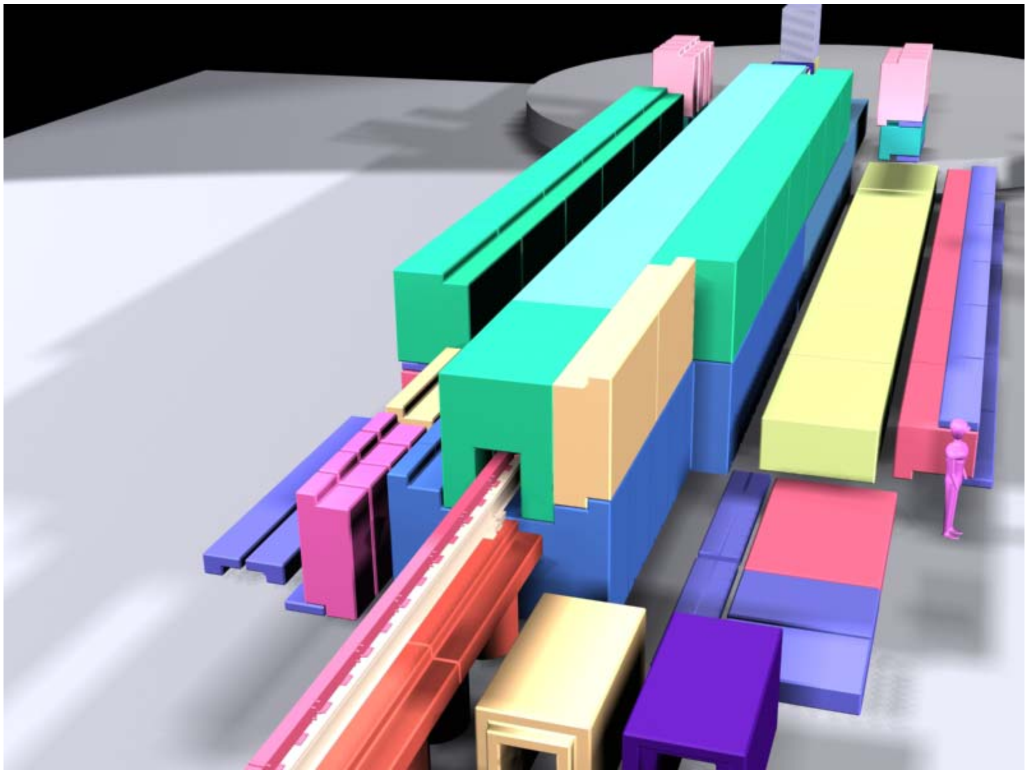


Step 3. Chopper installation.

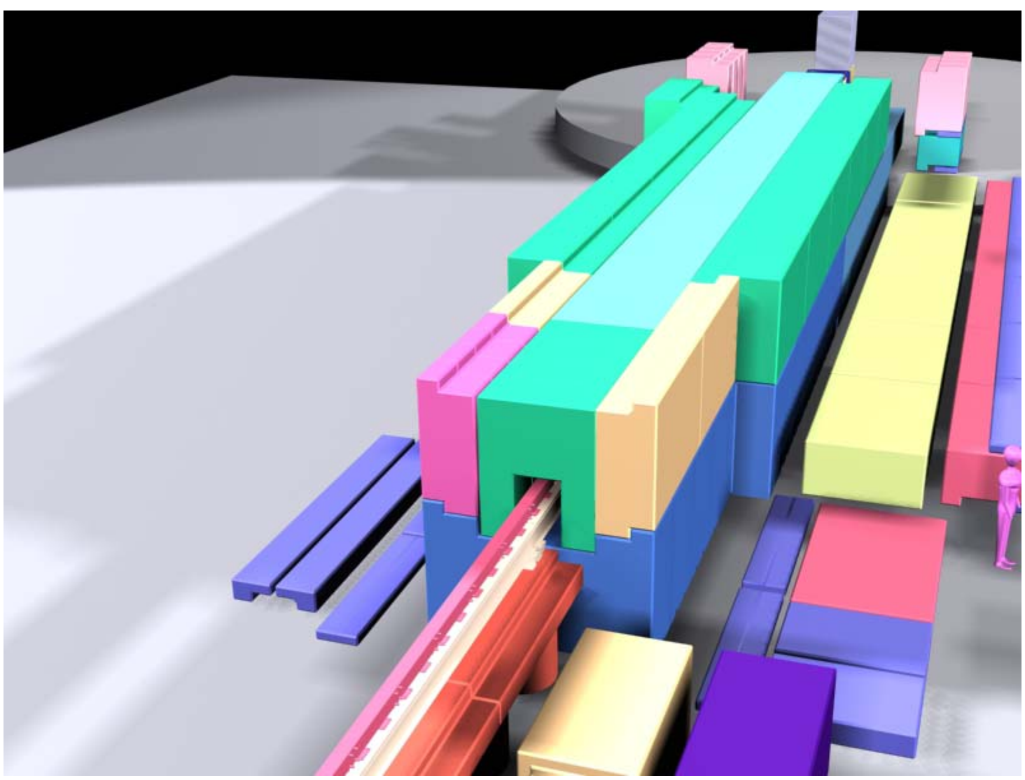


Step 4. Guide installation.

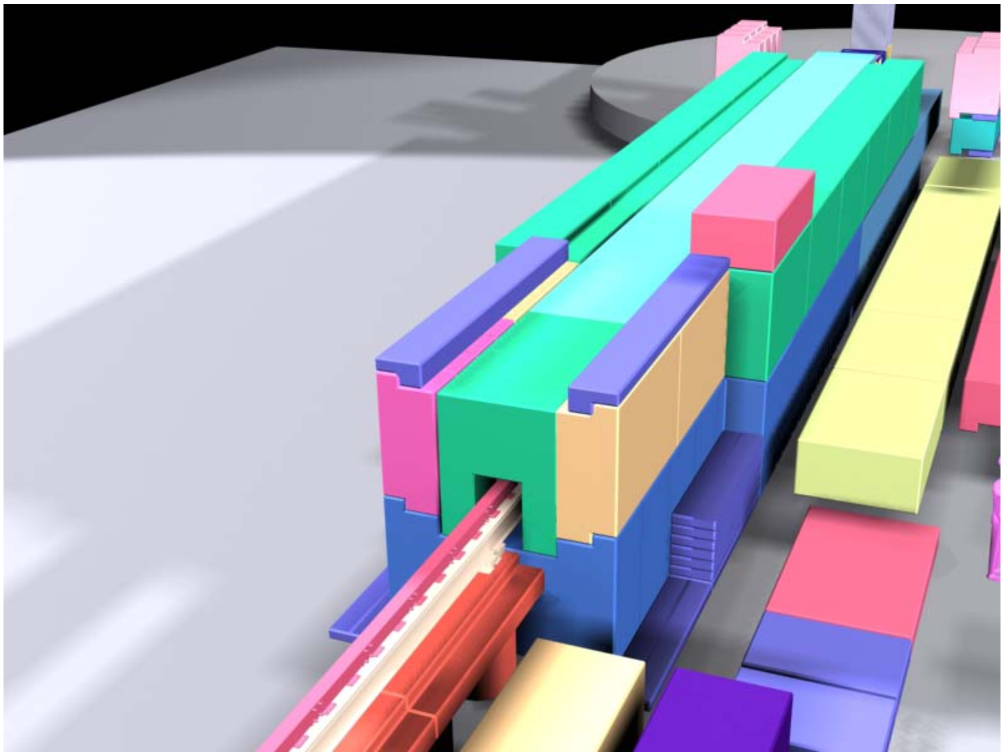
Step 5. First course of shielding installed.



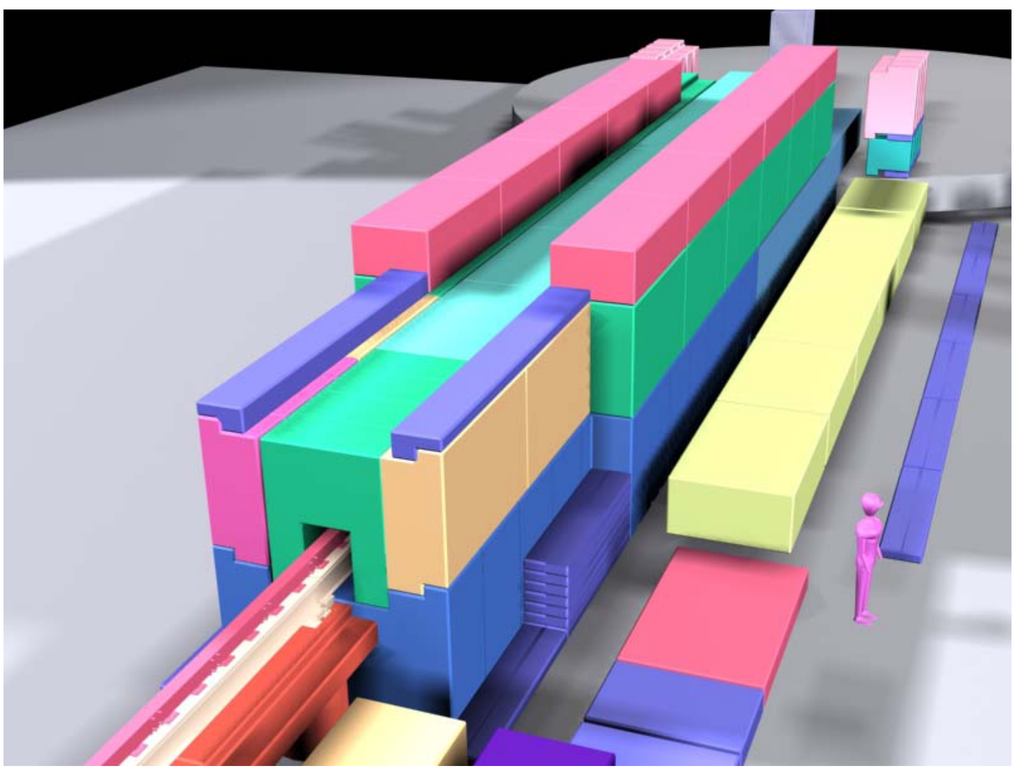
Step 6. Typical side shield installation.



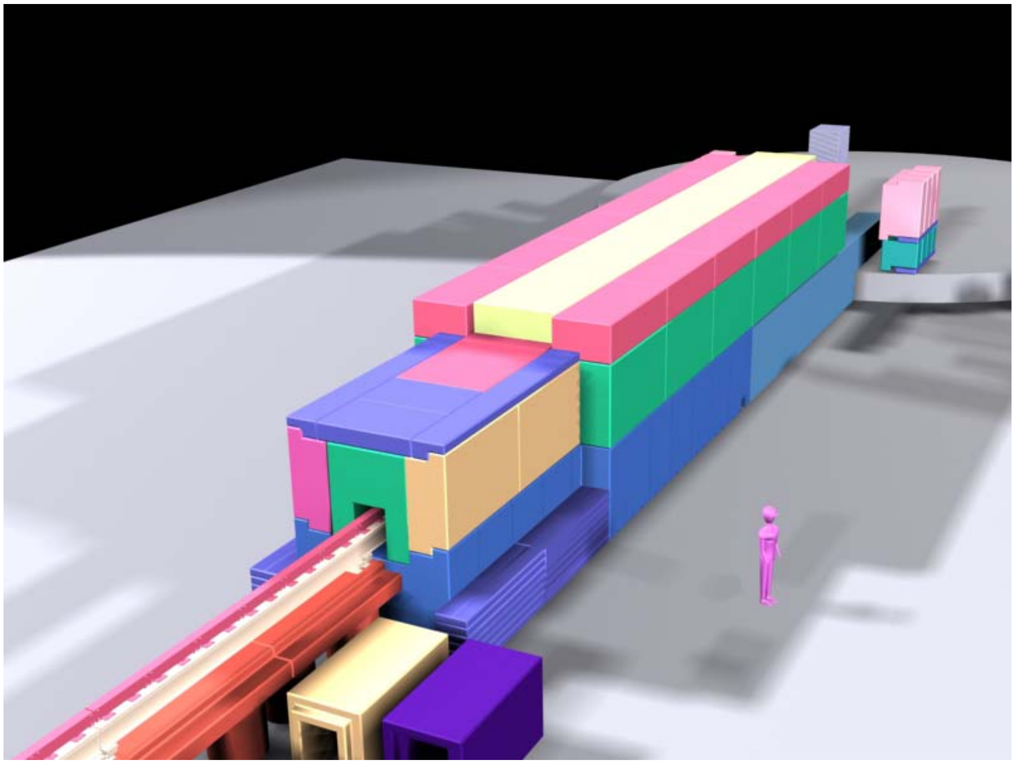
Step 7. Remainder of side shield installed.



Step 8. Top outside shielding installed.



Step 9. Remainder of top outside shielding installed.



Step 10. Completed shield installation.

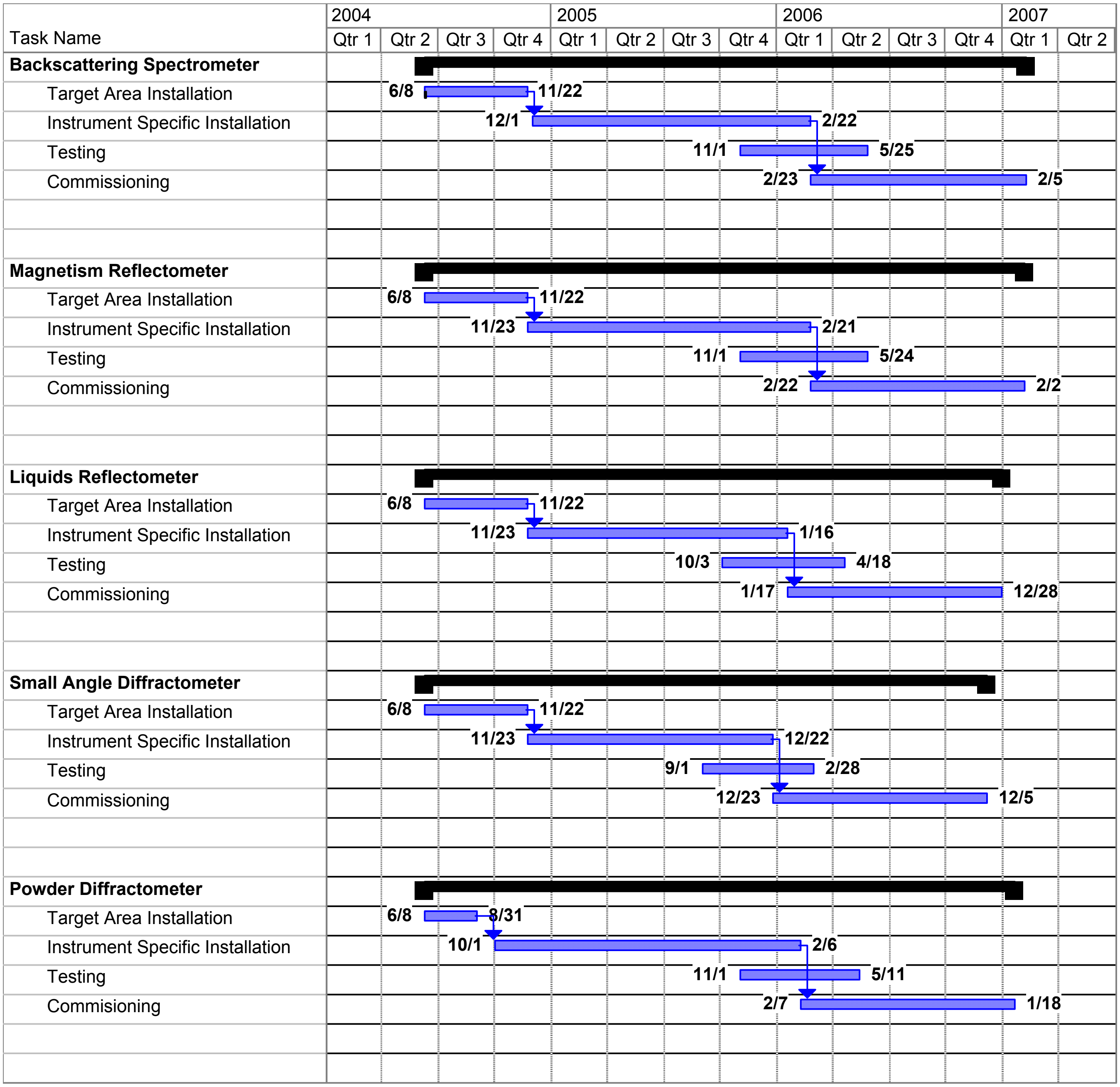


Fig. 10-3. Instrument installation schedules

11. SYSTEMS TESTING

11.1 PURPOSE

After completion of installation, a series of systems tests will be conducted for appropriate level 4 WBS elements under the individual instruments (WBS 1.7.x) to confirm that components are correctly fabricated, assembled, and installed and that all equipment and components meet specified operational characteristics.

A listing of the systems tests for Instrument Systems level 4 WBS elements is provided in Table 11-1. This table also identifies the parameters or features that will be demonstrated for each test.

11.2 SCHEDULE

The schedule for the systems tests is included in the installation schedule in Fig. 10-3. This summary is taken from the SNS baseline detailed schedule for the Instrument Systems subproject. In general, the systems tests commence with the end of installation for each system or assembly of components.

11.3 CRITERIA FOR SUCCESS/DELIVERABLES

The systems tests will be performed according to written procedures, and results will be documented. These procedures will include criteria or specified operating characteristics that must be met before completion of this phase of work. The criteria will be based on the list of parameters measured or features demonstrated shown in the third column of Table 11-1. Interface-related testes are also addressed in The Appendix.

Table 11-1. Typical systems tests for backscattering instrument (WBS 1.7.4)

Level 4 WBS	Test description	Start	Finish	Parameters measured or features demonstrated
1.7.4.1 System Integration	TBD			
1.7.4.2 Data Acquisition	TBD			
1.7.4.3 Detectors	TBD			
1.7.4.4 Choppers	Timing tests			Timing performance of installed chopper
1.7.4.5 Sample Environment	Vacuum tests			Leak rate of sample enclosure
1.7.4.8 Instrument Specific	TBD			

11.4 METHOD OF ACCOMPLISHMENT

The level 3 WBS task leaders for each instrument will have primary responsibility for conducting these tests. The task leaders will also be responsible for preparing the test procedure and for documenting the test results.

11.5 RESOURCES REQUIRED

An estimate of the resources required to conduct these tests was developed as part of the SNS baseline cost estimate for each level 3 WBS element of Instrument Systems. These resources include engineering support, technician and craft labor support, and materials. In addition to the resources directly identified for systems tests, engineering support for these tests is included in a separate Title III support category for some level 3 WBS elements.

12. INTEGRATED SYSTEMS TESTING

12.1 PURPOSE

After completion of the systems tests on each level 4 WBS element under each instrument, integrated systems tests will be conducted. These tests will confirm that all systems are working in an integrated fashion to achieve required performance levels.

Typical integrated systems tests for each instrument include the following:

- PPS operation.
- Data acquisition system and timing system operation.
- Data acquisition system and sample environment system operation.

12.2 SCHEDULE

The schedule for the Instrument Systems integrated systems tests is included in the installation schedule.

12.3 CRITERIA FOR SUCCESS/DELIVERABLES

The integrated systems tests will be performed according to written procedures, and the results will be documented. These procedures will include criteria or specified operating characteristics that must be met before completion of this phase of work.

12.4 METHOD OF ACCOMPLISHMENT

The level 3 WBS task leaders for Instrument Systems will have primary responsibility for conducting these tests.

12.5 RESOURCES REQUIRED

An estimate of the resources required to conduct these tests was developed as part of the SNS baseline cost estimate for each level 3 WBS element of Instrument Systems. These resources include engineering support, technician and craft labor support, and materials. In addition to the resources directly identified for integrated systems tests, engineering support of these tests is included in a separate Title III support category for some level 3 WBS elements.

13. NEUTRON INSTRUMENT READINESS REVIEW

This chapter outlines the readiness review process, based on the Accelerator Safety Order, DOE Order 420.2A, that will be applied to verify that each instrument is ready for commissioning and subsequent routine use in research. Each instrument is a major facility in itself, and the instrument readiness review process will be repeated after each instrument is made ready for use. At least one instrument (possibly a temporary instrument) is needed to perform the neutron measurements that will be needed to demonstrate that CD-4 has been achieved. Therefore, the target commissioning readiness review (See Section 5) will apply parts of the instrument readiness review process as needed.

Although each instrument review is comprehensive with respect to usage of that instrument, the scope of each of these reviews can, and should, be limited with respect to generic readiness areas such as training, configuration control, and radiological protection. The generic aspects of areas such as this will be covered by the Target ARR (see Chapter 5). Therefore, each instrument readiness review can proceed under the assumptions that the SNS has developed and is applying good radiation protection, industrial safety and hygiene, work control, configuration control, and training programs, etc., and will concentrate on specific areas important to safe operation of the instrument is being reviewed.

13.1 PURPOSE

The purpose of the instrument readiness review is to ensure that each instrument is safe to operate and is ready for commissioning.

13.2 SCHEDULE

Such an assessment must be completed for each instrument (including those provided by IDTs) before that instrument can begin commissioning with beam. The assessment of each instrument is independent from that for any other instrument, and these assessments will not necessarily be scheduled at the same time. We anticipate that assessments for 3 to 5 instruments will be completed by the time of CD-4.

13.3 CRITERIA FOR SUCCESS/DELIVERABLES

The readiness assessment must show that the instrument satisfies two criteria:

1. **The instrument must be safe to operate with the shutter open and neutrons generated by the target/moderator/reflector system coming down the beam line.**
    a. The PPS and all necessary shielding must be in place to prevent any inappropriate access of staff or users to potential radiation areas around the instrument.

b. The instrument must have sufficient safeguards in place, such as rails, kick plates, emergency doors, vacuum interlocks, etc., to reduce nonradiation hazards to an approved level.

2. **The instrument must be sufficiently complete to begin useful commissioning with beam.**

   a. At a minimum, at least some of the detectors must be installed and functional, the data acquisition system must be installed and functional, and other essential components such as major parts of the beam line optics must be in place and functional.

13.4 METHOD OF ACCOMPLISHMENT

Each instrument shall have a review to assess its operational readiness. Upon passage of such a review, the instrument will be considered to be complete and ready to begin commissioning. The composition of the committee for such reviews is TBD, but it should include representatives of, or persons designated by, the facility Radiation Safety Committee and representatives familiar with the operation of neutron-scattering instruments and possible user pitfalls. If appropriate, the safety and operational parts of this review can be conducted separately.

13.5 RESOURCES REQUIRED

Required resources include the following:

1. Review committee with membership to review radiation safety, occupational safety, functionality, and operational procedures for one or more instruments.
2. Instrument scientist and other personnel as necessary to present the case.
3. All procedures governing operation of the instrument.

14. INSTRUMENT COMMISSIONING

14.1 PURPOSE

To bring each instrument to a state where it is ready for routine operation in the user program.

14.2 SCHEDULE

Commissioning for each instrument will be independent from that of the other instruments, and the schedule is likely to be different for each instrument. Commissioning of a given instrument will begin once the readiness review has been satisfactorily completed for that instrument. Commissioning of a given instrument will be considered complete when the instrument scientist and appropriate levels of management certify that that instrument is ready for routine user operation.

14.3 CRITERIA FOR SUCCESS/DELIVERABLES

The instrument scientist for the instrument in question will have to certify that the instrument is ready for general user operation. Appropriate levels of management (TBD) would have to concur in this certification. Such certification will imply that

1. the instrument has been properly calibrated, and
2. the instrument performance meets advertised specifications.

14.4 METHOD OF ACCOMPLISHMENT

Initial stages of commissioning will involve a series of test measurements to be carried out by the instrument operations staff [instrument scientist(s) and technicians]. These tests and measurements will determine at a minimum of the following:

1. Radiation doses in accessible areas are within acceptable limits.
2. Instrument components are functioning neutronically as designed.
3. Instrument backgrounds (unintended signals measured by the detectors) are within acceptable limits.
4. Performance (resolution and range for the variables of interest) is within acceptable limits.
5. The instrument is calibrated.
6. Measurements on known samples produced the expected results.

We anticipate that some of these tests will indicate the need for modifications to the instrument so that the actual early parts of the commissioning program will consist of alternating periods of testing and modification until the desired results are achieved. Many of these tests can be completed entirely or at least in part during low-power operation.

Once these initial tests and modifications have been satisfactorily completed, the instrument may undergo a period of "friendly user" operation before it is certified as ready for general user operation. Friendly users are persons outside SNS who are knowledgeable users and who will be tolerant of less than nominal operation of the facility or instrument (e.g., many unscheduled down periods, instrument not yet functioning optimally). Such friendly users would typically be IAT or IDT members. They would be performing actual experiments and would help us to encounter and solve many of the problems that would otherwise first appear when in general user operation. It is unlikely that friendly user operation would be appropriate during low-power operations.

14.5 RESOURCES REQUIRED

Commissioning will be primarily the job of the instrument operation staff. This will include the instrument scientist(s) and technician(s) assigned specifically to that instrument and will also involve assistance from members of the various support groups (data acquisition, choppers, etc.).

If a friendly user mode is included as part of commissioning, the User Office will also have to be involved to provide the necessary training and logistical arrangements for the friendly users.

Because it is likely that some modifications to the instrument will be required to bring it to its optimal operating state, we can expect that the demand for materials and supplies for that instrument will be at least twice as high as it will be once operation becomes routine.

APPENDIX – Target Systems/Instrument Systems Installation and Testing Interfaces

Table A-1 shows the installation and testing sequence for instrument beam line components in or near the target station, along with the prerequisites for each step and the responsible party.

Table A-1. Installation and testing sequence for instrument beam line components in or near the target station

	Step	Responsible Group[a]	Prerequisites
1.	With the target liner and core vessel in place, establish a nominal centerline for each beam line with core vessel insert support flange as reference point.	IS	Target liner Core vessel
2.	Stage remainder of instrument shielding near beam line and wait for settling.	IS	Shielding
3.	Pressure and vacuum test window(s) in core vessel inserts to ensure that they meet leakage criteria.	IS	Core vessel inserts
4.	Install core vessel inserts. Install core vessel insert after bulk shielding is installed in the liner and before installation of the shutters. Install core vessel inserts using remote insertion fixture.	TS	Core vessel Core vessel inserts Shutter rails Remote insertion fixture Shutters not installed
5.	Connect and test vacuum line for testing core vessel insert flange seal.	TS	Vacuum system and manifold
6.	Test seals between inserts and core vessel to make sure each meets leakage and overpressure criteria.	TS	Core vessel Core vessel inserts
7.	Make and test cooling water connections to each core vessel insert.	TS	Manifolds and necessary utilities Flow or other control Monitoring systems
8.	Make and test any helium or other connections to core vessel inserts.	TS	Manifolds and necessary utilities

			Flow or other control Monitoring systems
9.	Recheck the beam centerline using a reference on the core vessel insert and take into account any deviations.	IS	TBD
10.	Install shutter inserts into shutters using shutter insert insertion fixture – Target Group.	TS	Shutters Shutter inserts Shutter insert insertion fixture
11.	Install shutters into target station – Target Group.	TS	
12.	Make and test connections (if any) to each shutter insert.	TS	Manifolds and necessary utilities Flow or other control Monitoring systems
13.	Verify alignment of shutter insert.	IS	
14.	Install configurable shielding between shutter and liner wall.	IS	Configurable shielding
15.	Install plate flanges (with beam port opening) on liner flanges.	IS	Plate flanges
16.	Test plate flange seals to ensure that they meet leakage and overpressure criteria.	TS	Plate flanges installed
17.	Install instrument components as indicated in Chapter 10.	IS	Instrument components
18.	Shield uninstrumented beam ports – coordinate with installation of instrument shielding.	TS	Instrument shielding Shielding for uninstrumented ports

[a]TS = Target Systems (WBS 1.6), IS = Instrument Systems (WBS 1.7).

Procedures will need to be prepared for each of these items. Although there will be small differences in procedures from beam port to beam port, procedures will be mostly the same for each port. Preparation of most procedures will require both Target Systems and Instrument Systems input.