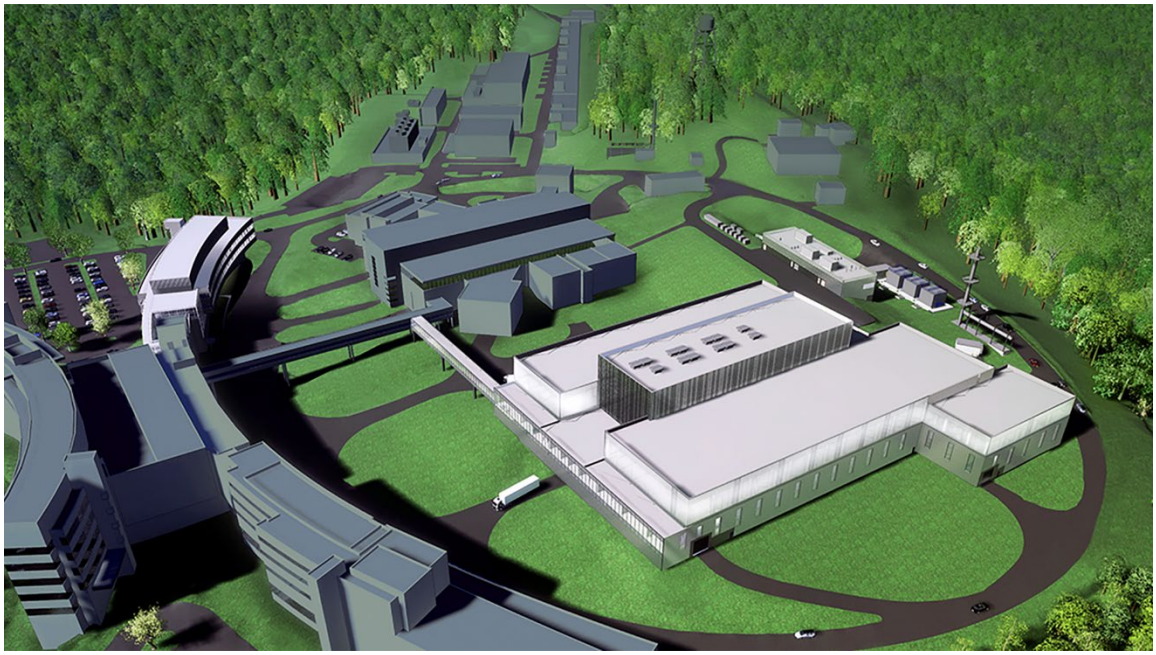
Second Target Station Project: Fabrication and Manufacturing Strategy



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Second Target Station Project

MANUFACTURING & ACQUISITION STRATEGY

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1. INTRODUCTION

This document details the process for acquiring, fabricating, and manufacturing the components for the Second Target Station (STS) Target Assembly. The STS is a planned spallation neutron source facility that will utilize an accelerator-based system's proton beam to strike a rotating tungsten target. The target assembly, shown in Figure 1, is made up of three main subassemblies: the shaft, target segments, and drive. The following sections will go into detail on vendors, manufacturing and assembly details, testing, and risks associated with the main subassemblies. This document covers the target assembly manufacturing plan up to when the assembly is ready to be installed into the Second Target Station core vessel.

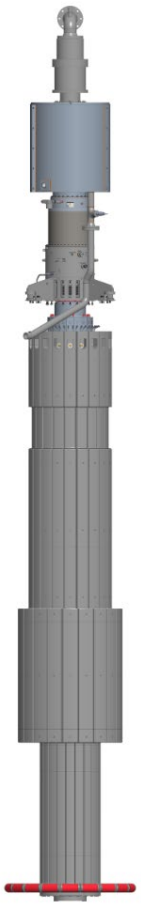

Figure 1 - Target Assembly, Cross Sectional View

1.1 FABRICATION APPROACH

The target assembly will be procured in three distinct procurement packages, with a final integration to be handled by ORNL second Target Station team. The procurement packages include:

Table 1. Procurement package overview

Procurement Package	ORNL part numbers	Vendor Scope	ORNL Scope	Selection Method
Drive Assembly	0000001787, 0000001800	Procure and fabricate components, assemble drive, factory acceptance test	Oversight, factory witness factory acceptance test	Best Value
Upper Shaft Forgings	0000004456, 0000004457	Forge and machine shaft uppers	Material certification and review	Best value
Lower Shaft weldment	0000002985	Weld and machine lower shaft	Material certification and review	Best Value
Segment leg fabrication	0000005039	Weld and Machine	Material certification and review, witness pressure testing	Best value
Segment Foot fabrication	0000077806	Spallation block, riser leg, welding, machining, subcontract management*	Provide specification for segment foot materials, approve/recommend material vendor and key subcontractors, shop plans and process	Best value
Luminescent coating	0000064918	Apply luminescent coating	Technical oversight and coordination by S.03.05	Sole Source
Integration	0000004343		ORNL to assemble shaft to drive, segments to drive	N/A – performed by ORNL

**Note: ORNL will be intimately involved in the vendor selection, reviewing material hold points and material acceptance for the spallation package*

All procurement packages will involve hold points for key processes (HIP, etc.) and dimensional inspections, as well as requests for all testing and certifications of raw stock. These hold and inspection points will be specified on the drawing fields and contract terms. FOB destination and shipped are to be shipped only after acceptance by ORNL design and installation team.

2. SHAFT

The shaft assembly, shown in Figure 2, is judged to be a low risk and fast turnaround manufacturing process because it consists of mostly simple structures to fabricate. The primary structures are fabricated from large round forgings and welded sections. Local vendors are capable of fabricating and assembling the required components.

The shaft is made up of 3 sections that will be bolted together and a central water line. Note that the crown is manufactured as part of the drive package, but is assembled (By ORNL) as part of the shaft. The shaft and drive have been designed to handle significant out-of-balance conditions (30kg-m), and therefore does not require balancing at assembly. The following paragraphs go into detail on how each section will be manufactured.

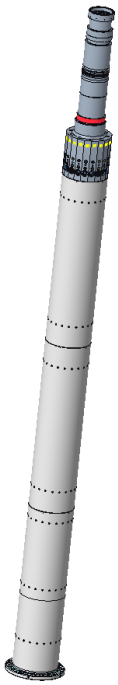

Figure 2 - Shaft Subassembly

2.1 (000004456 & 000004457) UPPER SHAFT AND MIDDLE SHAFT MANUFACTURING

The upper and middle shaft are made up of large single forgings as shown in Figure 3. The shaft sections will be bolted together. The long central hole and clearance holes for the tie rods will be provided by the forging provider. The forging and machining can be provided by vendors such as Elwood City Forge and Scot Forge (among others).

2.2 (0000002985) LOWER SHAFT MANUFACTURING

The lower shaft, shown in Figure 4, provides the locating features for the target segments. The lower shaft is a welded construction employing a large forging, welded flanges, welded in inner plates, and hardened alignment pockets. The initial shape will be machined from a large near net forging, this will require a larger machining center; many of which are available at local machine shops. This will be followed by the installation and welding of the inner divider plates and upper mounting flange. The weldment will be provided with the long tubes attached. (Tubes are to be welded to the crown at assembly of the shaft)

The complete weldment will be welded together, and pressure tested. Pockets will be cut into the flange on the lower shaft for pocket installation. Segment location pockets will be machined after welding and then Kolsterized. Precision measurements and machining will be required for proper target positioning. The welding and machining will be completed by a single vendor, with the machining to be completed after welding and prior to shipment.

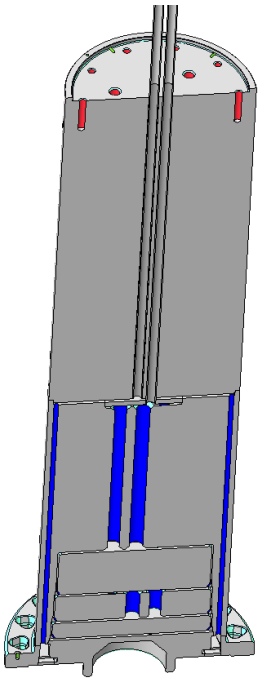

Figure 3 - Lower Shaft, Sectioned View

3. TARGET SEGMENT

The target segments are the most difficult subassembly to manufacture. The manufacturing process requires precise machining, multiple bonding processes, welding, and testing. The target assembly requires 20 target segments for initial assembly and three target segments per year for maintenance. Due to the volume and complexity of segments, this manufacturing process will require a long-term relationship with manufacturing vendors, with ORNL assuming ownership of all tooling. Manufacturing the target segments will require multiple vendors for specialized processes. The overall coordination among vendors will be managed by a single vendor, with significant ORNL oversight and inspection. The target segment, shown in Figure 5, is made with two subassemblies: the target block and the target leg. The following sections go into detail on the manufacturing process of these subassemblies.

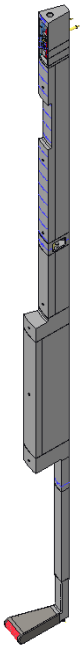

Figure 4 - Target Segment Subassembly

3.1 TARGET BLOCK VENDOR QUALIFICATION

The complexity of the target block warrants a risk averse approach to procurement. To ameliorate risk, the STS project will purchase the target segments in 3 waves:

1. QTY: 1 for destructive examination. The vendor will produce a single target foot according to all drawings, inspections, and NDE methods. The foot will then be delivered to ORNL for further NDE and cut open for destructive examination. Upon confirmation of the product delivered by the process, the vendor will be authorized to proceed
2. QTY 2 (spares) The vendor will produce two targets for use as spares for operation
3. QTY: 20 The vendor will then produce 20 targets for use in the beam

3.2 TARGET BLOCK OVERALL PROCESS

Figure 6 shows the process for manufacturing the target blocks from the stock material up until the block is furnished to the leg vendor.

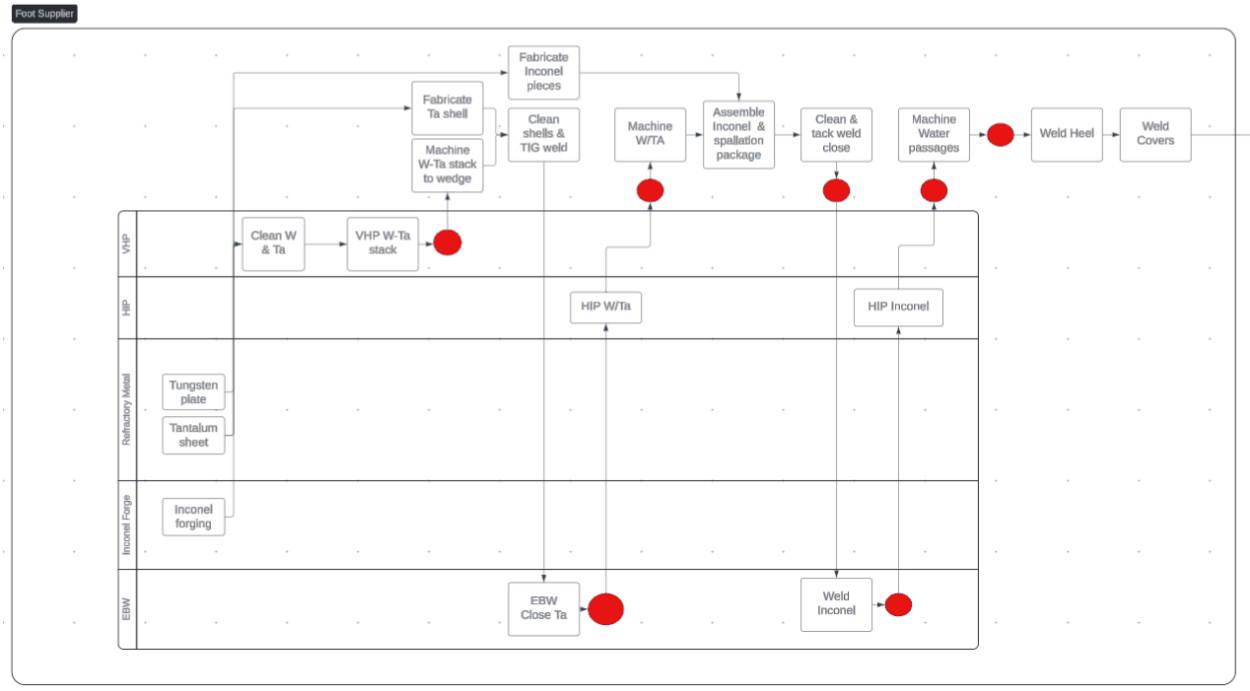

Figure 5 - Target Block Manufacturing Overview

3.3 TARGET BLOCK MATERIAL PROCUREMENT

Raw material procurement will be managed by the foot vendor in accordance with ORNL developed specifications and associated material certifications.

3.4 TARGET BLOCK MANUFACTURING

The target block fabrication is the most critical and novel subassembly with the target assembly structure. Proper bonding in the target block, between the multitude of layers, is essential for target performance as the heat deposited from the proton beam needs to be transferred away from the target block. Voids, fractures, or unbonded sections decrease the heat transfer rate from the heat deposition location to the coolant pipes, which decreases target lifetime. In addition, grain growth and precipitate formation during the thermal cycles must be minimized to maintain predicted fatigue life.

The machining in the early stages of the target block is not dimensionally sensitive. Typical industry standards of around plus or minus 0.1mm are acceptable. Surface finish and cleanliness are critical and will be performed in accordance with ORNL specifications. In both the vacuum hot press (VHP) and hot isostatic pressing (HIP) bonding steps surface finish and CTE mismatch drive residual stress formation and target fatigue life.
All welding on the Inconel surround will be electron beam welding. The electron beam welding shop will be responsible for assembly, cleanliness, closure, and leak checking of the assemblies prior to HIP. The vendor will develop specialized weld qualifications on representative test coupons. Target block manufacturing will involve several vendors due to the complexity, which creates risk from the lack of responsibility between vendors. Manufacturing steps and specifications will be provided to a vendor to manage the process, with several hold points for ORNL inspection.

ORNL will receive each target block to perform an independent dimensional check. Additionally, ORNL will perform ultrasonic thickness testing, ultrasonic bond testing, and transient thermal test to ensure bond integrity.

3.5 TARGET LEG MANUFACTURING

The target leg can be assembled once the target block has been manufactured. There are critical connections between the target block and target leg components that cannot be welded if the target leg is assembled separately from the target block. The target leg will be machined in separate parts to allow for coolant pipes to be run through the leg to the target block.

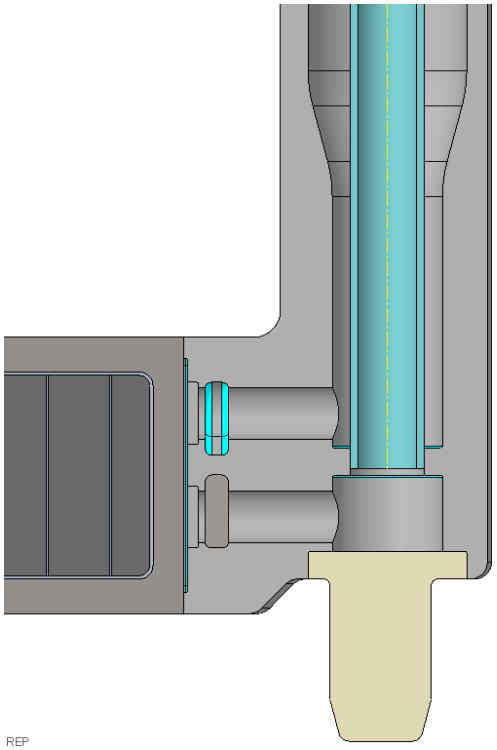

Figure 6 - Target Segment Bottom, Cross Sectional View

The target leg vendor will fabricate and weld the target foot onto the segment leg. This involves fabricating the leg and then welding the internal tube and pin onto the leg.

3.6 TARGET LUMINESCENT COATING

The target leg vendor will ship the completed leg to StonyBrook University for application of the luminescent coating. S.03.05.03 is responsible for managing the technical aspects of coating and shipping the leg back to ORNL. The leg will be provided with a nose guard for shipping and installation.

4. DRIVE

4.1 ASSEMBLY

The drive assembly, shown in Figure 14, consists of machined parts and off-the-shelf mechanical and electrical components. The size and complexity of these components require specific attention to detail during assembly and checkout. The machining, assembly, and acceptance of the drive (without shaft or segments) testing will be performed by a single vendor to ensure a functional product. A single vendor responsible for assembly and fabrication will expedite rework of non-conforming materials and will also expedite rework in the event the design documents have errors and omissions. Detailed aspects of the design are often caught during the assembly process and most easily handled when the system integrator can provide rework services under the same contract.

ORNL resources will be on-site and integrated with the assembly and fabrication vendor to ensure that Nonconforming materials, redlines and change requests are handled appropriately. The culmination of the effort is a factory acceptance test for the drive with an as-built drawing set.

The complexity and size of the components call for the use of local and domestic vendors. The vendors would be responsible for machining the needed parts and assembling the drive. The following list goes into detail on some of the critical components of the drive.

4.2 MOTOR

A frameless servo motor has been selected to drive the target assembly. Large frameless servo motors mount directly on the shaft to employ the structure of the shaft directly. The preferred vendor, Kollmorgen, has a line of radiation hardened materials that they are willing to employ on the motor. The size, geometry and construction are stocked catalog items, built with radiation tolerant materials. The motor is easily accessed in-situ and will require preventative maintenance. Several motors are expected over the lifetime of the drive, and it is desirable to have a working relationship with several vendors with a design envelope and performance specifications that are not unique to a single vendor.

4.3 CROWN

The crown is a large, machined component fabricated from an Inconel 625 forging with internal water passages and sealing surfaces. It is designed to last the life of the facility. Certain surfaces will require hardening to survive multiple replacement activities of the water block, bearing assembly, and motor assembly. This crown will require typical turning, hardening (Kolsterising) and small amounts of welding,

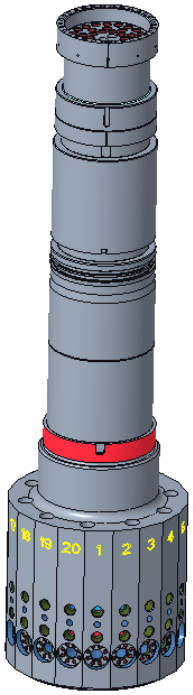

Figure 7 - Crown

4.4 BEARINGS

The drive is supported by standard bearings available from Schaeffler, (and other vendors). The bearings operate in ambient conditions, that is they are not in the core vessel vacuum and can employ radiation resistant greases and oils.

4.5 LUBRICATION

The bearings will be lubricated with Moresco RG-42-1s which has demonstrated superior performance within radiation environments. The grease will be metered into the bearings by an automated lubrication system controlled by the drive control system.

4.6 ROTARY VACUUM SEAL

The rotary seal between the shaft and housing is a customized seal cartridge that includes graphite face seal, where the mechanical faces of the stationary and rotating components are in direct contact. The seal prevents grease and oil from entering the core vessel and spoiling the rough vacuum. The geometry of these seals is customized, but the sealing technology is well developed and available from several vendors including, Chesterton, Saint-Mary's Carbon, ROC Carbon, and Technetics group. Graphite has a very high level of radiation resistance. A similar graphite face seal is used at the European Spallation Source on the helium rotary seal.

4.7 ROTARY WATER SEAL

The joint between the stationary water piping (facility) and the rotating water valve block is a modified off the shelf rotary union from DSTI and likely available from several vendors. The rotary union is a common supply and return (two port) union that will have modified materials of construction for radiation

resistance. The modification of an off-the-shelf part will narrow the available vendor pool but will not force the project to rely on a single vendor for the initial procurement or later in the life of the facility.

4.8 WATER MANIFOLD

The manifold is a machined and turned distribution element. This machined element integrates off-the-shelf dry break couplings.

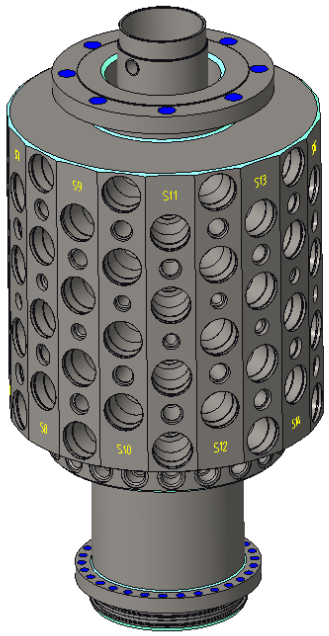

Figure 8 - View of distribution manifold

4.9 RESOLVER

The drive will employ an off-the-shelf resolver to determine the angular position of the targets in the core vessel while also being able to withstand high levels of radiation. The integration vendor will buy the resolver as a catalog item.

5. ASSEMBLY

After the system has undergone a successful factory acceptance test, the drive, shaft and segments will be assembled in the Mockup Test Stand (MUTS) at ORNL. During this assembly, the drive will be bolted to the shaft, and the target segments will be hung in place. Assembling prior to core vessel installation is intended to allow for demonstration of segment installation, alignment, removal, and critical drive maintenance operations on the complete target assembly. The MUTS will be used to allow rotation for a planned 1,000 hours to ensure reliable operation. There will be laser tracker monuments on the target drive so the assembly can be surveyed prior to installation. The target blocks will be mapped to the laser tracker monuments, so their locations are known relative to the target drive. A full mapping will be completed prior to disassembly and installation in the core vessel. This mapping ensures that the installation team will know the target block and shaft locations after the shield blocks are in position