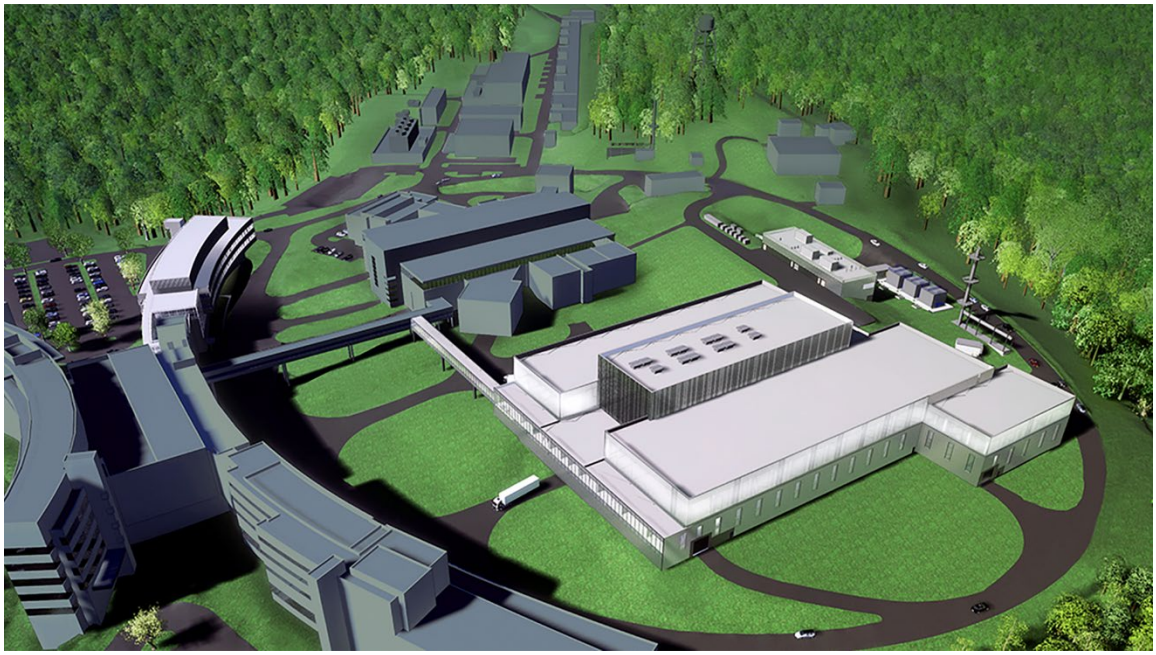
S03100400-TDO10000 R01

Second Target Station Project: Target FDR – Remote Handling Overview



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August 2026

OAK RIDGE National Laboratory

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Second Target Station Project

TARGET FDR – REMOTE HANDLING OVERVIEW

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Outline

INTRODUCTION

The Second Target Station (STS) project will upgrade the existing Spallation Neutron Source (SNS) that currently operates at Oak Ridge National Laboratory by delivering a new target station optimized for high brightness neutron production. At the heart of that system are several critical perishable components, including the target assembly. The target assembly is comprised of three main sub-systems: drive assembly, drive shaft, and segments (20X).

Due to the irradiated conditions of the components at the end of operational periods, it will be necessary to develop processes and tooling to facilitate removal and replacement of these items using remote handling techniques to provide adequate radiation protection to workers and the environment.

This document will provide an overview of the remote handling operations that will be employed to support the required maintenance operations for the various target assembly components. Additionally, the procedures outlined also demonstrate compliance with the following target assembly requirements:

- 1504: Segment shall be capable of replacement within 240 hours
- 1622: Seal or drive bearing shall be capable of replacement within 72 hours
- 1624: All instrumentation shall be capable of replacement within 72 hours
- 2998: Motor assembly shall be capable of replacement within 72 hours

1 APPLICABLE DOCUMENTS

- S03020000-TOG10000; STS Target Assy Maintenance and Operations Manual
- S03120100-TRT10015; Analysis of Second Target Station Target Segment Removal Dose Rates

2 MAINTENANCE OVERVIEW

2.1 TARGET SEGMENT

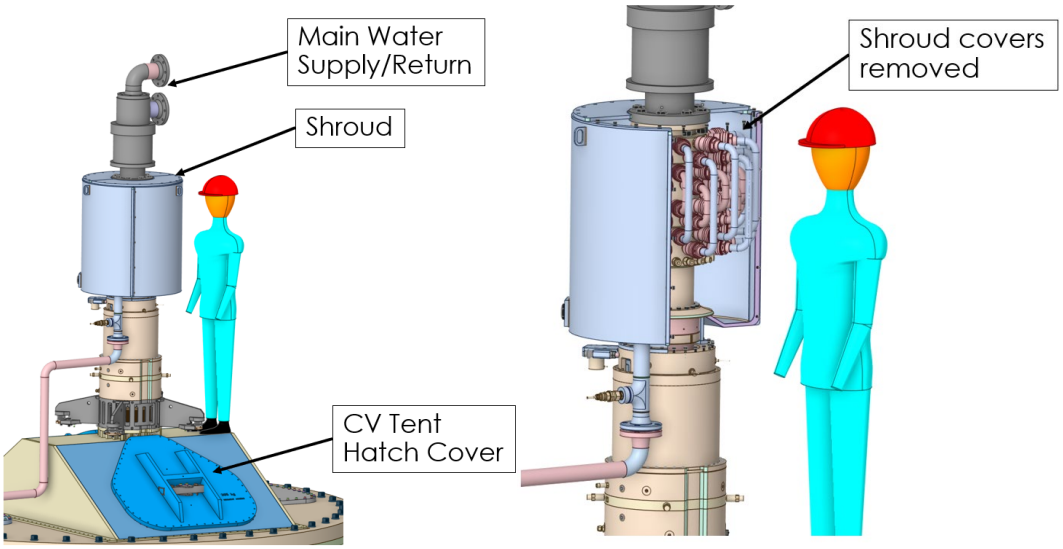
There are twenty (20X) target segments mounted on a rotating drive shaft. All segments are identical in design but are discretely controlled and monitored for cooling, function, and performance. The target segment design lifetime is 10 years. Target segment replacement interval (recommendation) is 3 segments per year for the first 5 years, then 2 per year afterwards. Alternate replacement intervals may be chosen upon entering operations. Regardless of interval, target segment replacement will be a regularly scheduled event performed by STS personnel.

To replace a target segment, the general sequence subsequently outlined will be followed. *Sequence of steps and estimated time durations are based on similar processes and experiences from SNS.

After establishing beam-off conditions, a recommended decay time of 8 hours has been established. During this time, venting the core vessel to atmosphere can be conducted. Removing hydrogen and making the MRA inert can also be conducted, although not required. Additionally, work to remove the Target Drive Room (TDR) roof supplemental shielding and

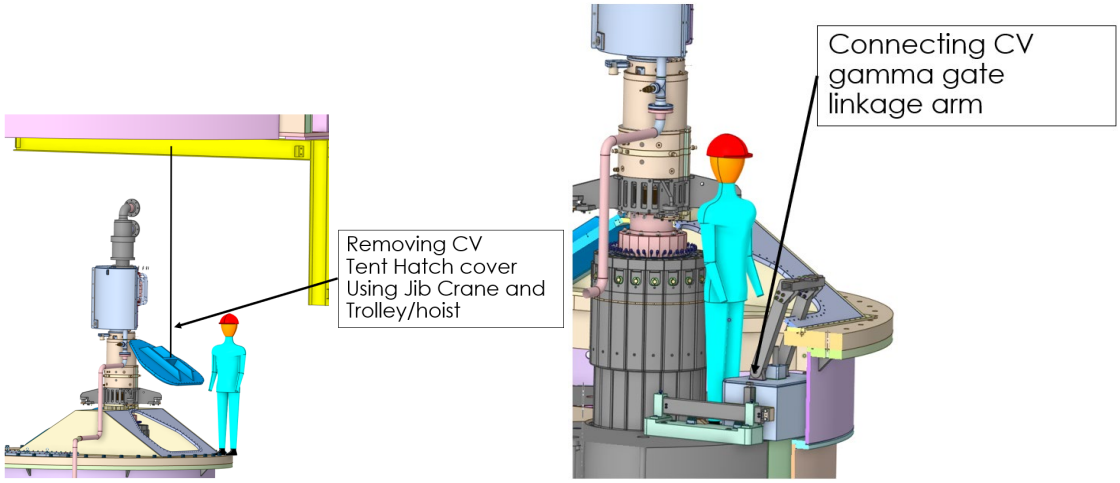
remove the specific TDR roof hatch that vertically aligns above the target segment access port can be completed during this time. Final preparations for target segment removal and replacement involve lifting, transferring, and installing the TDR gamma door and connecting it to the PLC controls cabinet and making sure it is operational.
Upon personnel entering the TDR, the initial set of tasks to be performed all occur working above the core vessel lid. All tasks are accomplished via hands-on techniques. Turn on the CV-Target air cooling system and turn off the main water supply to Loop #1. Drain and blowdown the target crown assembly. Optionally, Herculite® may be placed on the floor and on/around the target drive assembly to help control contamination risk potential during the maintenance operations.

Unbolt and remove partial shroud in pieces	1 hr



Some potential risks associated with the steps above include requiring longer decay times before performing hands-on work and accidentally damaging any wiring or sensors mounted beneath the shroud thus requiring repair or replacement.

Rig jib crane to CV tent hatch covers	0.5 hr
Unbolt CV tent hatch cover (66X)	0.5 hr
Lift and transfer CV tent hatch cover in TDR	0.5 hr
Connect linkage arm of CV gamma door to drive unit, remove shield block seismic restraints	1 hr
Connect CV gamma door to control cabinet, test motion.	1 hr
Install, setup, and align remote cameras in TDR. Verify function	2 hr

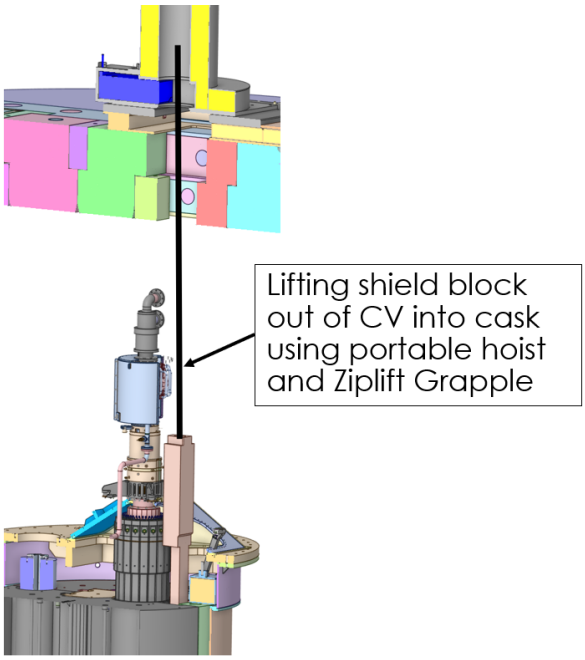


Some potential risks associated with performing these steps include difficulty in removing all CV tent hatch cover screws, damaging the seal or sealing face during hatch removal, inability to connect linkage arm to gamma gate, and improper function of gamma gate.

After completion of preparatory work both within the TDR and in the high bay, then work to remove components out of the core vessel shall begin. This work will involve personnel working at the top of the shield stack housed within the core vessel as well as at the high bay floor elevation. For this work, some tasks are hands-on while others are performed remotely using customized tooling. These tasks focus on removal of the target shield block, which is an irradiated but reuseable component.

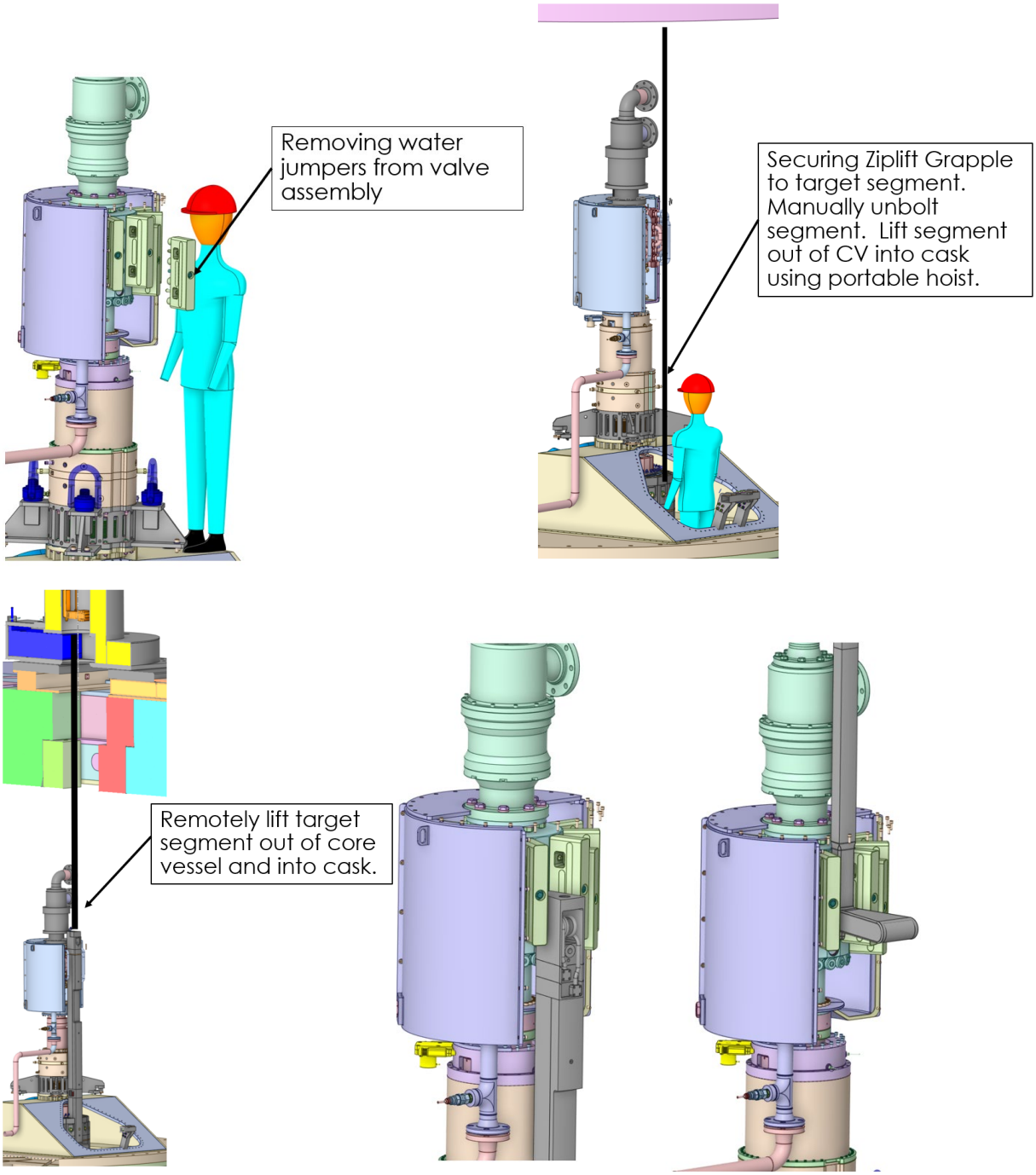
Lift, transfer and install shield block cask adjacent to TDR gamma door. Unbolt cask bottom plate.	1.25 hr
Lift, transfer and install cask onto TDR gamma door	0.5 hr
Lift, transfer and install portable hoist onto cask. Connect hoist utilities. Verify function.	2 hr
Lower chain from hoist and attach Ziplift grapple to shield block	0.5 hr
Retract shield block out of CV into cask	0.75 hr
Disconnect Ziplift from shield block. Remove hoist from cask.	2 hr
Lift cask off TDR gamma door and install onto bottom plate. Secure bottom plate. Transfer cask to temporary storage area	1.5 hr

As part of the use of the portable hoist, both the CV gamma door and TDR gamma door will be opened/closed in various configurations during different parts of the process to minimize radiation exposure effects originating from the core vessel and its components.



Potential risks associated with these steps include rigging and removing the shield block into the cask. Potential binding or misalignment as the shield block is removed or installed could require multiple attempts to complete these steps. Additional alignment and guiding features will continue to be developed for this operation.

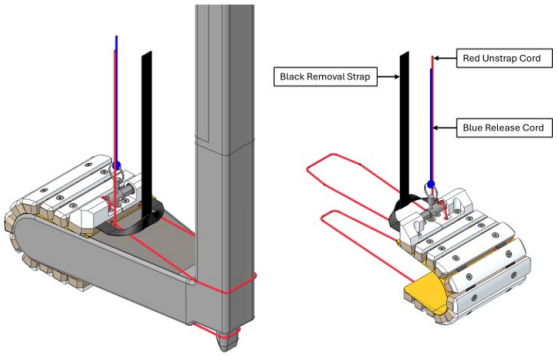
Disconnect segment-specific supply and return water jumpers from crown, connect N2 input line and drain output line	1 hr
Perform target segment blowdown	3 hr
Lift, transfer, and install segment cask to TDR gamma door	1 hr
Lift, transfer and install portable hoist onto cask. Connect hoist utilities. Verify function.	1 hr
Lower chain from hoist and attach Ziplift grapple to target segment	0.5 hr
Disconnect segment from drive shaft	0.5 hr
Retract segment out of CV into cask	0.75 hr
Disconnect Ziplift from segment. Remove hoist from cask.	3 hr
Transfer cask to temporary storage area	0.5 hr



Potential risks for performing these steps include target segment blowdown not complete or takes more time than anticipated, damage to the drain and purge ports requiring repair or replacement, damage to the segment-shaft sealing surface requiring repair, gamma doors unable to open/close as required, and rigging and removal of the target segment into the cask. Potential binding or misalignment as the segment is removed or installed could require multiple attempts to complete these steps. Additional alignment and guiding features will continue to be developed for this operation.

Total time to remove one target segment is currently estimated to be completed in less than 90 hours. For removing additional segments, personnel would rotate the target assembly into the next applicable segment removal location and perform the applicable steps from above. The time to remove two additional segments is estimated to be completed in less than 60 hours.
*NOTE: Operational steps outlined above do not include any radiological survey activities that will be part of the maintenance procedures.

Installation of new segments follows much the reverse process for removal. The time to install a single new target segment is estimated to be completed in less than 80 hours. This time includes cleaning up of all equipment within TDR, re-installation of TDR roof hatch plug and TDR supplemental shielding, turning on all utilities, re-establishing CV vacuum conditions, and finally turning beam on. Critical hands-on process steps in the installation process include the removal of the target segment nose protector/installation fixture after the new segment is installed/located properly in the core vessel and completing the target segment leak testing in-situ using air/N2/other gas prior to establishing water flow to the segment.



Based on the planned operations, tooling, and estimated time durations outlined above requirement 1504 is satisfied initially assuming an 8-hour workday, 5 days per week during maintenance outage period.

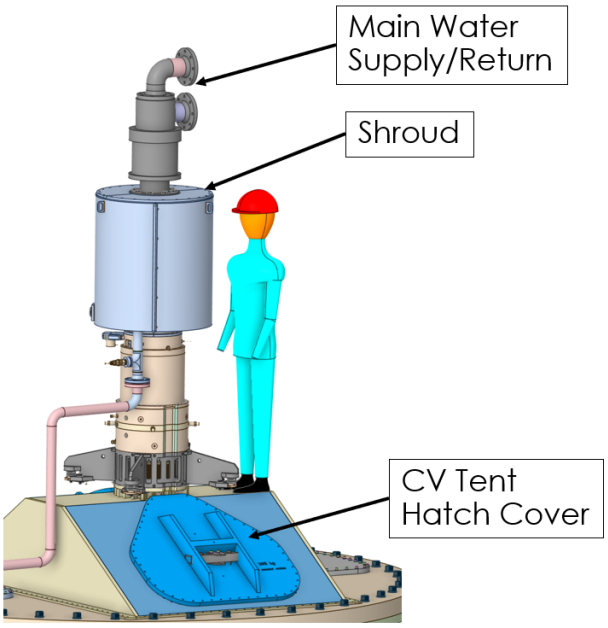
2.2 TARGET DRIVE ASSEMBLY

The target drive assembly is comprised of several key sub-assemblies and is mounted at the top of the drive shaft. The drive assembly is comprised of a rotary union/valve assembly for receiving and distributing cooling water to the segments and shaft, a motor assembly containing motor, resolver, and other sensors, and finally a bearing assembly which contains the support bearings and seals for the shaft and segments and support structure for the drive assembly. The target drive assembly design lifetime is 6 years. The target drive can be removed and replaced during a single maintenance period, or various sub-assemblies of the drive may be replaced at differing intervals. Target drive assembly replacement will be a regularly scheduled event performed by STS personnel. Additionally, some limited target drive assembly maintenance can be completed without the removal of the TDR supplemental shielding and roof hatches and without the need to use the high bay crane.

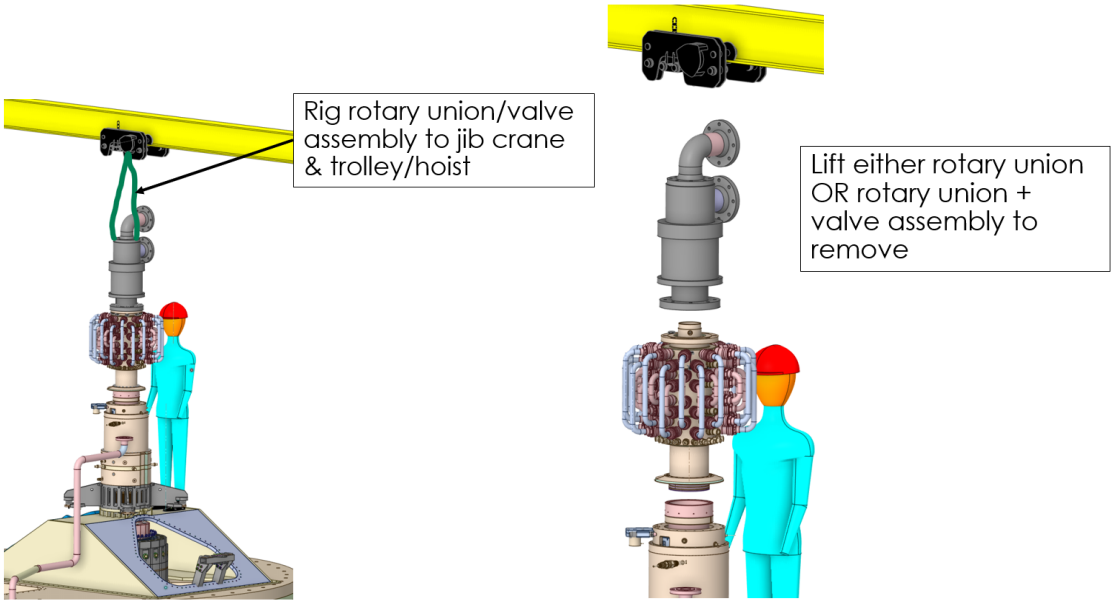
To replace a target drive assembly or any of its sub-assemblies, the general sequence subsequently outlined will be followed. For rotary union, valve assembly, motor assembly, or bearing assembly replacement, the core vessel atmosphere will need to be vented to atmospheric conditions. These conditions are required to support the target air cooling system that will be utilized during these maintenance tasks. Additionally, like above Herculite® may be utilized around the working area to control contamination risk potential. Radiological surveys will also be conducted during these maintenance process steps.

After establishing beam-off conditions, a recommended decay time of 8 hours has been established. Upon personnel entering the TDR, the initial set of tasks to be performed all occur working above the core vessel lid. All tasks are accomplished via hands-on techniques. Turn on the CV-Target air cooling system and turn off the main water supply to Loop #1. Drain and blowdown the target crown assembly.

Unbolt and remove entire shroud in pieces. Unbolt and remove shroud drain line.	2.5 hr



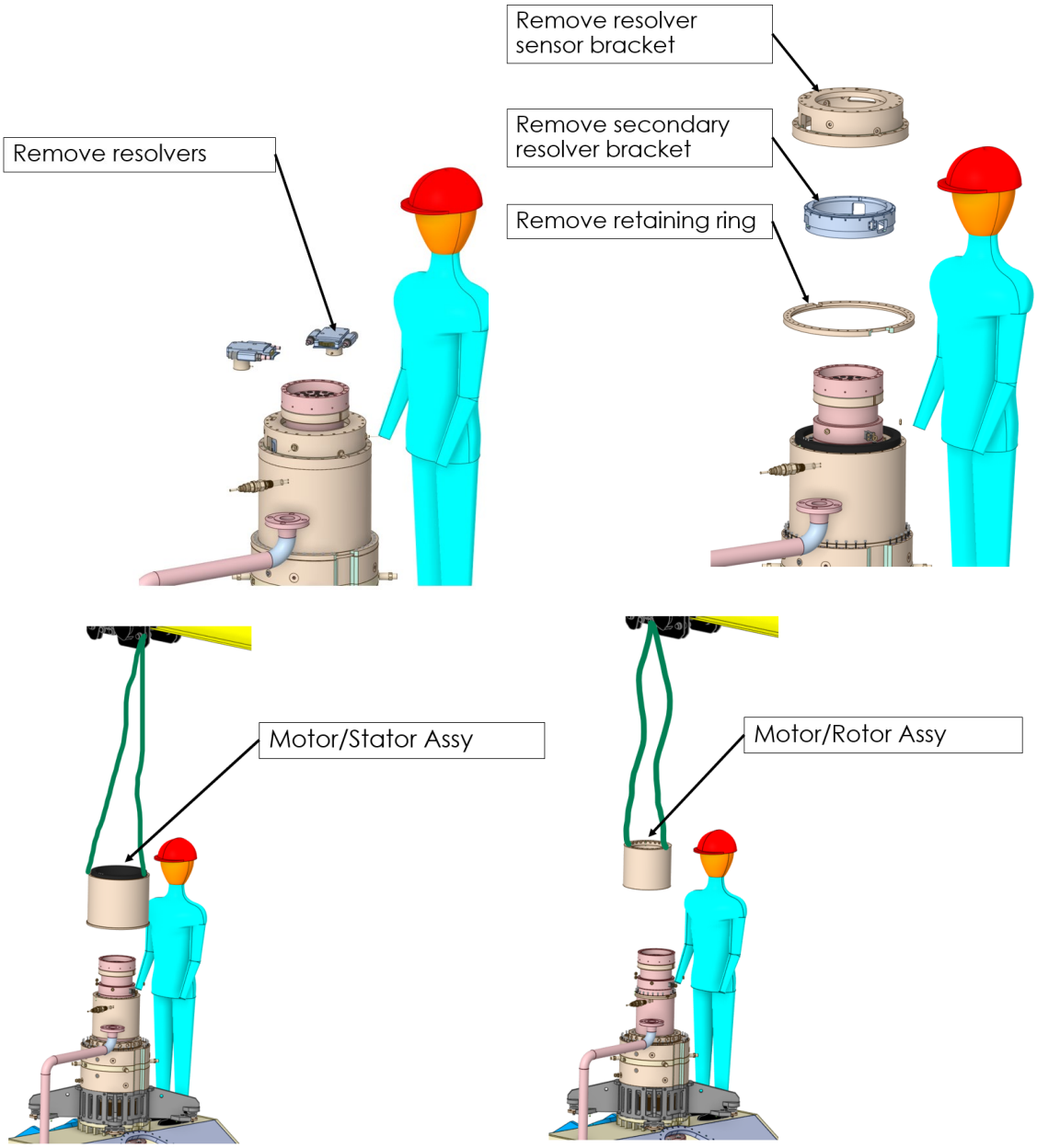
Rig TDR hoist to rotary union/valve assembly	1 hr
Disconnect main water jumper lines from rotary union	1 hr
Unbolt either rotary union (8 screws) from valve assy OR unbolt valve assy from target crown (40 screws)	1 hr
Lift component off target drive assy. Transfer away to further processing. Unrig item from hoist	0.5 hr



A new rotary union/valve assembly may be pre-assembled and ready to install prior to performing this maintenance event. The total time (including decay time) to remove and install a new assembly as shown is estimated to be completed in less than 50 hours.

If additional target drive sub-assemblies are required to be replaced, then proceed to the next section for motor assy removal.

Disconnect motor electrical connections, water lines	1.5 hr
Remove resolver assemblies, resolver/sensor mount brackets, motor retaining ring	2 hr
Rig TDR hoist to motor stator assy	1 hr
Lift component off crown, transfer away within TDR, unrig from hoist.	0.5 hr
Rig TDR hoist to motor rotor assy	1 hr
Lift component off crown, transfer away within TDR, unrig from hoist.	0.5 hr

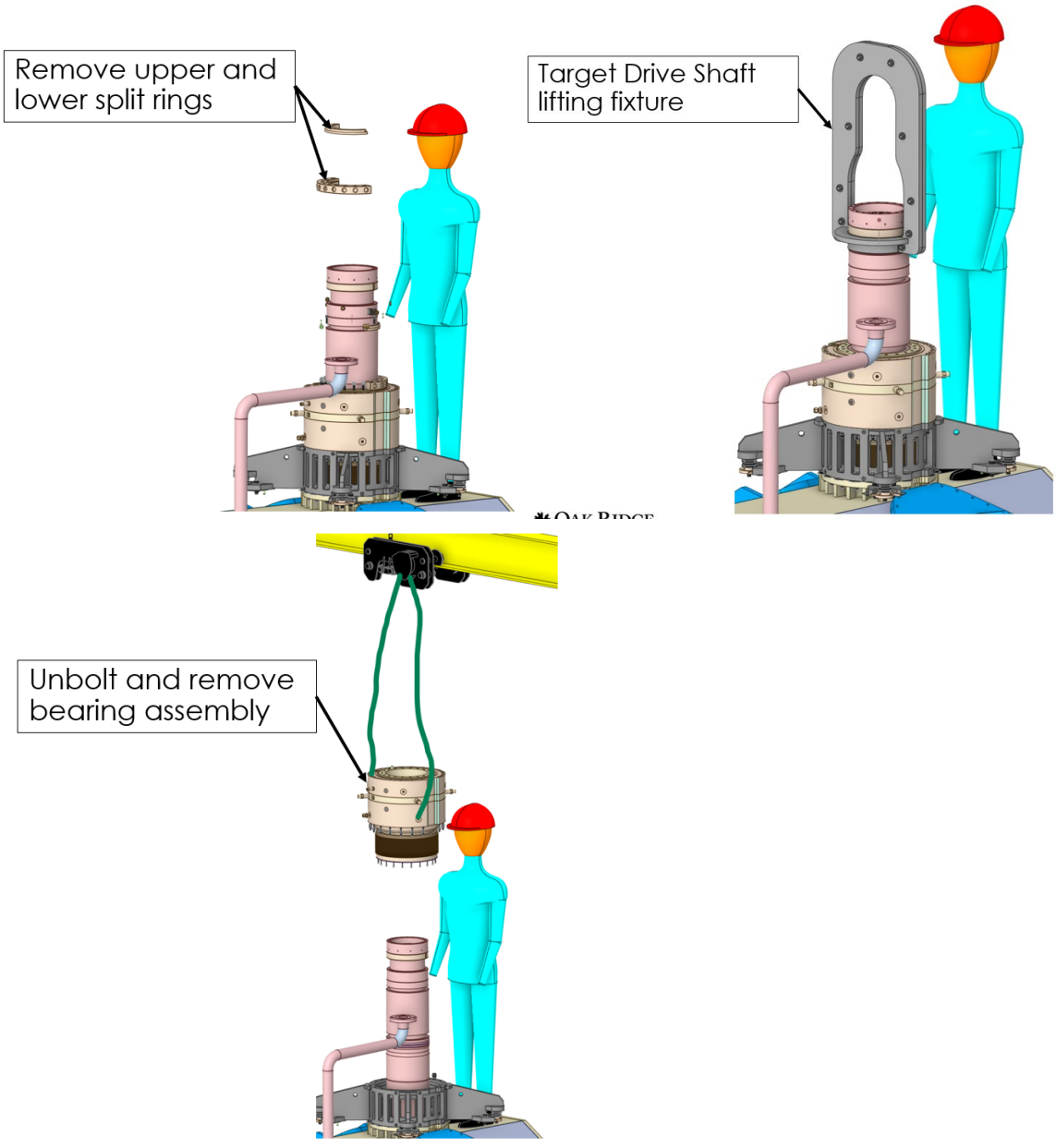


Similar to above, a new motor assembly may be pre-assembled and ready to install prior to performing this maintenance event. The total time to complete motor replacement is estimated to be completed in less than 90 hours.

If the final target drive sub-assembly (bearing assy) is required to be replaced, then proceed to the next section.

As part of bearing assembly replacement, remove TDR supplemental shielding and Target Segment & MRA roof hatch plugs	4 hr
Unbolt and remove upper split ring	0.5 hr

Rig overhead crane and lifting fixture to drive shaft. Slightly raise shaft	2.5 hr
Unbolt and remove lower split ring. Sit drive shaft down onto support lock ring. Unrig overhead crane from shaft. Unrig lift fixture	2.5 hr
Unbolt bearing assy and bellows assy from target drive structural weldment	2 hr
Rig TDR hoist to bearing assy	1 hr
Lift component off target drive assy. Transfer away to further processing. Unrig item from hoist	0.5 hr



Potential risks for performing the steps for replacing any of the components that make up the target drive assembly include target crown draining and blowdown not complete or takes more

time than anticipated, damage to the various crown sealing surfaces requiring repair or replacement, rigging and removal (or inability of removal) of the crown components within the TDR, failure of seals or other components that could cause oil (or other materials) to enter the core vessel environment. Potential binding or misalignment as the crown components are installed could require multiple attempts to complete these steps.

Similar to above, a new bearing assembly may be pre-assembled and ready to install prior to performing this maintenance event. The total time to complete bearing replacement is estimated to be completed in less than 145 hours.

*At the time of the FDR, the 90-hour time estimate to complete a target motor replacement and the 145-hour time estimate to complete a bearing replacement do not meet the requirements specified in 2998 and 1622. With additional process development and hands-on training, it is probable to reduce operational durations for both tasks, but it is difficult to predict if the 72-hour requirement could be achieved.

2.3 TARGET DRIVE SHAFT

The target drive shaft is a water-cooled sectioned structural assembly connected with bolts. It is designed to receive the target segments and target drive via bolted joint interfaces. The target drive shaft design lifetime is greater than 40 years (life of facility). Therefore, no regularly planned maintenance activities are associated with the drive shaft. Initial evaluation and design have confirmed the drive shaft could be removed and replaced during an off-normal event if required.

3 CONCLUSION

Remote handling tooling and operations are deemed necessary and essential to support target assembly maintenance operations of removal and replacement. This document has provided a summary overview of the planned remote handling operations at the time of the target assembly final design review (FDR). Additional planning and development will continue beyond FDR. A mockup test stand (MUTS) is also within the remote handling scope and is expected to be constructed prior to beam-on operations of the facility. This MUTS will be used to develop, test, and practice all remote handling operations.
The remote handling scope and methodology appears reasonable for supporting these maintenance operations. The requirements associated with maintenance operations are not fully satisfied, but the results are deemed acceptable to move the design forward into FDR.

4 WASTE DISPOSAL PREPARATION

After removal of the target segments from the core vessel post beam operations, they will be transferred to the service cell for waste disposal preparation activities. The scope of these activities is the responsibility of Remote Handling (S.03.10). These activities are required to be performed on every target segment to facilitate the ability to ship these items offsite and be received at an appropriate waste disposal facility. These activities include temporary storage for decay, dewatering and drying of target segments, downsizing target segments, and waste disposal loading. Temporary storage will be provided in the service cell to allow the irradiated target segment components to decay (cool down) to reach acceptable activation/dose rate levels to facilitate processing. Dewatering and drying will be performed to evacuate any residual water from the segment after completing the blowdown procedure. Downsizing

the segment will be completed in the service cell to allow for the segment to have an appropriate form factor to properly fit in the designated shipping container. Waste disposal loading of the downsized target segment items will be completed in the service cell. This process will package QTY 2 segments, in a downsized configuration, in a waste disposal liner and subsequently loaded into an appropriate shipping container to transfer to the disposal site.

The target drive assembly components can be removed and replaced post beam operations using all hands-on techniques. The drive assembly geometry is a much smaller form factor than the segments in addition to the fact it can drain all residual water from the items while still in its operational location, thus not requiring additional dewatering or drying or downsizing in the service cell. Storage for decay for these items can be provided within the service cell, although it is not necessarily required due to the much lower activation/dose rate levels originating from these items. These parts may be packaged into a similar shipping container as the segments, or alternatively other shipping containers may be selected for transfer to disposal sites.

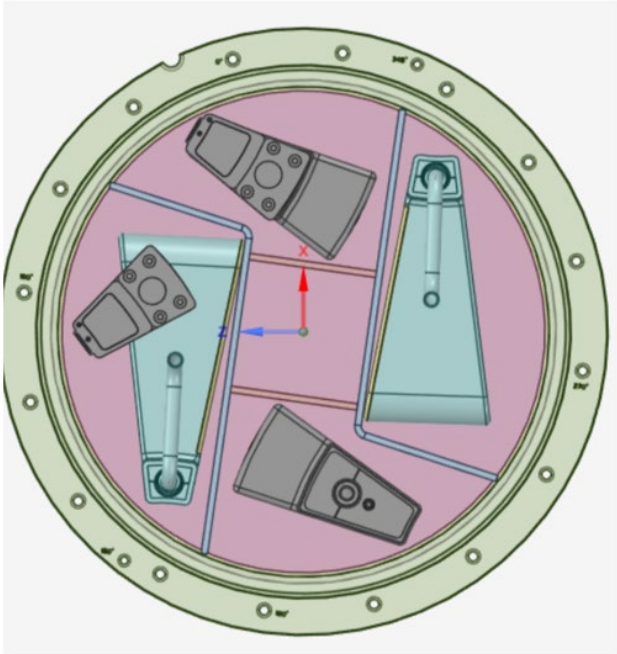


Figure 1: Target Segments inside Disposal Liner

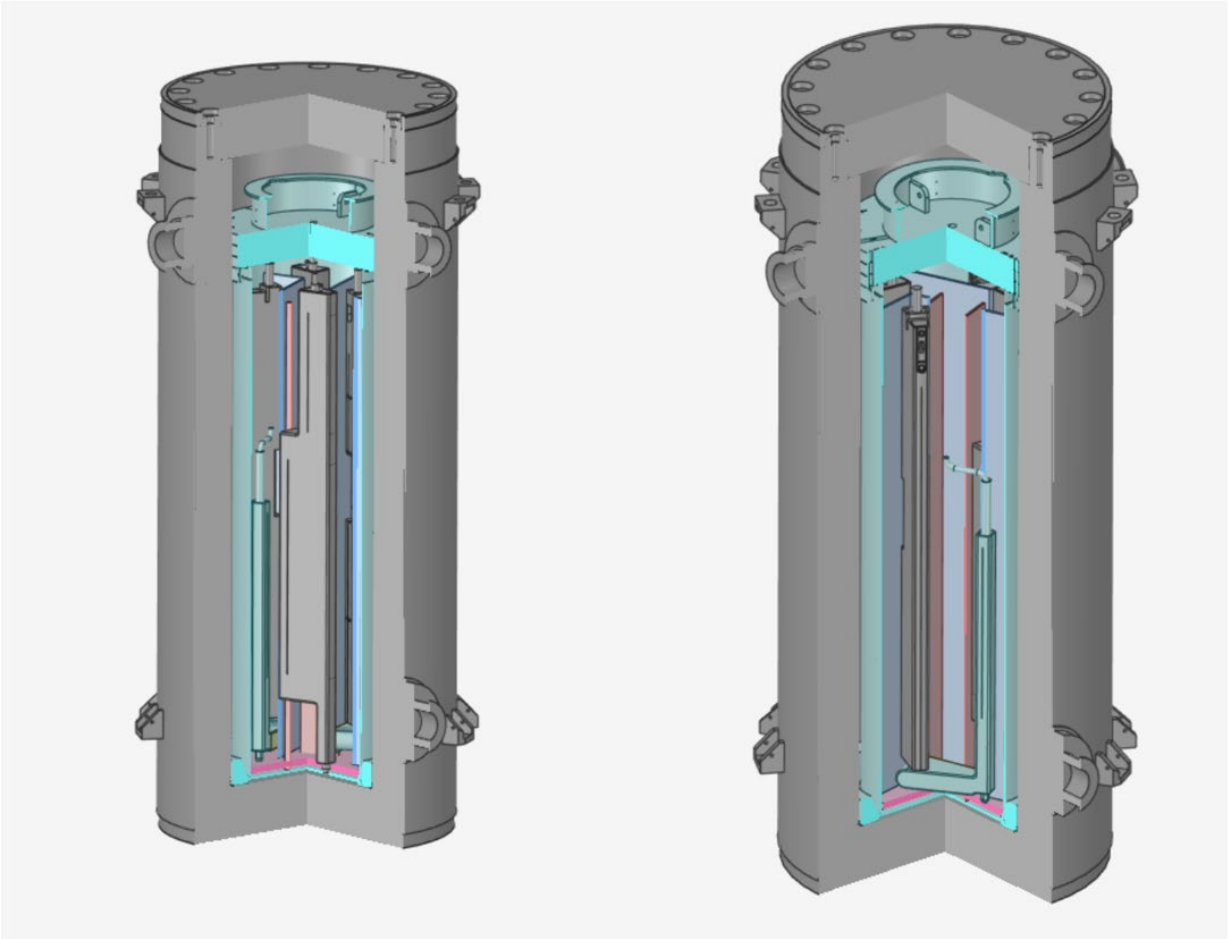


Figure 2: Target Segment Waste Disposal Package inside Shipping Container