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NSTX-U 2nd Neutral Beam Relocation

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Abstract— The NSTX-U project required doubling the Beam Injection Power and extending pulse length. As a result, a second neutral beam (BL2) was brought in from the old TFTR Test Cell. The TFTR beam line had a Tritium contamination level of 120 million dam/100 sq. cm. The overall weight of BL2 was 72 Ton and its components weighed much as 40 Tons. Transporting the beam line from the TFTR Test Cell to the NSTX-U Test Cell without spreading contamination was a major priority. The components of BL2 were disassembled in order to simplify transportation and be able to decon all parts of the beam line. Decon reduced tenaciously held tritium contamination within the beam line surfaces to approximately two orders of magnitude. Some building structures had to be removed including 9 Ton lintel shield blocks and HVAC ducts to open up space for the beam line transportation. The 40 Ton NB Box was transported from the TFTR Test Cell to the NSTX-U High Bay area by sliding it over air casters and was then moved into the NSTX Test Cell by using the overhead crane to lift it above the 22 ft shield wall. The Lid was then brought in and placed inside the Box followed by other components including the 90" Flange, Magnet, Ion Dump, Exit Spool, TIV, Calorimeter, platforms and Beamline Sources. Three High Voltage Enclosures (HVE) were installed in the NSTX-U Test Cell and connected to the beamline sources using transmission lines. At completion of the 2nd Neutral Beam relocation, a platform was built to provide walkway to and from the 1st Neutral Beam and existing NSTX-U Test Cell Platforms.

Keywords— *NSTX-U; Neutral Beam; Decon; High Voltage Enclosures*

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I. INTRODUCTION

The Princeton University's Plasma Physics Laboratory (PPPL) had successfully completed an upgrade project of its experimental fusion reactor, known as National Spherical Torus Experiment Upgrade (NSTX-U), with a cost of $96 million under contract from the US Department of Energy (DOE). As part of this upgrade project, a second Neutral Beam Injector (NBI) which is named BL2 was added to the NSTX-U reactor [1]. The NSTX-U BL2, which was brought in from the old TFTR Test Cell (TC), used to be TFTR BL4 and was used in the Deuterium-Tritium experiment. The BL2 was required in order to double the neutral beam injection power and extend pulse length for the experimental fusion reactor [2].

The BL2 overall weight was around 72 Ton. The components of BL2 needed to be disassembled because the 75 Ton overhead crane in the NSTX-U TC was not capable of carrying the full weight of BL2 together with lift fixtures, slings, shackles and other rigging equipment necessary during the lift. Another reason for disassembling the BL2 was that the components of the beam line including the cryo insulation and o-ring seals were more than 2 decades old and would need replacement. The desire to minimize the tritium contamination within the NSTX-U Vacuum Vessel during the transportation of the beam line was also another very important reason for disassembling. Therefore; the NBI project plan included disassembly, decontamination, refurbishment, relocation, reassembly, and alignment.

II. DECONTAMINATION AND REFURBISHMENT OF THE 2ND BEAM LINE

Disassembly of the beam line began after it was pumped and vented for over 20 times to reduce stray airborne tritium and it was confirmed that no tritium was identified on the stack dats measurements. The beam line elements were set up in the TFTR TC for decon and refurbishment. The calorimeter, ion dump, bending magnet and shield, 90 inch flange, BL Lid and panels, and the beam box itself were configured into high contamination stations. Decon was performed by hand-over-hand cleaning using windex and rags as well as deionized water and low pressure sprayers. The personal protective equipment used during the decon activities include double PC suits, triple gloves, boots and breathable air hoods. Decon reduced

tenaciously held tritium contamination within the beam line surfaces approximately two orders of magnitude or more from a high of 120 million dam/100 sq. cm. See Figure 1 for more information.

Fig. 1. PPPL Technicians Performing Decontamination

A new Lid Stand was designed and built in order to support the large lid weldment while allowing the cryo panels to remain suspended beneath the lid without obstruction and also to be able to transport the Lid assembly. The refurbishment also included new o-rings, new cryo insulation, a few minor repairs, leak checking, and component reassembly. Also, a new ion dump full energy plate was fabricated and installed to eliminate a major source term of tritium captured within the metal lattice structure from beam impingement.

Decontamination was also performed on the TFTR TC floor and wall surfaces in order to be able to work the construction activities.

III. TRANSPORTATION OF THE NEUTRAL BEAM BOX

Relocation required some remedial work to remove two door lintels and HVAC ducting that had been installed across the large door between the TFTR TC and the NSTX-U TC. Significant design, hoisting and rigging, and decon was performed to assist the remedial work and allow the passage of the large beam box and even taller BL Lid in its stand. The two lintel shield blocks were 1 ft X 4 ft X 26.5 ft in size, weighed 9 Ton each and were seating about 20 ft above the floor. These blocks were carefully removed from the area. Preparation work was also performed in the NSTX-U TC to open up floor space and allow the beam line to enter the TC and land at its intended location. Adjacent to the South end of the NSTX-U TC is an area called the South High Bay. The large door from TFTR TC communicates with the South High Bay.

The neutral beam box was 12 ft X 14.3 ft X 18.5 ft in size and it weighed 40 Ton. The box was moved by crane to the door and positioned on air castors. A special lift fixture was designed and built to support the lift. Sheet steel runways were prepared from the TFTR TC into the South High Bay. The 50 Psig air castors were manually adjusted and controlled during the move through the door. The beam box was pulled with one forklift in tow and braked with another forklift from the rear. Figure 2 shows photos from when the beam box being transported on air casters.

Fig. 2. The 40 Ton Neutral Beam Box being Transported using Air Casters

The box was moved into the South High Bay and then lifted over the 22 ft tall shield wall, across the NSTX-U TC and placed in the NW corner on the floor. Prior to box move, the NSTX-U TC was draped in very light drop cloth plastic to minimize any possibility of contamination reaching the equipment below the flight path of the lift. Figure 3 shows the box being moved to the NSTX-U TC.

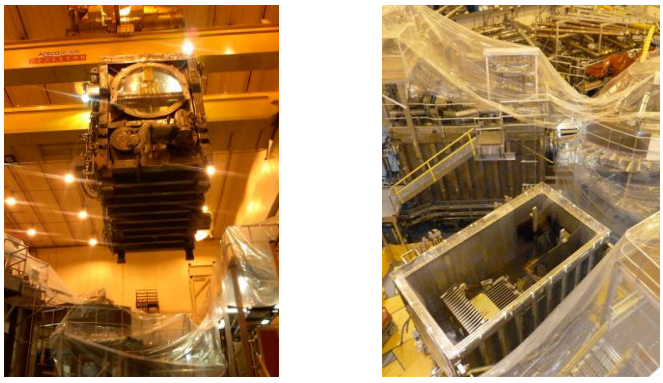


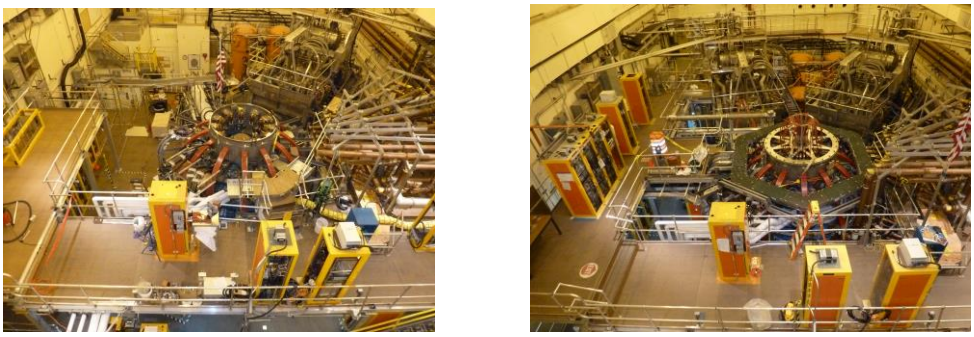
Fig. 3. The Neutral Beam Box Lifting to the NSTX-U TC

IV. OTHER CONSTRUCTION ACTIVITIES

After the box was placed in its designated location in the NSTX-U TC, the Lid was transported from the TFTR TC in a similar fashion with the NB Box. The Lid was lifted by the overhead crane in the TFTR TC and suspended; the Lid Stand was brought to the door and positioned on air castors; the Lid was then reinstalled in the stand. The Lid was towed into the South High Bay and braked in similar fashion to the beam box. The small 18 ton hook was used for the Lid because it has a higher vertical range. Figure 4 shows photos of the Lid being transported to the NSTX-U.

Fig. 4. Neutral Beam LID Installation

The box and lid were reassembled on the floor. Supports were placed under the beam line to adjust it to the mid plane of the machine. The beam line was aligned for trajectory aiming, mid plane height, and pitch and roll level. The beam line alignment was assisted by Metrology Tools and Software. This alignment was made very challenging because of the uneven NTC flooring.



(a) Prior to BL2 Relocation (b) After BL2 Relocation

Fig. 5. Photos of the NSTX-U TC Before and After the Installation of the 2ND Beam Line

The relocation continued with the installation of the 90" Flange, Magnet, Ion Dump, Exit Spool, Duct, Bellow, TIV, Calorimeter, source platforms and Beam line Sources. The three HVEs were installed in the NTC and connected to the 2nd beam line sources using three transmission lines. Platforms were built around the 2nd Neutral Beam to provide walkway to the 1st Neutral Beam and NSTX-U TC platforms. Figure 5 shows photos of the NSTX-U TC before and after the completion of the beam line transportation.

V. CONCLUSION

The relocation of NSTX-U BL2 was completed successfully. Tremendous work was performed to prevent the spread of contamination during transportation and also to decrease the radiation levels to within manageable parameter. The hoisting and rigging crew did an outstanding job in executing this critical job safely and efficiently. The beam line is functioning for experimental applications as planned.

ACKNOWLEDGMENT

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The authors would like to thank the entire NSTX-U project team.

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