



# ENG-033 - CRR - CHIT RESOLUTION REPORT

## NBI DUCT GUARD CHIT RESOLUTION REPORT

*NSTXU\_1-2-4-3-1\_CRR\_100*

*Rev. 1*

Work Planning #:  
Effective Date: **03/06/2020**  
Prepared By: **Yusi Cao**

Reviewed By	Timothy N. Stevenson, Responsible Engineer	02/28/2020 11:30:27 AM
Reviewed By	Yusi Cao, Preparer	02/26/2020 10:42:31 AM
Reviewed By	William R. Blanchard, Design Review Chair	02/27/2020 12:00:48 PM
Approved By	Yuhu Zhai, Project Engineer	03/06/2020 11:03:32 AM



# **Chit Resolution Report for NBI Duct Guard**

**NSTXU\_1-2-4-3-1\_CRR\_100, R1**

Prepared By:

\_\_\_\_\_  
Cognizant Individual – A. Cao

Reviewed By:

\_\_\_\_\_  
Design Review Chair – W. Blanchard

Approved By:

\_\_\_\_\_  
NSTX-U Project Engineer – Y. Zhai



# Record of Changes

Rev.	Date	Description of Changes
0	11/07/2019	Initial Release
1	02/24/2020	Updated with chits from the FDR

## Summary of Chits

Review	ID	Chit	Status
Heating Systems DVVR	HCDNB17	The second duct is different from the first one, how was it qualified for long pulse and/or re-ionization heat load? In general how is re-ionization protection of the ducts implemented?	Closed
NBI Duct Guard CDR	NBIDUCTGD CDR01	Please assess if there is a disruption calculation for the EXISTING shields. If there are no calculations of record, consider appending them to the calculation that will be filed associated with this design.	Closed
NBI Duct Guard CDR	NBIDUCTGD CDR02	The ceramic bushing looks very fragile. The thickness of the bushing needs to be increased to make it machinable and easy for installation. The nut should be hand tightened and welded to the stud afterwards.	Closed
NBI Duct Guard CDR	NBIDUCTGD CDR03	Minimize or eliminate trapped area for vacuum purpose regarding the shield bolting design	Closed
NBI Duct Guard CDR	NBIDUCTGD CDR04	Cost and Schedule discussion only included design. Recommend meeting with NB team to determine if they have resources allocated if not generate BCP.	Closed
NBI Duct Guard CDR	NBIDUCTGD CDR05	consider extending ceramic bushing to prevent plate to stud contact if the plate slides.	Closed
NBI Duct Guard CDR	NBIDUCTGD CDR06	account for or ensure stud preload is not lost due to thermal cycles.	Closed
NBI Duct Guard CDR	NBIDUCTGD CDR07	Please assess if there are practical means to install one or more TCs behind the plate, respecting the requirement for maximum duct clearance.	Closed
NBI Duct Guard CDR	NBIDUCTGD CDR08	Update requirements as needed including for heat loads due to pulse lengths and duct pressures as well as EM and disruption loads	Closed
NBI Duct Guard FDR	ITFTWFDR01	Ensure the vespel part is under temperature limit	Closed
NBI Duct Guard FDR	ITFTWFDR02	Must finalize and obtain approver signature for Chit Resolution Report, NSTXU_1-2-4-3-1_CRR_100. Also, need to finalize the signatures and filing of NSTXU_1-2-4-3-1_CALC_100. Also, please obtain PE (Yuhu) signature on the DRP (per NSTXU QA Plan)	Closed
NBI Duct Guard FDR	ITFTWFDR03	convert memo on re-ionizing heat load to a calculation	Closed

# Table of Contents

1	CLOSED: HCDNB17 – Review Duct Re-ionization Protection.....	6
2	CLOSED: NBIDUCTGDCDR01 - Append Disruption Calculation .....	6
3	CLOSED: NBIDUCTGDCDR02 - Consider Design Improvements.....	7
4	CLOSED: NBIDUCTGDCDR03 - Minimize Vacuum Trapped Area .....	7
5	CLOSED: NBIDUCTGDCDR04 - Review Resources and Cost.....	8
6	CLOSED: NBIDUCTGDCDR05 - Ensure Electrical Isolation.....	8
7	CLOSED: NBIDUCTGDCDR06 - Ensure Stud Preload .....	8
8	CLOSED: NBIDUCTGDCDR07 - Consider Using Thermocouples .....	9
9	CLOSED: NBIDUCTGDCDR08 - Update NBI Duct Requirements .....	10
10	CLOSED: ITFTWFDR01 – Check Vespel Temperature.....	10
11	CLOSED: ITFTWFDR02 – Finalize Documentation.....	11
12	CLOSED: ITFTWFDR03 – Convert Memo to Calculation .....	11



## **Introduction**

This report provides resolution of (Recovery WBS 1.04.01.03) chits and recommendations originating from the NBI Duct Guard CDR/FDR and from the Heating Systems DVVR.

The chits in the NSTX-U Recovery chit log can cite the sections in this report as evidence of closure. The chit resolution described herein is aligned with the chit tables in the NBI Duct Guard CDR/FDR and from the Heating Systems DVVR dashboards.

## 1 **CLOSED:** HCDNB17 - Review Duct Re-ionization Protection

Review	ID	Chit	Review Board Comment
Heating Systems DVVR	HCDNB17	The second duct is different from the first one, how was it qualified for long pulse and/or re-ionization heat load? In general how is re-ionization protection of the ducts implemented?	N/A

A task has been created to address the need for design changes and protection of the Bay K duct. The chits and design reviews described herein directly address design changes to prevent damage of the vacuum vessel and sputtering of stainless steel into the plasma. Project SBS 1.2.4.3.1 confers a duct guard for usage in NSTX-U operations.

## 2 **CLOSED:** NBIDUCTGDCDR01 - Append Disruption Calculation

Review	ID	Chit	Review Board Comment
NBI Duct Guard CDR	NBIDUCTGDCDR01	Please assess if there is a disruption calculation for the EXISTING shields. If there are no calculations of record, consider appending them to the calculation that will be filed associated with this design.	Concur

The existing molybdenum duct shield in Bay A, the first neutral beam duct, does not have a calculation document filed for disruption loads. Additionally, a set of molybdenum shields is currently installed directly upstream of the proposed duct shield in Bay K, the second neutral beam duct. Analysis using conservative disruption parameters was be appended as part of the calculation document (NSTXU\_1-2-4-3-1\_CALC\_100) prepared, checked, and signed for the NBI Duct Guard FDR, held on 12/16/19. This qualifies the design of the currently installed shields for NSTX-U operations.

### 3 **CLOSED:** NBIDUCTGDCDR02 - Consider Design Improvements

Review	ID	Chit	Review Board Comment
NBI Duct Guard CDR	NBIDUCTGDCDR02	The ceramic bushing looks very fragile. The thickness of the bushing needs to be increased to make it machinable and easy for installation. The nut should be hand tightened and welded to the stud afterwards.	Concur

The design layout presented at the NBI Duct Guard CDR was conceptual and did not include finer design details. The ceramic bushings and washers presented at the FDR will be sized appropriately to withstand disruption loads. Each nut will be spot welded to their respective stud.

### 4 **CLOSED:** NBIDUCTGDCDR03 - Minimize Vacuum Trapped Area

Review	ID	Chit	Review Board Comment
NBI Duct Guard CDR	NBIDUCTGDCDR03	Minimize or eliminate trapped area for vacuum purpose regarding the shield bolting design	Concur

The final design presented at the FDR accounts for trapped volumes and virtual leaks. Due to thermal expansion, many of the slots and clearance holes used to attach the various plates are oversized. Because of this, the design inherently vents the trapped volumes.



## 5 CLOSED: NBIDUCTGDCDR04 - Review Resources and Cost

Review	ID	Chit	Review Board Comment
NBI Duct Guard CDR	NBIDUCTGDCDR04	Cost and Schedule discussion only included design. Recommend meeting with NB team to determine if they have resources allocated if not generate BCP.	Concur

The neutral beam group has already allocated resources for the fabrication and installation of the proposed duct guard, per the WAF provided by M. Cropper, titled "Neutral Beam Maintenance and Repair." \$144k has been allocated under cost center 1150, work package HTGS, and job number X290. An updated, post FDR, cost estimate has been provided and presented at the FDR using the Fast Track estimating software.

## 6 CLOSED: NBIDUCTGDCDR05 - Ensure Electrical Isolation

Review	ID	Chit	Review Board Comment
NBI Duct Guard CDR	NBIDUCTGDCDR05	consider extending ceramic bushing to prevent plate to stud contact if the plate slides.	Concur

The ceramic bushing in the final design has been extended for full coverage of the stud, which will prevent contact if the plate slides.

## 7 CLOSED: NBIDUCTGDCDR06 - Ensure Stud Preload

Review	ID	Chit	Review Board Comment
NBI Duct Guard CDR	NBIDUCTGDCDR06	account for or ensure stud preload is not lost due to thermal cycles.	Concur

As per section 3 of this report, each nut will be spot welded to their respective stud such that stud preload is not lost due to thermal cycling.

## 8 **CLOSED:** NBIDUCTGDCDR07 - Consider Using Thermocouples

Review	ID	Chit	Review Board Comment
NBI Duct Guard CDR	NBIDUCTGDCDR07	Please assess if there are practical means to install one or more TCs behind the plate, respecting the requirement for maximum duct clearance.	Concur

The proposed duct guard shall be shadowed by the currently installed molybdenum plates, upstream in the Bay K duct. This prevents a leading edge for the neutral beam to strike. Additionally, a ceramic washer must be inserted below the plates for electrical isolation. Because of these requirements, the maximum thickness of the plate shall be 1/8". Due to this maximum thickness and the desire to keep the plate a standard size, the implementation of a thermocouple would require modification of the plates to accommodate the thermocouple and wire. By slotting a molybdenum plate, there is an increased risk of a cracking, which will propagate along the length of the slot. Molybdenum is an inherently brittle material at lower temperatures, and after extended thermal cycling, may crack and fail due to such a design feature.

A second factor which makes the implementation of a thermocouple difficult is that there are no convenient feedthrough ports around the Bay K area. This would require a long thermocouple wire and the occupancy of a port in a different bay.

A third factor is that the expected thermal loading of the molybdenum plate, from the calculation appended to the FDR, does not approach recrystallization temperature of TZM molybdenum. No damage is expected to the plate, even under the conservative thermal loading applied for the calculation.

The combination of these factors makes it impractical to install a thermocouple.

## 9 CLOSED: NBIDUCTGDCDR08 - Update NBI Duct Requirements

Review	ID	Chit	Review Board Comment
NBI Duct Guard CDR	NBIDUCTGDCDR08	Update requirements as needed including for heat loads due to pulse lengths and duct pressures as well as EM and disruption loads	Concur

A standalone requirements document, NSTXU\_1-2-4-3-1\_RD\_100 Duct Shield Requirement, has been prepared, uploaded, and signed. This requirements document details the expected thermal loads due to NSTX-U pulse lengths and duct pressures. Additionally, EM and disruption loads are accounted for in the requirements document and calculated in the calculation document.

## 10 CLOSED: ITFTWFDR01 – Check Vespel Temperature

Review	ID	Chit	Review Board Comment
NBI Duct Guard FDR	ITFTWFDR01	Ensure the vespel part is under temperature limit	Change to appropriate material if necessary.

The published operating temperature limit of DuPont Vespel SP-1 (polyimide) is 300 deg C. From the analysis performed in NSTXU\_1-2-4-3-1\_CALC\_100, the NB Duct Guard plates are expected to reach a ratcheted front face temperature of upwards of 548 deg C. Although the analysis is conservative and Vespel is an isolating material, the NB Duct Guard drawing has been modified to use ceramic coated 316 stainless steel washers/bushings, instead of Vespel. These components have a melting temperature that far exceeds Vespel, and are qualified for even the most severe temperatures in the NB duct.

## 11 CLOSED: ITFTWFDR02 – Finalize Documentation

Review	ID	Chit	Review Board Comment
NBI Duct Guard FDR	ITFTWFDR02	Must finalize and obtain approver signature for Chit Resolution Report, NSTXU_1-2-4-3-1_CRR_100. Also, need to finalize the signatures and filing of NSTXU_1-2-4-3-1_CALC_100. Also, please obtain PE (Yuhu) signature on the DRP (per NSTXU QA Plan)	Concur

Final documentation has been filed and approved with all required signatures per the NSTX-U QA plan.

## 12 CLOSED: ITFTWFDR03 – Convert Memo to Calculation

Review	ID	Chit	Review Board Comment
NBI Duct Guard FDR	ITFTWFDR03	convert memo on re-ionizing heat load to a calculation	Confer with Y. Zhai, R. Ellis, and P. Titus. Update requirement document to reference calculation instead of memo.

NSTXU\_1-2-4-3-1\_CALC\_100, revision 0, referenced a memo document, HEAT191031YC01 that provided an estimate for re-ionization load on the NB duct guard plates. As per ITFTWFDR03, the memo document has been consolidated into NSTXU\_1-2-4-3-1\_CALC\_100. Revision 1 of this calculation document has been released and is filed. The requirement document has been updated to reference the calculation instead of the memo.