National Spherical Torus eXperiment Upgrade

Chit Resolution Report for TF/OH Bundle Repair

NSTXU_1-1-3-3-1_CRR_101, Rev 1
(Also includes SBS 1.1.3.3.2)

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Record of Changes

Rev.	Date	Description of Changes
0	1/31/2020	Initial Release
1	2/17/2020	Added Post FDR CHITs

Summary of Chits

Review	ID	Status
Magnets DVVR	MTF04	Closed
Magnets DVVR	MTF06	Closed
Magnets DVVR	MTF13	Closed
Magnets DVVR	MTF22	Closed
Magnets DVVR	MTF30	Closed
Magnets DVVR	MTF34	Closed
Magnets DVVR	MTF36	Closed
Magnets DVVR	MTF39	Closed
Magnets DVVR	MOH03	Closed
Magnets DVVR	MOH05	Closed
Magnets DVVR	TFOH02	Closed
Magnets DVVR	TFOH03	Closed
TF/OH Bundle Reliability PDR	TFOHBUNRELPDR01	Closed
TF/OH Bundle Reliability PDR	TFOHBUNRELPDR02	Closed
TF/OH Bundle Reliability PDR	TFOHBUNRELPDR03	Closed
TF/OH Bundle Reliability PDR	TFOHBUNRELPDR04	Closed
TF/OH Bundle Reliability PDR	TFOHBUNRELPDR05	Closed
TF/OH Bundle Reliability PDR	TFOHBUNRELPDR06	Closed
TF/OH Bundle Reliability PDR	TFOHBUNRELPDR07	Closed

TF/OH Bundle Reliability PDR	TFOHBUNRELPDR08	Closed
Magnets DVVR	MTF30	Closed
Cooling Water System Interlock PDR	CWSINTPDR01	Closed
Cooling Water System Interlock PDR	CWSINTPDR02	Closed
Cooling Water System Interlock PDR	CWSINTPDR03	Closed
Cooling Water System Interlock PDR	CWSINTPDR04	Closed
Cooling Water System Interlock PDR	CWSINTPDR05	Closed
Cooling Water System Interlock PDR	CWSINTPDR06	Closed
Cooling Water System Interlock PDR	CWSINTPDR07	Closed
Cooling Water System Interlock PDR	CWSINTPDR08	Closed
Cooling Water System Interlock PDR	CWSINTPDR09	Closed
Cooling Water System Interlock PDR	CWSINTPDR10	Closed
Cooling Water System Interlock PDR	CWSINTPDR11	Closed
Cooling Water System Interlock PDR	CWSINTPDR12	Closed
Magnet RP Scope FDR 1	RPMAGTASK1-01	Closed
Magnet RP Scope FDR 1	RPMAGTASK1-02	Closed
Magnet RP Scope FDR 1	RPMAGTASK1-03	Closed
Magnet RP Scope FDR 1	RPMAGTASK1-04	Closed
Magnet RP Scope FDR 2	RPMAGTASK2-01	Closed
Magnet RP Scope FDR 2	RPMAGTASK2-02	Closed

Magnet RP Scope FDR 2	RPMAGTASK2-03	Closed
Magnet RP Scope FDR 2	RPMAGTASK2-04	Closed
Magnet RP Scope FDR 3	PRMAGSCOPEFDRIII01	Closed
Magnet RP Scope FDR 3	PRMAGSCOPEFDRIII02	Closed
Magnet RP Scope FDR 3	PRMAGSCOPEFDRIII03	Closed
Magnet RP Scope FDR 3	PRMAGSCOPEFDRIII04	Closed
Magnet RP Scope FDR 3	PRMAGSCOPEFDRIII05	Closed

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1 FDR CHITs

Review	ID	Chit
Magnet RP Scope FDR 1	RPMAGTASK1-01	Consider issuing a drawing ECN to the TF Bundle water fitting drawing to resolve the parker/swagelock disparity in lieu of a visual inspection (which requires kapton removal).

Closed: Concur, a note will be added to the new TF Bundle drawing noting parker/swagelock fittings are nearly identical. No need to do visual inspection for part

Review	ID	Chit
Magnet RP Scope FDR 3	PRMAGSCOPEFD RIII02	NSTXU_1-1-3-3-2_CALC_100 is pending review in DMS. However, the signatories on DMS don't match those on the PDF uploaded to the FDR II dashboard. Furthermore, the draft uploaded in DMS is altogether missing the calc and checker forms which appear in the PDF. Please ensure that the DMS upload includes all pages (calc & checking) and has the appropriate signatories. Please ensure that it then gets fully signed in DMS.
Magnet RP Scope FDR 3	PRMAGSCOPEFD RIII03	NSTXU-CALC-133-20-00 is a legacy calculation but the link in the NSTXU Documents Index is broken. Calculation is not retrievable. Please work with Kathleen to ensure that, at a minimum, the link is restored (pending a mass migration of legacy documents into DMS).
Magnet RP Scope FDR 1	RPMAGTASK1-04	NSTXU_1-1-3-3-2_CALC_100 has been properly signed via PDF signatures. There is a pending DMS entry for it, but the review/approval personnel that were defined in DMS don't match those that signed the PDF. Work with Kathleen to ensure consistency when this CALC gets uploaded to DMS.

Closed: CALC properly uploaded and approved in DMS on 2/28/2020

Review	ID	Chit
Magnet RP Scope FDR 2	RPMAGTASK2-01	Please review your resolution to chit *PDR09 and PDR12...can't use budget justifications for these. Explain how Yuhu's calculation and the existing instrumentation configuration show the machine is properly protected. For Yuhu's calculation and 09, I believe the answer is that the allowed tolerance on flow is generous, and so small variations in flow are not important. For 12, the P&ID 5GA522 needs to be examined to resolve the issue.

Closed: Readdressed the previous CHITs PDR09 and PDR12. PDR09: NSTXU_1-1-3_CALC_101 shows that the flow tolerance is great, and small variations are inconsequential
PDR12: Drawing 5GA522 Sheet 19 details PF5 instrumented with two supply valves and one return, which accommodates for either supply

Review	ID	Chit
Magnet RP Scope FDR 2	RPMAGTASK2-04	The posted DRP is not numbered and not signed. DRP needs to be properly finalized in DMS. Since this is a different scope from FDR1, please ensure you don't overwrite the FDR1 DRP. Need an DRP for each, I suppose, since they're separate scopes.
Magnet RP Scope FDR 3	PRMAGSCOPEFDR III04	The DRP posted on the dashboard requires the document # and rev fields populated on the front page. It must then be uploaded and fully signed in DMS.
Magnet RP Scope FDR 1	RPMAGTASK1-02	The Design Review Plan needs to be finalized & signed (if available, consider populating the CRR number and including CALC_100.

Closed: DRP signed 2/25

Review	ID	Chit
Magnet RP Scope FDR 2	RPMAGTASK2-03	I am concerned that the strategy that has been developed, while correct for plasma/coil operations, is not correct for the bakeout configuration. This is a requirements problem first, then an issue with design (but is luckily only a SW issue). Please work with Gerhardt/Cropper/Petrella to sort this out.

Closed: Auxillary Requirements document has been updated with the proper language to capture the full design. The DC supplies have flow switches that are read by the Bakeout PLC, and Cooling provisions for the TF coil shall be identical to that during normal operations.

Review	ID	Chit
Magnet RP Scope FDR 3	PRMAGSCOPEFD RIII01	NSTXU_1-1-3-3-1_CRR_101 must be fully signed and posted in DMS
Magnet RP Scope FDR 2	RPMAGTASK2-02	CRR has been signed in PDF, but is called CRR_XXX. Please obtain a valid DMS number and file in DMS. Thank you.
Magnet RP Scope FDR 1	RPMAGTASK1-03	Chits from previous review need to be officially closed. This means we need to finalize (sign/file) the Chit Resolution Report.

Closed: Uploaded to DMS on 2/27/2020

Review	ID	Chit
Magnet RP Scope FDR 3	PRMAGSCOPEFD RIII05	Please make a measurement of the resistivity of the "grout" material.

Closed: Resistivity will be measured and noted in report

2 Cooling Fitting Upgrade

Review	ID	Chit
Magnets DVVR	MTF04	Perform the cooling fitting upgrade/retrofit to the fittings in the upper bulkhead
Magnets DVVR	MTF34	Lack of hardware verification during the assembly of coil cooling systems

Closed: CHIT RPMAGTASK1-01 Rejects these CHITs as unnecessary as Swagelok and Parker have nearly identical specs. Testing will still be done on the fittings following ENG-014

3 TFOL Cooling Tubes

Review	ID	Chit
Magnets DVVR	MTF06	The cooling tubes on the new TFOL were damaged during manufacturing. They were repaired, but it is unclear that they are reliable enough to last the full NSTX-U shot cycle

Magnets DVVR	MTF13	Cooling tubes on several of the inner legs were twisted/distorted during removal from VPI mold. They passed all pressure and flow tests and have been strain relieved, however care must be taken when working neat or with thses components
Magnets DVVR	MTF36	The TF water tubes extend top and bottom and are vulnerable to damage. While care is used in handling, some small dings and detentes appear. These tubes are difficult to mend, require protection if possible, and need delicate care during maintenance evolutions to avoid water leaks and thus preserve the life of the Centerstack.

Closed: -Hydrostatic tests were performed after after fabrication to 1.5x operating levels. We will perform this test again

-Hydrostatic tests are performed again after re-assembly of connecting hoses to 1.5x operating levels.

-Tubes are physically protected in-place by barriers.

-Tubes are inaccessible from outside the machine once assembled.

4 Cap Block Rings

Review	ID	Chit
Magnets DVVR	MTF22	Examine the spacing and material of the Cap Block rings (top and bottom) and cooling tubes. "Top Cap Block Ring" and "Bulk Head Block Inner Ring

Closed: No Stainless Steel materials located near energized parts. No action needed other than to update the drawing.

5 G-10 plate

Review	ID	Chit
Magnets DVVR	MTF39	Thermal stresses between thick G-10 plate and cooling tubes at the top/bottom of TF cool.

Closed: Cooling tube thermal expansion accommodated by nitrile washer between bulkhead bracket and G-10 bulkhead. Also addressed by simple hand calculation at a separate review by Steve R. explaining the G10 washers provide more than adequate relief for thermal growth

6 OH Ground Plane

Review	ID	Chit
Magnets DVVR	MOH03	Resistivity of the OH ground plane does not meet original requirement. Re-apply to proper specification

Closed: Perform OH Ground Plane Test Procedure to apply paint and measure the resistivity to ensure limits are within range.

7 OH Ground Plane Strap

Review	ID	Chit
Magnets DVVR	MH05	Consider re-design of OH ground plane strap to eliminate reliance on a single break, and improve attachment scheme. Introduce a second break, or otherwise reduce chance of toroReviewal short. Reduce reliance on G-10 piece to hold in place, if G-10 breaks then strap will fall off.
TF/OH Bundle Reliability PDR	TFOHBUNRELPD R04	Confirm adequacy of upper ground plane electrical connection (the intent of the chit MOH5)

Closed: MH05: A review of supporting calculations indicate the forces on the plate are small. The G-10 used is used as an electrical isolation spacer, and not a mounting bracket. The existing design is simple and robust and does not require change.

Calculation NSTXU_1_1_3_3_2_CALC_100_OH_Ground_Plane has been filed and satisfies this CHIT

8 TF/OH Grounding

Review	ID	Chit
Magnets DVVR	TFOH02	The wires in the TF-OH gap were grounded for the first run campaign. Recent calculations show that the electric field can be reduced by floating the wires. This should be assessed in light of larger grounding consideration.

Closed: The wires will be isolated from centerstack structural materials and brought to a termination block that is serviceable from the exterior of the machine. This will allow for floating, grounding, the addition of resistors, and the ability to test each wire in-situ.

9 Ground Plane Resistivity

Review	ID	Chit
TF/OH Bundle Reliability PDR	TFOHBUNREL PDR02	Please assess the documentation of the ground plane resistivity; calculation should be filed at minimum.

Closed: Calculation NSTXU_1_1_3_3_2_CALC_100_OH_Ground_Plane has been filed to detail ground plane resistivity requirements.

10 Ground Plane Power Dissipation

Review	ID	Chit
TF/OH Bundle Reliability PDR	TFOHBUNRELP DR03	Confirm that minimum tolerance value of ground plane paint resistivity does not lead to excessive power/energy dissipation in the paint

Closed: The voltage on the ground plane decays rapidly, from 600V to 50V in less than 30 milliseconds; therefore, the power dissipation is not a concern. See NSTXU_1_1_3_3_2_CALC_100_OH_Ground_Plane

11 Aquapour

Review	ID	Chit
Magnets DVVR	TFOH03	Wire stuck in Aquapour should be left floating, rather than tied to CS casing. This will minimize E-field perturbation and avoid bringing 2kV into the gap during CHI. Ends of wire should be insulated but accessible for periodic insulation resistance measurement

Closed: Same as TFOH02. The wires will be isolated from centerstack structural materials and brought to a termination block that is serviceable from the exterior of the machine. This will allow for floating, grounding, the addition of resistors, and the ability to test each wire in-situ.

12 OH Shims

Review	ID	Chit
TF/OH Bundle Reliability PDR	TFOHBUNRELPDR01	While this chit is out-of-scope for this PDR, the inspection of Aquapour wires evidenced as-built shims placed in-between the OH coil and its base. It is unclear if this as-built condition is a concern. It is recommended that the analysis group investigates whether motion between the OH and TF could cause issue with the visible interference with these shims and/or if the uneven bearing that the shims impose on the OH is problem.

Closed: This issue has been addressed in the G10 ring peer review and detailed calculation has been filed (NSTXU_1-1-3-3_CALC_104. Additional prototype testing was conducted, and a grout filler will be added to distribute the loads more uniformly.

Review	ID	Chit
MCS LOWER G10 RING RESOLUTION Peer	MCSLOW10RRESPR02	Consider if a “belly band” solution for keeping the shims in place will increase the risk of tracking across the tops of the TF Flags and take appropriate measures to minimize

Review		

Closed: Installation Procedure will be utilized to cover the TF faces, flash-shield slots, and any areas the epoxy may contaminate

13 Humidity

Review	ID	Chit
TF/OH Bundle Reliability PDR	TFOHBUNRELPD R05	The NTC humidity and therefore dew point is a significant risk to the machine beyond the Facilities responsibility to proves it. Evaluate dew point control requirements, define interfaces for hardware, responsibilities, and operations, revise operating procedures, ensure adequacy of interlocks, and considers RAMI.

Closed: The facilities are updating the HVAC system to address the cooling and particularly the humidity/dew point. The requirements of ~35% dew point have been included in the facilities scope for the test cell. In the mean-time, humidity and dew point remain a factor in conducting daily hi-pot tests.

14 Parker and Swagelok

Review	ID	Chit
TF/OH Bundle Reliability PDR	TFOHBUNRELPD R07	The Parker and Swagelok are each designed for ~4000psig. The as-built configuration (Parker nut/Swagelok body) should be pressure tested on bench to verify adequate margin.

Closed: All fittings will be tested according to ENG-014 Hydrostatic Test

15 Megger/Hipot

Review	ID	Chit
TF/OH Bundle Reliability PDR	TFOHBUNRELPD R08	Do a megger/hipot before FDR, but have an HV SME involved in the procedure and execution in order to assess the unusual configuration.

Closed: A Megger Test schedule has been established. Every 6 months the test will be performed. Data is recorded and logged.

16 Preload Bolt Tension

Review	ID	Chit
Magnets DVVR	MTF30	It sounded as a concern that if the preload bolts tension between the G-10 ring and SS flange is reduced, there is a concern that the slippage and twisting may develop at the flange-G10 interface. Install some positive means, like shear keys to prevent it and reduce the risk of motion

Closed: The preload tension on the bolts is significantly less that the allowable to the tension. Jiarong's calculation shows loads of 600-1000 lbf.

1. Grout the Type-1 bolts to register the skirt interfaces to provide positive restraints at the skirt interfaces.
2. Rely on the aquapour & friction, to provide restraint at the G10/TF interface.

17 Cooling Water Interlock

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR01	The PLC software should annunciate which flow switch caused the system to trip - so we know which FS or flow path was the cause. Consider displaying this at PLC HMI and EPICS.

Closed: There are currently individual flow switch alarms that will be displayed at the local PLC HMI

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR02	Revise the existing requirements document to specify if loss of flow in ANY cooling path shall shut the supply pumps down OR if only loss of flow on the TF & OH shall shut the supply pumps down. It is our current interpretation that any loss of flow event should shut the supply pumps down to minimize water leaks & potential damage from them, however the requirement document does not explicitly include paths other that the TF & OH.

Closed: Add the requirements to 3.1 c of Auxiliary Requirement Document

When loss of flow is detected on any TF, OH, PF, or other misc. switch monitored by the cooling system, the supply pumps shall be shut down, and supply/return valves shall be turned off

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR03	The delamination risk exists for the TF outer legs as well; if cooling is lost in one of the conductors of the outer legs, but the others are cooled, then thermal stresses to some extent will develop. The requirements should reflect this case, either by stating the specific case of the outer TF legs, or a more generic statement about "loss of cooling" cases in coils with "bonded conductors".

Closed: By shutting the pumps and valves off to stop the water flowing, Yuhu has done a calc on the inner legs calc ref NSTXU_1-1-3_CALC_101

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR04	Add a mode to the logic to allow testing of flow switches during the morning startup (prior to plasma operations and excluding plasma operations) without dropping pumps out.

Closed: A test mode will be introduced to allow water to flow, and manually check each of the flow switches to ensure PLC reads correctly

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR05	Is the resolution of the flow switches good enough to protect against flow imbalances that would harm the coil.

Closed: By shutting the pumps and valves off when a leak is detected by the flow switch, we will reduce the flow imbalance that will keep harm to the coil at the minimum

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR06	Consider adding PLC logic to stop pumps based on differential between water temperature of parallel cooling paths.

Closed: Considered, but not needed, because proposed change will shut down pumps and supply/return valves when an issue with the cooling path is detected.

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR07	Need "bakeout" mode in Water System PLC to allow condition with flow in outer layer only during bakeout (desirable) without turning off pumps.

Closed: There is no bakeout flow switch detection path for the Cooling Water System. The bakeout PLC monitors the flow level

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR08	Loss of flow triggers loss of permission for the next shot. Consider interrupting the current shot & de-energizing magnets ASAP.

Closed: The loss of water will disable the permission for FCPC to arm the coil for the next shot. If a shot is started it will not be stopped.

Review	ID	Chit

Cooling Water System Interlock PDR	CWSINTPDR09	A discussion about detecting a partially blocked flowpath, a blockage that is insufficient to trip the flowswitch , could be detected by looking at the temperatures. This is a secondary detection of the flowrate. There has been talk of installing flowmeters. If that work is done that would be a more direct method for detecting flow problems. Consider deferring the analysis and programming to detect partial blockages until nearing coil-cooling operations, and if flowmeters have been installed a cost savings will be realized. There is no requirement for partial flow.

Closed: NSTXU_1-1-3_CALC_101 shows that the flow tolerance is great, and small variations are inconsequential

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR10	For the FDR, will need to consider the new Software QA guidelines, if they are released. This may mean an independent code review of the ladder logic, or, software module testing if possible.

Closed: We are using the current approved Software Change Notice which follows the QA guidelines to update the software change.

Review	ID	Chit
Cooling Water System Interlock PDR	CWSINTPDR11	TF ONLY is a mode of the OH preheater system. In this mode OH water is valved off. This mode should be accommodated in the flowswitch-checking logic. This nuance is not in the requirements for this review.

Closed: This will be part of the program change. During TF ONLY mode, only TF water flow switches are monitored

Review	ID	Chit

Cooling Water System Interlock PDR	CWSINTPDR012	Consider adding individual flow switches in PF5Ua, PF5Ub, PF5La, PF5Lb, so that flow in individual a/b sub-coils can be detected and interlocked.

Closed: Drawing 5GA522 Sheet 19 details PF5 instrumented with two supply valves and one return, which accommodates for either supply