

# PFC FDR CHIT Resolution Report

Chit resolution report: NSTXU\_1-1-1-1\_CRR\_chit\_100

REVISION 0

September 6, 2019

**PREPARED BY:**      **Jonathan Klabacha**                      9/6/2019 9:59:59 AM

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Jonathan Klabacha,

**APPROVED BY:**      **Kathleen Lukazik**                      9/6/2019 11:50:55 AM

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**Chit Resolution Report: NSTXU\_1-1-1-1\_CRR\_chit\_100**

*List of chits closed in this report on the cover, details inside the report*

CHITS closed in this report are indicated in the Table of Contents. Each CHIT begins a new page.

*Attach total log of chits, including all those previously closed and those not yet closed.*

Attached

Cognizant Individual:

(sign and date)

Approver (\*): \_\_\_\_\_ (sign and date)

(\* ) For CDR and PDR the DRC, for FDR and after FDR the Main Approver (A-1: Chief Engineer, A-2 and A-3: DRC) DRC  
=Design Review Chairperson

## Change Log

<b>Revision</b>	<b>Date</b>	<b>Description</b>
0	8/9/2019	Initial Release

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We witnessed in testing that the rod(pin) bends and could potentially crack the tile. The solution of adding the grafoil bushing is a good option; but it helps to be tested to see if it sets. 15

**PFCPEMPFDR10 16**

Slide 12 of Bob's presentation on the OBD-R12 tile assemblies shows four shoulder screws to attach the transition plate to the OBD structure, only two of which (at the end) have marginal access for a modified hex-key to tighten them. The other two are intended to have welded-on Belleville washers to provide inhibition of rattling when the heads were slid along the key-hole slots. We discussed the possible (I would say "probable"! ) need for a wedge feature on the key-hole slot but it occurs to me that the weld will constrain the deformation of the Belleville washer, which is undesirable. Use a wedge plus a spring washer of some different type with a threaded hole so it is trapped on the screw without welding?. 16

**PFCPEMPFDR12 17**

NSTXU-CALC-11-31-00 assumes the HTP can be shimmed to within 0.003-0.005". This is not currently in the installation plan (HTP surface flatness of 0.010" was previously discussed with HTP COG). Calculation thus indicates that one of three things is required: A) The tile fish scale should be redone to the expected HTP value, or B) the HTP COG should concur that the required surface flatness can be delivered, or C) the reassembly WAF should be revisited to ensure shimming in the IP is consistent with this requirement. 17

**PROJPDR26 17**

How the Grafoil under the HHF tiles will react to pre-loads + heating is not understood. Testing should be done to make sure the tiles will maintain the proper pre-loads and positioning. 18

**PFCPEMPFDR13 18**

In slide 11 of Andrei's talk on IBDH, the 90 degree rotated tie-bar design is shown (similar to an IKEA furniture locking cam ring). Depending on the preload applied by the Belleville stacks, this might need a large torque to make the initial rotation - but once vacuum tribology and the occasional halo current has gone through the pull-down pins, they might get welded to the tie-rods. What would then be the recovery method to disassemble these components? Can you use some mismatch of alloys (maybe Monel against Inconel?) to avoid the welding effect? 19

**CSCFDR29 19**

Suggest assessment of center stack first wall under worst deformation cases and making sure internal and external (PFC) components are not damaged, or stressed more than expected.

NOTE: The original chit was split into two separate chits (see CSCFDR17 and 29). One is on the potential interference between Casing and the PFC (external CSCFDR29), and the other one is the interference between casing and the OH coil OD (internal of casing assembly CSCFDR17) 20

**LHFPDR3 23**

PFC performance & requirements must consider/asses tile to field alignment as well as tile to tile alignment. 24

**PROJPDR33 24**

PFC Supplier of graphite is unwilling to guarantee material properties. However, they will supply test data with each provided piece of material. If they are willing to share historical data on these values with us (e.g. ~35+ most recent reports), we can construct statistically significant confidence intervals for the true mean & std dev of each of the measured properties. Though short of a guarantee, it will be sufficiently reliable and should ameliorate the uncertainty which is complicating our design process. 25

**CSCFDR14 25**

Add thermocouples where the casing bakeout thermal analysis shows critical strains and or temperature limits. 26

**CSCFDR16 26**

Consider adding thermocouples where the thermal analysis shows critical strain differentials or temperature limits. 27

## **POLARPEER31**

*Regarding the “small tile” option with a single bolt on each tile, it is important to build in a keyway groove or equivalent structure in the back plate that engages with the tiles to keep the tiles from rotating about the bolt – lesson learned from C-Mod inner wall tiles.*

---

Tile down selection review was completed and the small tile option was not selected.  
Castellated tile geometry was selected.

## **POLARPEER34**

*Regarding the “small tile” option: Consider castellated design of smallish tiles instead of a full array of separate very small tiles.*

---

Tile down selection review was completed and the small tile option was not selected.  
Castellated tile geometry was selected.

## **PFCPEMPFDR01**

*Please ensure that the high vacuum outgassing test of the purchased graphite will be also included in the test plan.*

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High vacuum outgas testing requirements are specified in the Statement of Work for Bakeout of NSYX-U Recovery Tiles (NSTX-U-SOW-PFC-003-00).

## **PFCPEMPFDR02**

*Review the numerous procurements and determine which ones require Statements of Work to ensure that suppliers understand and agree to all technical and QA requirements, and that all steps are taken during the manufacturing and delivery process are compliant with project needs.*

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PFC related procurements will be carried out following the Statement of Work (SOW) documents listed below:

<b>PFC SOW</b>	<b>Document No.</b>
Graphite Manufacturing	NSTXU_1_1_1_1_SOW_101
Metal Manufacturing	NSTXU_1_1_1_1_SOW_100
NSTX-U Graphite Material Property Test Program	NSTX-U-SOW-PFC-001-00
Bakeout of NSTX-U Recovery Tiles	NSTX-U-SOW-PFC-003-00
Plasma-Facing Materials and Components Testing and Evaluation	NSTX-U-SOW-VVIH-001-00

### **PFCPEMPFDR03**

*Calculation 11-10 section 3.1 mentions a "PPPL material database." No reference is provided for this information. What properties were used in this analysis? This comment applies to other calculations as well: PFC calculation reports generally specify the types of materials used but do not provide explicit material property information.*

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ANSYS material properties used in calculations are included in the digital archive. Link has been made through the FDR dashboard. This is the analysis group database used within the PFC group. Link to the FDR dashboard:

<https://sites.google.com/pppl.gov/20180926pfcs-pempfdr/home>

## **PFCPEMPFDR04**

*The CSA tiles nearest to the center-tube have a sharp internal angle of about 140 degrees, at the thinnest point of these "not quite L-shaped" tiles. Wouldn't it be a good idea to radius that internal corner by a few cm, to improve its margin against unforeseen extreme loads, achievable at negligible cost?*

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The CSA Row 6 tile drawing (E-ED1423) has a 0.020" radius for the edge in question. Internal discussions with the fabrication shop has shown this is not a problem to manufacturer. All other sharp edges have a standard "break sharp edges 0.005/0.020" definition. No sharp edges will be present, unless otherwise noted. The SOW for graphite manufacturing will have a machining definition that will also detail edge requirements for any direct from CAD manufacturing.

<b>PFC SOW</b>	<b>Document No.</b>
Graphite Manufacturing	NSTXU_1_1_1_1_SOW_101

## **PFCPEMPFDR06**

*As the pre-load is the most significant source of stress on the tiles (quoting the presenter - mechanical stresses at the fixtures decrease when tiles are heated), consider carry out pre-load tests to support analysis result.*

The confidence in the analysis done on the tiles is high and the software that was used was qualified through our Software Quality Assurance following QA-028. The table below covers the calculations used to quantify the stresses within the tiles. Prototypes do not add validity to the final design, but prototypes are being manufactured as a project risk mitigation strategy.

<b>Physical Quantity</b>	<b>Calculation #</b>	<b>Comment</b>
Electromagnetic Loads on CSA Tiles	<a href="#">NSTXU-CALC-11-11-00</a>	Provides all EM loads on the Center Stack Angled tiles
CSA Structural Analysis	<a href="#">NSTXU-CALC-11-21-00</a>	Validates the design of CSA tiles
Heat Flux Enhancement and Fish Scale Angles for CSA Tiles	<a href="#">NSTXU-CALC-11-28-00</a>	Calculates heat flux enhancement of CSA tiles and determines fish-scale angle which minimizes tile heating.
Electromagnetic Loading and Structural Analysis of CSFW PFCs	<a href="#">NSTXU-CALC-11-10-00</a>	Determines EM Loading and verifies the design of CSFW tiles
Eddy Currents in OB12 PFCs	<a href="#">NSTXU-CALC-11-24-00</a>	Determines EM Loading for OBD12 tiles
OBD12 Halo Force Restraints	<a href="#">NSTXU-CALC-11-23-00</a>	Verifies OBD12 tile assembly properly restrained against inplane halo current forces
Fish Scale Directionality of OBD12 Tiles	<a href="#">NSTXU-CALC-11-22-00</a>	Determines angles required for OBD12 tile ramping and castellations
Analysis of OBD12 Langmuir Probe Sensors	<a href="#">NSTXU-CALC-11-25-00</a>	Validates performance of OBD12 Langmuir probes
Analysis of OBD12 Thermocouple Sensors	<a href="#">NSTXU-CALC-11-26-00</a>	Validates performance of OBD12 thermocouples
Analysis of OBD12 Hold-Down Assembly	<a href="#">NSTXU-CALC-11-29-00</a>	Verifies acceptable contact stresses between OBD12 tiles and hold-down assembly
Thermal and Structural Analysis of OBD12 Tiles	<a href="#">NSTXU-CALC-11-27-00</a>	Verifies design of OBD12 tiles
Tile Shaping of IBDH High Heat Flux Tiles	<a href="#">NSTXU-CALC-11-31-00</a>	Determines IBDH tile-tile and castellation-castellation gaps required to eliminate direct heating
Tile Shaping of IBDV Tiles	<a href="#">NSTXU-CALC-11-32-00</a>	Determines IBDV tile-tile and castellation-castellation gaps required to eliminate direct heating
Thermal and Structural Analysis of IBDH Row 1 Tiles	<a href="#">NSTXU-CALC-11-18-00</a>	Verifies design of IBDH Row 1 tiles
Stresses in IBDH and IBDV Pin-Lockbar Assembly	<a href="#">NSTXU-CALC-11-30-00</a>	Verifies design of pin and locking bar used in IBDH/IBDV support structure

PFC Fields and dBdts	<a href="#">NSTXU-CALC-11-08-00</a>	Determines the B and dB/dt values for PFC tiles for machine operating and disruption scenarios
Thermal and Structural Analysis of IBDV High Heat Flux Tiles (Rows 3-4)	<a href="#">NSTXU-CALC-11-19-00</a>	Verifies design of IBDV Row 3-4 tiles
Thermal and Structural Analysis of IBDV Low Heat Flux Tiles (Row 2)	<a href="#">NSTXU-CALC-11-20-00</a>	Verifies design of IBDV Row 2 tiles
Electromagnetic Loads for OBD4-5 PCHERs Tiles	<a href="#">NSTXU-CALC-11-12-00</a>	Determines EM Loading for OBD PCHERs tiles
Thermal and Structural Analysis of OBD Row 3 Tiles	<a href="#">NSTXU-CALC-11-14-00</a>	Verifies design of OBD Row 3 tiles and support structure
Thermal and Structural Analysis of OBD Row 4 Tiles	<a href="#">NSTXU-CALC-11-15-00</a>	Verifies design of OBD Row 4 tiles and support structure
Thermal and Structural Analysis of OBD Row 5 Tiles	<a href="#">NSTXU-CALC-11-16-00</a>	Verifies design of OBD Row 5 tiles and support structure

## **PFCPEMPFDR07**

*Calculations make reference to PFC-180613-AK-01. This appears to be a procedure for doing some of the PFC FEA. (1) I could not find this reference in the dashboard. (2) Has this procedure been vetted / checked?*

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PFC-180613-AK-01 has been filed in the NSTX-U document management system with the appropriate reviews and signatures.

## **PFCPEMPFDR08**

*We witnessed in testing that the rod(pin) bends and could potentially crack the tile. The solution of adding the grafoil bushing is a good option; but it helps to be tested to see if it sets.*

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Repeat testing (static and fatigue) was performed for tile subjected to shear pin loading. The tests incorporated the grafoil inserts presented at the FDR. Deformation of the grafoil bushings was observed and determined to be acceptable for achieving the design function; no significant damage to the tile was observed in any test. The memo documenting this testing is NSTX-U-REC-171-00.

## **PFCPEMPFDR10**

*Slide 12 of Bob's presentation on the OBD-R12 tile assemblies shows four shoulder screws to attach the transition plate to the OBD structure, only two of which (at the end) have marginal access for a modified hex-key to tighten them. The other two are intended to have welded-on Belleville washers to provide inhibition of rattling when the heads were slid along the key-hole slots. We discussed the possible (I would say "probable"!) need for a wedge feature on the key-hole slot but it occurs to me that the weld will constrain the deformation of the Belleville washer, which is undesirable. Use a wedge plus a spring washer of some different type with a threaded hole so it is trapped on the screw without welding?.*

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Testing was done to assess OBD12 assembly installation using a prototype transition plate. The results of the prototype testing demonstrated that the OBD12 design is viable and indicated that use of a simple fixture as well as jacking screws would be helpful for installation. The prototype testing results were documented and filed in NSTX-U-REC-171-00.

## **PFCPEMPFDR12**

*NSTXU-CALC-11-31-00 assumes the HTP can be shimmed to within 0.003-0.005". This is not currently in the installation plan (HTP surface flatness of 0.010" was previously discussed with HTP COG). Calculation thus indicates that one of three things is required: A) The tile fish scale should be redone to the expected HTP value, or B) the HTP COG should concur that the required surface flatness can be delivered, or C) the reassembly WAF should be revisited to ensure shimming in the IP is consistent with this requirement.*

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The inter-castellation step size will be 0.009" and the inter-tile step size will be 0.036". These assume the HTP will retain a surface profile tolerance of 0.010" per plate. The IBDH drawing has been adjusted to reflect the GD&T of the front surface as 0.004" surface profile tolerance and provide \*reference\* thicknesses (i.e. since the surface profile is defined with 3 datum features, allowing the control required). The forward helicity case is covered with this adjustment and the physics program will prioritize forward-helicity performance.

### **PFC Calculation**

### **Document No.**

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Tile Shaping of IBDH High Heat Flux Tiles

NSTXU-CALC-11-31-00

Tile Shaping of IBDV Tiles

NSTXU-CALC-11-32-00

Fish Scale Directionality of OBD12 Tiles

NSTXU-CALC-11-22-00

## **PROJPDR26**

*How the Grafoil under the HHF tiles will react to pre-loads + heating is not understood. Testing should be done to make sure the tiles will maintain the proper pre-loads and positioning.*

---

We have experience using this grafoil in several NSTX and NSTX-U PFC designs. No issues have been reported with its performance or degradation (relaxation, cracking, flaking or otherwise). Analysis of the grafoil used in HHF designs (Calculation Reports NSTXU-CALC-11-17-00, NSTXU-CALC-11-18-00 and NSTXU-CALC-11-19-00) did not raise any concerns about the ability of the grafoil to withstand design loads. Testing will not be pursued based on the HHF analysis and the materials prior use in the machine.

## **PFCPEMPFDR13**

*In slide 11 of Andrei's talk on IBDH, the 90 degree rotated tie-bar design is shown (similar to an IKEA furniture locking cam ring). Depending on the preload applied by the Belleville stacks, this might need a large torque to make the initial rotation - but once vacuum tribology and the occasional halo current has gone through the pull-down pins, they might get welded to the tie-rods. What would then be the recovery method to disassemble these components? Can you use some mismatch of alloys (maybe Monel against Inconel?) to avoid the welding effect?*

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PFC team is utilizing silver coating per ASTM B700-08 (min. 5.0 um) on all hardware to avoid galling.

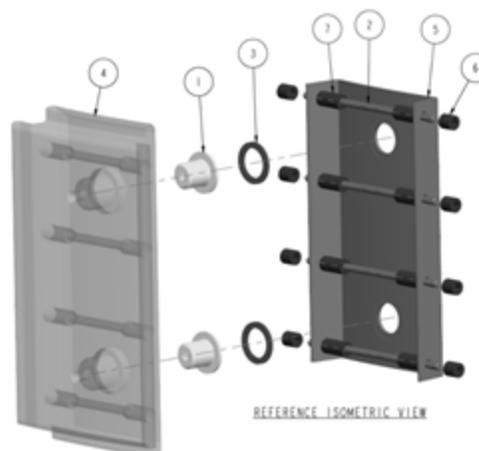
## **CSCFDR29**

*Suggest assessment of center stack first wall under worst deformation cases and making sure internal and external (PFC) components are not damaged, or stressed more than expected.*

*NOTE: The original chit was split into two separate chits (see CSCFDR17 and 29). One is on the potential interference between Casing and the PFC (external CSCFDR29), and the other one is the interference between casing and the OH coil OD (internal of casing assembly CSCFDR17)*

The deformation of CSFW and CSA tiles under PFC design loads was analyzed and reported in calculations NSTXU\_1\_1\_1\_1\_CALC\_036 and NSTXU\_1\_1\_1\_1\_CALC\_034. Additional analysis was done to assess deformation of the CS PFCs, as described below.

The P6 Operational CSC FDR maximum deflection Load Case (LC5) and the bakeout (LC10) were imported to a breakout model containing PFC CSFW and CSA assemblies; the CS deformations were applied as an enforced displacement boundary condition. The P2 Operational load case was also analyzed. Analysis of each breakout model was performed using simplified (bonded) contacts in order to assess deformation of the CSFW backing plates. The deformation of each backing plate, which would drive deformation in the mounted PFC, was assessed by comparing the relative deformation between each locating pin hole on the backing plates. The CSFW assembly components per NSTX E-ED1456 (See excerpt below) were included in the breakout models.

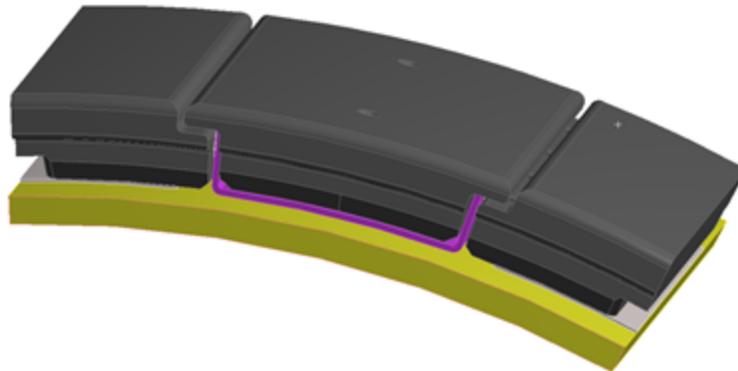


1	C-01410-2	TUBULAR SPACER, CENTER CHIT	GRAPHOL	8"
2	C-01410-3	TUBULAR SPACER, ADJUSTING TILE	GRAPHOL	8"
3	C-01411-1	BACKING PLATE, ROW 1-21	INCONEL 718	1
4	C-01410-1	TILE, ROW 1-21 - TILE SPILE 2	ETIG GRAPHITE	1
5	C-01408-1	WASHER, 0.5 x 0.8 x 0.030 x 0.030 - BOTTOM	INCONEL 718	2
6	C-01414-1	LOCATING PIN	INCONEL 718	4
7	C-01440-1	TIE BRIDGE NUT, TILE, ROW 1-21	A-286	2
8	E-ED1456-01	TILE, ROW 1-21, SPILE 2 ASSEMBLY	---	---
ITEM NO.	DRAWING NO.	DESCRIPTION OR DISPOSITION	MATERIAL	QTY REQD

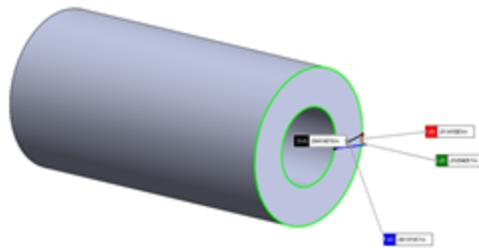
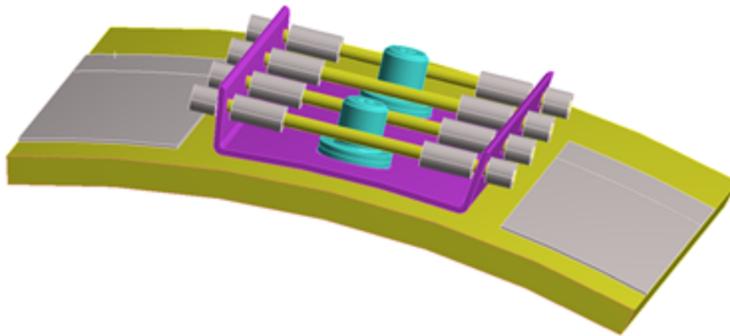
PARTS LIST

The CSFW subassembly breakout model is shown, along with details of the grafoil bushings.

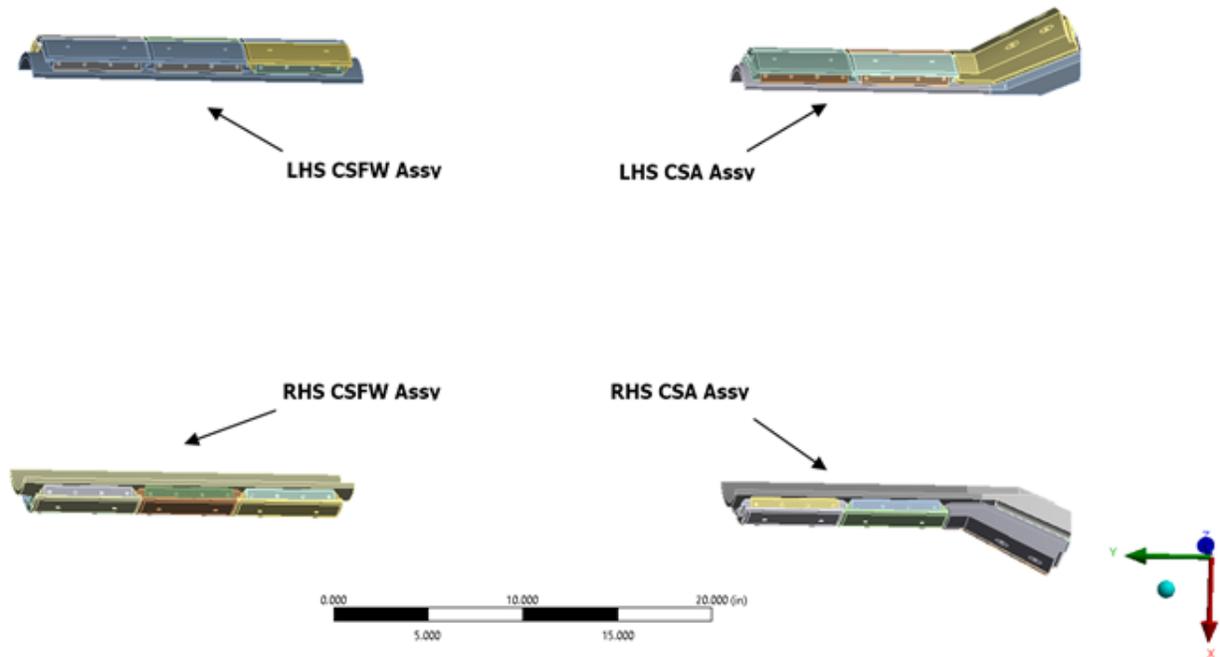
Geometry  
5/15/2019 1:40 PM  
TIN 10  
Alloy 605  
Alloy 718  
Grafoil  
Graphite 200 A610



Geometry  
5/15/2019 1:40 PM  
TIN 10  
Alloy 605  
Alloy 718  
Grafoil



The CSC displacements were mapped to four regions of the CS PFCs as shown below.

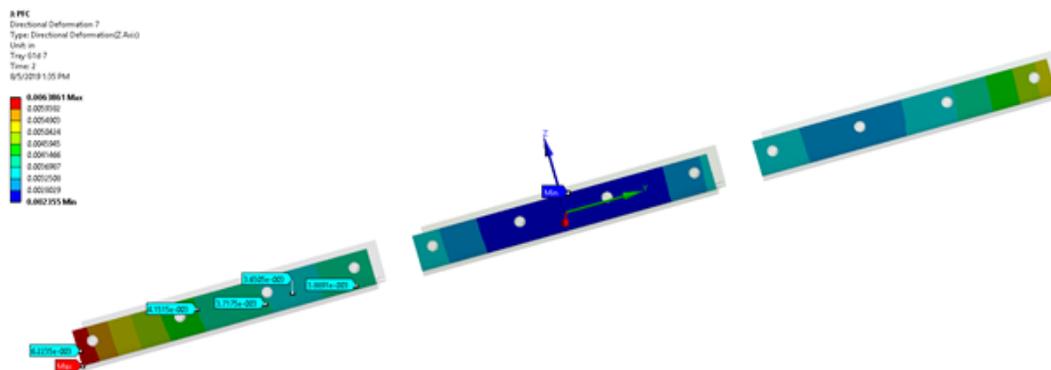


The worst case relative deformations for each region are reported in the table below.

### Relative Backing Plate Deformation

CSC Load Case	P6	P2
LHS CSFW	1.86E-03	1.92E-03
LHS CSA	1.84E-03	1.75E-03
RHS CSFW	<b>-2.07E-03</b>	-1.90E-03
RHS CSA	-2.01E-03	-2.03E-03

A deformation plot showing the peak relative deformation observed (P6, RHS CSFW) is given below.



**Conclusion**

The radial thickness of the Grafoil bushings is 0.06in. The Grafoil Manual states that flexible graphite typically offers 35-45% compressibility and 10-15% recovery. With the current bushing thickness, this means that compressions in the range of 0.021in. – 0.027in. would be deemed acceptable. The pin-to-pin hole deflection under worst-case CS deformation would result in compression of the bushings well within the acceptable range. Note that the deformations reported are the *total deflection* between pin holes, and that the deflections would be absorbed by bushings at each pin.

## **LHFPDR3**

*PFC performance & requirements must consider/asses tile to field alignment as well as tile to tile alignment.*

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The SRD for plasma facing components, NSTX-U-RQMT-SRD-003-02, specifies performance requirements considering field alignment and tile-tile misalignment. All PFC designs meet their respective requirements.

## **PROJPDR33**

*PFC Supplier of graphite is unwilling to guarantee material properties. However, they will supply test data with each provided piece of material. If they are willing to share historical data on these values with us (e.g. ~35+ most recent reports), we can construct statistically significant confidence intervals for the true mean & std dev of each of the measured properties. Though short of a guarantee, it will be sufficiently reliable and should ameliorate the uncertainty which is complicating our design process.*

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To guarantee the material properties, the vendor provided data will not be used. Testing will be carried out on each billet of graphite as received, and the material that reaches the requirements will be designated for use in PFC tiles. See NSTX\_1\_1\_1\_1\_SOW\_104

## **CSCFDR14**

*Add thermocouples where the casing bakeout thermal analysis shows critical strains and or temperature limits.*

---

Thermocouple location requirements are defined in the PFC diagnostic requirements document (NSTX-U-RQMT-RD-004). Between the PFC FDR and the PFC diagnostics FDR, extensive work was done on sensor location and cabling. After the final set of sensor locations was decided, we updated the requirements document to reflect that. Rev. 1 of the PFC Diagnostics and Fueling RD was signed in February 2019. Sensor locations were discussed at the PFC Diagnostics FDR.

<https://sites.google.com/pppl.gov/20190305pfc diagnostics fdr/requirements-project-documents>

## **CSCFDR16**

*Consider adding thermocouples where the thermal analysis shows critical strain differentials or temperature limits.*

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Thermocouple location requirements are defined in the PFC diagnostic requirements document (NSTX-U-RQMT-RD-004). Between the PFC FDR and the PFC diagnostics FDR, extensive work was done on sensor location and cabling. After the final set of sensor locations was decided, we updated the requirements document to reflect that. Rev. 1 of the PFC Diagnostics and Fueling RD was signed in February 2019. Sensor locations were discussed at the PFC Diagnostics FDR.

<https://sites.google.com/pppl.gov/20190305pfc diagnostics fdr/requirements-project-documents>

## All Chits

Review Date	Chit Code	Review	Recovery WBS	SBS Element	CHIT	Resolution
14-Feb-2017	VVIHBI12	Vacuum Vessel & Internal Hardware DVVR	1.1.1	PFCs - High Heat Flux	Consider Thermally Annealed Pyrolytic Graphite ( <a href="https://en.wikipedia.org/wiki/Annealed_pyrolytic_graphite">https://en.wikipedia.org/wiki/Annealed_pyrolytic_graphite</a> or <a href="http://www.thermacore.com/products/thermal-straps.aspx">http://www.thermacore.com/products/thermal-straps.aspx</a> ) to preferentially control heat flow near PF1B redesign.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Analysis has shown that the requirements are met with the current designs. The graphite grades have been chosen depending on the PFC region and requirements.
21-Apr-2017	POLARPER01	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	How will we test any high-heat flux PCFs (tiles or integrated plates)? Have we identified proper facilities and secured operational time and allowed for it schedule?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  HHF testing has been completed at Advanced Research Laboratory. See report NSTX-U-REC-084-00.
21-Apr-2017	POLARPER07	Polar Region Design Integration Peer Review	1.1.1	PFCs - Integration	Considering the conservative NSTXU allowable stress criteria for graphite & CFC allow PFC design to be qualified by test rather than analysis.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Creating the actual load cases within the machine are impossible in a testing facility. Tile load specific testing has been complete. Design to the FDR fits within the stress criteria.
21-Apr-2017	POLARPER08	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	fish scaling is hardly compatible with power in the wrong direction and inefficient when the ratio gap/tile is large or the vertical installation tolerance is large	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  No reverse helicity is required in the outboard set of tiles. A reverse helicity case is included in tables 4.2-1 and 4.3-1 of the PFC SRD and analysis of this scenario is shown in calculation reports

						NSTXU-CALC-11-18-00 and NSTXU-CALC-11-19-00.
21-Apr-2017	POLARPEER09	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	SFD reversed-helicity regions. These will be in the private flux regions, which in traditional divertor geometries have much lower parallel heat fluxes than the main SOL flux regions. SFD divertors have wider zones of very low poloidal field near the nulls and so the private flux regions will get more of the power exhaust due to cross-field transport - but how much? If significant, maybe you should make the poloidal extent of the tiles where the typical SFD has reversed poloidal field have bidirectional ski-ramping (imbrication), although this will reduce the useful wetted area there for SFD and standard divertor operation.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>See solution to CHIT POLARPEER08 above. The SRD provides the new heat load definitions. Bi-directional designs with isotropic graphite would not meet heat flux and temperature requirements.</p>
21-Apr-2017	POLARPEER20	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Reconsider embedded tile heaters in IBDH only to try and avoid bellows overheating. Look at the MAST-U design.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Project level planning has decided to address bake-out challenges via a range of solutions including the magnet sling design and heat transfer plate. No embedded heaters are needed. Calculation report NSTXU-CALC-10-6-00 details bakeout analysis.</p>

21-Apr-2017	POLARPE ER23	Polar Region Design Integration Peer Review	1.1.1	PFCs Integration	Examine proposed tile designs with respect to (1) issues associated with large amounts of lithium dust (2) post-run clean-up schemes to remove lithium hydride coatings	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>NSTX had previously made use of aqueous acetic acid solutions to react away lithium compounds. Previous procedures, at times, also called for the use of mechanical scrubbing with abrasive pads. New procedures will have to be developed to remove lithium compounds from the device.</p> <p>All tiles can be removed, if need be, from the vessel and soaked in an aqueous bath to completely eliminate lithium compounds. In this extreme case, all compounds can be eliminated if need be. Alternatively, more targeted removals can be effected with limited application of aqueous acetic acid solutions and inter-castellation abrasive tools (e.g. dental floss).</p>
21-Apr-2017	POLARPE ER24	Polar Region Design Integration Peer Review	1.1.1	PFCs - Low Heat Flux	Assess if bending stresses in CSFW trays due to away from the wall halo current induced forces is above yield	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Trays and hardware have been analyzed and see calculation report NSTXU-CALC-11-10-00 (W. Syed)</p>
21-Apr-2017	POLARPE ER26	Polar Region Design Integration Peer Review	1.1.1	PFCs Integration	Tile edge temperature limit. My recollection of JET and MAST designs is that the leading edges have the same temperature limit as the main wetted surface, 1300°C (I believe- but yes, it is a fuzzy value to do with onset of cluster sputtering). Since the "C bloom" is very aggressive, why would you let even small areas go way above its temperature threshold?	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The tile temperature limits are defined in the SRD and the engineering team works to meet those requirements. The physics program conducted a literature review of carbon bloom phenomena and this was used to inform the present temperatures</p>

						used in the SRD (rev 01) of 1600C surface-average and 2000C edge.
21-Apr-2017	POLARPE ER28	Polar Region Design Integration Peer Review	1.1.1	PFCs - Low Heat Flux	The design of OBD-R1 tile should be able to accommodate holes and/or gas pipes for the divertor gas injection system. There are presently two orifices in the lower divertor tiles.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  No access holes through the top of the tile will be included. Instead, gas will be routed to the space previously used for CHI operation. This will allow for more toroidally symmetric gas injection for future experiments. Gas lines are routed in the outboard divertor copper plates and will not impinge OBD12 nor OBD345 designs.
21-Apr-2017	POLARPE ER29	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Pins in the IBDH need to consider the installation of these plates. If they need to come in at an angle to fit under the IBDV, will the pins fit and work?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The designs for the IBDH, IBDV, and IBDV-LHF are presented in the design reports NSTX-U-REC-076-00 and NSTX-U-REC-075-00. These detail the methods to address the functional requirements of the designs.
21-Apr-2017	POLARPE ER30	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Regarding the 'small tile' option with a single bolt on each tile, it is important to build in a keyway groove or equivalent structure in the back plate that engages with the tiles to keep the tiles from rotating about the bolt – lesson learned from C-Mod inner wall tiles.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Tile down selection review was completed and the small tile option was not selected. Castellated tile geometry was selected. (NA)
21-Apr-2017	POLARPE ER33	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Regarding the 'small tile' option: Consider castellated design of smallish tiles instead of a full array of separate very small tiles.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Tile down selection review was completed and the small tile option

						was not selected. Castellated tile geometry was selected. (NA)
21-Apr-2017	POLARPE ER35	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Small tile design: Regarding the concern of line contact between the hold-down pin and tile hole and its impact on the failure mode / stress limit of the system – make simple mockups and perform pull testing to qualify designs.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Tile down selection review was completed and the small tile option was not selected. Castellated tile geometry was selected. (NA)
21-Apr-2017	POLARPE ER38	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Consider the effect of vacuum welding on shear pins. There are many potential solutions but this should be considered in the design.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  T-bar and shear pin are dissimilar metals (Inconel and Stainless Steel). Vacuum welding should not be an issue.  Hardware components will be silver coated to avoid galling and vacuum welding. Drawing E-ED1415 specifies silver coating on the threads of OBD shear pins.
21-Apr-2017	POLARPE ER39	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Consider pre-loading cube tile rod bolt with bellville washer, sized properly will retain rotation locking feature (tabs) and allow compression of thermal contacting grapfoil under tile.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Cube-based design has not been selected for use in NSTX-U. (NA)
21-Apr-2017	POLARPE ER40	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Blind tapped holes. These were mentioned several times and I think many of them were for vacuum-side assembly. Don't forget to provide a central hole in the mating bolts to allow the trapped volume under the bolt tip to be pumped out - or else you'll have several hundred virtual leaks of about a bar-millilitre each!	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Standard vacuum design practices will be applied with vented hardware or vented blind holes as appropriate.

21-Apr-2017	POLARPE ER41	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	The present IBDH tile design (fish-scaled small tiles) appears to be incompatible with a large part of the planned divertor physics program. Snowflake divertor configurations will have some regions of reversed helicity field, while cusp-like configurations are likely to produce field angles below 1 degree. Some resolution must be found. Advanced magnetic divertor configuration research has been a salient point in NSTX and NSTX-U Research Programs.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The individual cube design has not been selected for use in NSTX-U at this time. (NA)
21-Apr-2017	POLARPE ER42	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Questions about the compatibility of the shaping IBDH and the divertor physics program will likely be raised for IBDV as well if that needs to be shaped. A portion of snowflake operational space will need to run two helicities there as well.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Reverse helicity is required in the NSTX-U-RQMT-SRD-003-01 (and following). Designs presented at FDR meet the present requirements.
21-Apr-2017	POLARPE ER43	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Investigate thermal paste products for enhancing heat transfer between CS cooling tubes and casing. (Tack welding can be used for mechanical fixation locally, but welding/brazing may be undesirable over large surface areas due to practical considerations or to avoid thermal distortion).	<a href="#">Close per Chit Resolution Report NSTX-U-REC-093</a>
01-Aug-2017	RPCDR04 5	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	IBDV (and others) - the 'dishpans' included in the lower heat flux regions are toroidally symmetric but the heat flux requirements are not. Evaluate if there's an advantage in heat flux handling while not complicating fabrication to make these asymmetric.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Latest designs for the LHF tiles include non-axisymmetric features to mitigate leading edges in these tiles. This is described in NSTX-U-REC-075-00.

01-Aug-2017	RPCDR04 7	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	investigate thermal fatigue cycles on grafoil sheets on IBD-H,V, optimum compression required	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Designs using grafoil do not apply large compression and remain in the linear region of the grafoil sheet. All designs have been transitioned to a "load controlled" scheme and maintain some preload on the grafoil.
01-Aug-2017	RPCDR04 8	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	Better specify the maximum inter-shot temperature requirements for the purposes of diagnostic integration.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Operational requirements are specified in the NSTX-U PFC SRD NSTX-U-RQMT-SRD-003-02.
01-Aug-2017	RPCDR04 9	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	Mounting the IBDH/IBDV castellated tile with a single fixture down the center could lead to rotation around that axis to take up tolerances. This leads to a change in heat flux angle which could be large relative to the shaping, leading to tile-to-tile changes in surface heat flux. Complete tolerance study impact on expected heat flux (different than other tiles) and consider alternate fixation if necessary.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  All designs of castellated tiles now feature dual hold-down rods. In addition, IBDV and IBDH tiles are trapped within the "frame" elements and these prevent rotation. OBD12 design features keys to prevent rotation and resist halo loads. See design reports in NSTX-U-REC-075-00, NSTX-U-REC-076-00, and NSTX-U-REC-077-00.
01-Aug-2017	RPCDR05 0	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	If the intention is to effectively remove heat through casing cooling, good thermal contact between IBDH tiles with underneath carrier plate is important for heat removal and reduced thermal stress in carrier plate, heat transfer plate and inconel casing. If it is ok for tiles to raise to 600 c (bulk perk), then it is better to thermally insulate the tile and the carrier plate, and have a	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  PFCs will feature load-controlled contact with grafoil gaskets to the mounting structures to aid in inter-shot cooldown.

					way to remove the heat radiated to other area in the vacuum vessel.	
01-Aug-2017	RPCDR05 2	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Low Heat Flux	On the OBD R1/R2 there are many front surface access holes. Consider adjusting design to avoid these totally or so they are between gaps.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The design of all high-heat flux tiles has been developed to eliminate front-access holes.
01-Aug-2017	RPCDR05 3	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	I quite like the castellated tile option (because I favour the much smaller component count) but only if it can be shown to have very small tension stress in the graphite at all times through the heating and cool-down cycle. Given some significant stresses at the root of the grooves where the single (?) tie-tube pulled against it, why not introduce more tie-tubes in each tile to spread the load better?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  All tile designs in the high-heat flux region (IBDV, IBDH, and OBD12) include two tie-down rods or lock-bars to distribute force over the tile. In addition, all designs feature tapered contacting surfaces to avoid stress concentrations and distribute the load along the rods. The contact stresses in all cases are resolvable via analysis and detailed in calculation reports NSTXU-CALC-11-18-00 (IBDH), NSTXU-CALC-11-19-00 (IBDV), and NSTXU-CALC-11-29-00 (OBD12).
01-Aug-2017	RPCDR05 4	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	The combined (IBD-H + IBD-V) is costed significantly higher than the OBD R1/R2 on a per area basis. (Ratio will vary depending on how whether you count low heat flux surfaces, etc., but is around 150% or higher). Since the design proposals are very similar, concerns about manufacturing many parts and alignment driving costs should be equally applicable (or inapplicable) to both regions.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Cost estimates and prototype purchasing has defined a better understanding of the purchasing and manufacturing of the PFC components.

01-Aug-2017	RPCDR05 5	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Low Heat Flux	<p>OBD R3-R5: While heat fluxes are lower, the OBD tiles will be impacted by faceting (see PFCR-MEMO-005). If tiles are modified, ensure they can meet allowables including enhancement due to faceting. If tiles are remade, consider shaping the front surface to undo local faceting.</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Tiles with faceting meet SRD heat fluxes. See calculation reports NSTXU-CALC-11-14-00, NSTXU-CALC-11-15-00, and NSTXU-CALC-11-16-00.</p>
01-Aug-2017	RPCDR05 6	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Integr ation	<p>The outer and inner vessels are supported independently. While outer divertor tiles supported by the copper plates can be accurately positioned relative to the inner horizontal divertor during assembly, what magnitude of permanent relative displacement might occur as a result of halo current forces and thermal displacements during operation, and what would be the effect on the performance of the tiles at the interface between inner and outer divertor?</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>We will position the tiles during installation. The present designs make use of in-vessel metrology and manufacturing tolerances to achieve known surface position tolerances in the vessel. Analysis of vessel deformation and the resulting impact on positioning is not within the scope of the PFC group at this time as defined in the SRD (NSTX-U-RQMT-SRD-003-01 and following).</p>
01-Aug-2017	RPCDR05 7	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Low Heat Flux	<p>OBD R1/R2: Consider shaping plasma facing surface to avoid heat flux enhancement due to faceting of the OBD support structure (see PFCR-MEMO-005).</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>PFCR-MEMO-005 was used to calculate effective increases and decreases in the surface heat flux as a result of faceted surfaces. Analysis including this additional enhancement indicates the current design with planar facets still meets the temperature limits defined in the SRD. Planar facets are expected to be more easily manufactured and will represent cost savings to the project so these are used in the final design. Analysis calculation for OBD12 is shown in NSTXU-CALC-11-17-00</p>

01-Aug-2017	RPCDR058	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Integration	In the analysis regarding the PFCs, it was suggested that the PFC would be adequately cooled only by radiation and that a grafoil sheet would only improve thermal transfer from here. This may be the case but it may also act as a radiation shield. Please could the design team ensure that it is content with this assumption going forwards. Note this is only a concern at low pre-loads where the conduction heat transfer is poor	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Grafoil will be included between all components ensuring some contact. Radiation only will not be relied upon.</p>
01-Aug-2017	RPCDR059	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Integration	Failure criteria of graphite. Please could the design team review their design criteria wrt stress and the cyclic loads on the graphite. I have provided some information to Mike Mardenfeld regarding what was done for MAST tiles and can be available for further comment as required	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>NSTX Structural Design criteria for brittle materials has been used through the PFC Recovery project. Development of new standards for design was not planned for our scope of work. Recommendations for revision or re-examination will be proposed to the PPPL Engineering team post-FDR. In particular, the use of flexural strength as a design criteria would be helpful.</p>
01-Aug-2017	RPCDR060	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Low Heat Flux	I am slightly concerned by the pin design for the centre column tiles. Particularly the following points; I) the stresses reported are hertzian, i.e. very localised are we comfortable that the solution is converged. ii) particularly the floating tile concerns me, I have not analysed this in any detail but the load appears to be taken over a small area. Push fitting the bushing from both sides may be challenging	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Bushings were proposed at the CDR but then it was planned to make use of qualification by testing. Testing indicates performance is marginal and may be sensitive to test apparatus misalignments. A grafoil gasket will again be used to spread the contact stress. See new analysis report calculation number NSTXU-CALC-11-10-00.</p>

					<p>ii) as mentioned by another participant, I am worried that the thermal expansion difference between the tile and supporting structure and if tis an be accommodated by the 4 pins. Again this may be exacerbated in the floating tile due to the geometry here</p> <p>Please could the design team review in the phase prior to PDR</p>	
01-Aug-2017	RPCDR063	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Low Heat Flux	<p>OBDR3-5 large pins may interfere with existing design of Mirnov coils. This can be resolved by i) redesigning the Mirnov coils to fit in a new location, or ii) shifting the large pin towards one end of the tile (if allowed).</p> <p>Note also that CS 2D Mirnov sensors are ~0.1" thicker than OBD Mirnov sensors...be careful to design for the right one!</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The Mirnov variants have been redesigned in close consultation with the PFC Diagnostic RE. See drawings E-ED1403-2, E-ED1404-2, and E-ED1406-2.</p>
01-Aug-2017	RPCDR070	NSTX-U Recovery Project - CDR	1.1.1.1	Plasma Facing Components	<p>Really an integration chit: The OBD R1/R2 design is presently "high heat flux". We have not defined, however, a reasonable means of pulling that heat out. That is to say, the plumbing on the OBD also passes through the plates. Do we intend to run gas cooling through both the IBDH and the big OBD/PP loops?</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>IBDH will have a cooling plate. There is no plan to run gas through the OBD copper plates nor the passive plate structures. Current designs meet requirements without active cooling. Ratchet calculations are summarized in each FDR presentation which indicates the relevant calculation reports.</p>

01-Aug-2017	RPCDR08 1	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Low Heat Flux	<p>The BBQ rails are not very symmetric to the vessel nozzles (I recall ~0.1" "errors"). The design should accommodate these as-build conditions.</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The OBD12 design is sensitive to these misalignments and includes the transition plate component to correct them out. This is detailed in design report NSTXU-REC-077-00. The design comes from in-vessel metrology detailed in NSTX-U-REC-085-00. Shimming of the OBD345 tiles is also included in the design and is described in report NSTX-U-REC-078-00.</p>
01-Aug-2017	RPCDR09 7	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	<p>Mechanical loads from disruptions on entire small block assembly with Inconel tray is required for comparison to castellated tiles in addition to off-normal heat loading and, in general, bringing analyses to equivalent levels between the two designs.</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The project determined the castellated designs would be used to eliminate installation time. Since the multi-block design is no longer considered, it is not analyzed so as to save costs to the project. The down selection report (NSTX-U-REC-089-00) details the analysis presented in support of this design decision.</p>
01-Aug-2017	RPCDR09 8	NSTX-U Recovery Project - CDR	1.1.1	PFCs - Integration	<p>If we are to rely on testing, we should take consideration that brittle material failures means you need to test a number of them because there's a distribution of results from testing.</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Material property testing is to be done once material shipments are received. Design is based on half the tensile ultimate as per NSTX Structural Design Criteria NSTX-CRIT-0001-02.</p>

01-Aug-2017	RPCDR099	NSTX-U Recovery Project - CDR	1.1.1	PFCs - High Heat Flux	Clarify the means by which we'll to judge the relative importance of different failure mechanisms (included in PFC requirements?) Floating cube/individual castellation may lead to similar impact, but full castellated tile and carrier plate have different failure mechanisms and failure risks.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The PFC SRD defines limiting temperatures and the NSTX structural design criteria defines allowable stresses. Designs that meet these requirements for the defined heat and electromagnetic loads are deemed technically acceptable. Further prioritization is made on cost and schedule considerations (cheaper and faster are better).
29-Sep-2017	LHFPDR1	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Interfaces need to be fully (in detail) described. When will this be done and how does this date affect FD phase analysis?  Interfaces to include (when applicable): Heat loads, temperature resistance, thermal, electrical loads:limits, etc.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Interfaces are fully defined. All PFC Interface Control Documents have been reviewed and signed. <a href="https://sites.google.com/pppl.gov/sytemengineering/interfaces/icds?authuser=0">https://sites.google.com/pppl.gov/sytemengineering/interfaces/icds?authuser=0</a>
29-Sep-2017	LHFPDR10	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Develop down-selection criteria for materials prior to completing materials characterization to avoid delays	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Material selection was done through material selection peer review. See MEMO PFC-180628-MAJ-03.
29-Sep-2017	LHFPDR11	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Confirm ramp tile peaking factors. They seem lower than one might expect (My need to qualify tiles on both sides of the gap)	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Calculation is done by geometry and trigonometric relationships.

29-Sep-2017	LHFPDR1 2	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Fix interface table of OBD R3/R5 to indicate that the interface is w/ OBD R2 of IBDH	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Interfaces are fully defined. All PFC Interface Control Documents have been reviewed and signed.  <a href="https://sites.google.com/pppl.gov/systemengineering/interfaces/icds?authuser=0">https://sites.google.com/pppl.gov/systemengineering/interfaces/icds?authuser=0</a></p>
29-Sep-2017	LHFPDR1 3	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Develop a justification for increased number of OBD thermocouples for bake and add to cost estimates and schedule.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The SRD and RD define the required number of thermocouples for each design area. Design of the variants and added costs have been estimated in the current WAF.</p>
29-Sep-2017	LHFPDR1 4	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Metrology data is not sufficient to generate tile to tile alignments as position could be not at the tile center. Generate estimate of variation expected in the data (presently +/- 0.05") due to this. Consider new metrology that would better isolate as built (and operated) alignment	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>PFC Designs that are sensitive to misalignments have made use of extensive metrology (see reports NSTX-U-REC-085-00 and NSTX-U-REC-087-00). When needed, repeat metrology is conducted. Intertile alignments in the high heat flux region are driven by the elimination of leading edges, required heat fluxes, and temperature limits. Other areas may have specified tile-to-tile tolerances which have been analyzed in the designs.</p>
29-Sep-2017	LHFPDR1 5	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Remove the fillet on all tile edges in the direction of the field as this services no purpose and limits heat flux handling	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Fillet has been removed from all designs. All tiles are now ramped</p>

						(see design report NSTX-U-078-00).
29-Sep-2017	LHFPDR1 6	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Analyze cases where sides of tiles are also heated. Consider spreading the 'ramp' over multiple tiles toroidally to account for large caps like CXRS (see sheet tab "Image for Chit LHF-PDR-11")	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The OBD12 tiles present a toroidally continuous set of tiles. OBD345 tiles which do include diagnostic access have unique tile variants that make use of ramps and chamfers to eliminate plasma impingement on metallic surfaces for the angles defined in the SRD.
29-Sep-2017	LHFPDR1 7	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Interface with CXRS COG (R. Bell) on changes to the poloidal CHERS changes	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  CHERS viewing geometry has been used to determine closure of these toroidal gaps. See design report NSTX-U-REC-078-00.
29-Sep-2017	LHFPDR1 8	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Analyze the heat flux on the bolt hole features on the OBD tiles	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Enhancement factors for leading edges at bolt holes has been included in the analysis. See analysis reports NSTXU-CALC-11-14-00, NSTXU-CALC-11-15-00, and NSTXU-CALC-11-16-00 for details.
29-Sep-2017	LHFPDR1 9	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Consider dropping the heat flux requirement for the R3 region. The OBD tile designs are presently stress limited and accommodating this heat flux is showing to be problematic	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  SRD has been revised and all designs are meeting requirements (see NSTX-U-RQMT-SRD-003-02 tables 4.4-2 and 4.4-3)

29-Sep-2017	LHFPDR20	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	If changing the hardware fasteners. Copper plating performed by manufacturer. Builds up and creates issues with fitup. We had to re-cut threads on fasteners used previously as well as the plating peeled off fasteners after cutting & iterations of installation/removal	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  DRC deemed this as "Out of Scope". Copper plating will be used to prevent galling.
29-Sep-2017	LHFPDR21	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	The full wireways for OBD diagnostics are not known past the tile where sensor is installed. Make a full wireway diagram to understand full modifications necessary, this includes interfacing with diagnostics from R1/R2	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  NSTX 345 drawings are being updated. OBD345 tiles have wire-way chamfers on both sides to accommodate PFC Diagnostic implementations.
29-Sep-2017	LHFPDR22	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	The gas lines for the CS gas fueling were field modified according to Gifford. Get as-built gas line paths.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Completed. CAD model is updated with filed modification for gas injection tube. See drawing E-ED1423 for detail.

29-Sep-2017	LHFPDR2 3	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	<p>Concider using test result previously performed to indentify an "equivalent failure load" and avoid detailed FEA of pin contact (see sheet tab "Image for Chit LHF-PDR-23")</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>This was considered. Qualification by test was the path forward in this design at all points of contact. Results indicated difficulty in implementing the test and marginal performance. New design makes use of gaskets. See analysis report NSTXU-CALC-11-10-00 and new drawings E-ED1455 &amp; E-ED1456.</p> <p>-----</p> <p>For pin-contact stresses in the CSFW design, the PDR analysis failed to converge indicating a "qualify by test" program. Subsequent testing (documented in report NSTX-U-REC-082-00) indicated that the design could not be qualified for the full load. The CSFW design was modified to include grafoil bushings and eliminate contact between hard, brittle materials.</p> <p>In the case of the lock-bar mechanisms in the high-heat flux designs, analysis has been able to converge and qualify the tiles without the need for testing. Analyses of these regions is detailed in reports NSTXU-CALC-11-18-00 (IBDH), NSTXU-CALC-11-19-00 (IBDV), and NSTXU-CALC-11-29-00 (OBD12).</p>
29-Sep-2017	LHFPDR2 4	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	<p>Confirm with the program that the cost/benefit of replacing R5 tiles is "approved"</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The project has maintained the minor modifications to OBD R5. The design was reviewed and confirmed at the FDR.</p>

29-Sep-2017	LHFPDR2 5	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	port mounted gap for OBD345 loads on toroidally facing side of tile to be checked ok.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Diagnostic variants to meet requirements for heat flux and avoiding metal impingement have been designed and analyzed. This includes the gap tiles.</p>
29-Sep-2017	LHFPDR2 6	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Engineer and technician should work together to gather the undocumented tile field modifications for diagnostic or other purposes and modify the design model accordingly.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>As built condition of the vessel has been documented and relevant CAD models updated. E-ED1400 has been updated using information gained with D-NSTX-IP-3989. Diagnostic and gas-line routings have been planned out and appropriate tiles modified to accommodate these components without requiring field modifications.</p>
29-Sep-2017	LHFPDR2 7	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	In the OBD 3-5 designs, there can be collisions at the over-under interface if the slats are misaligned. Consider reducing the flange on the under tile to add more clearance. Or another solution.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>In the OBD 345, nominal design gaps between tiles are:  Poloidal Gap Between OBD tiles = 0.061"  Toroidal Gap Between OBD tiles = 0.075"  The vertical step between tiles is 0.061".</p> <p>With shims, the maximum displacement to be corrected is 0.19" as presented at the PDR (slide 27). This will be done with as many as 3 shims of 0.062" thickness to bring all tile surfaces to</p>

						within 0.040". This will avoid collisions between tiles due to "slat" misalignments.
29-Sep-2017	LHFPDR28	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Centerstack-firstwall tile to tile tolerance req. needs iterating with achievable stackup	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Physics Requirement updated to 0.035" tile-to-tile step height.
29-Sep-2017	LHFPDR29	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	any locking hardware should be replaced after use.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Spirolock hardware is qualified for multiple time reuse. (Spiralock data). See link to Spiralock data: <a href="https://www.stanleyengineeredfastening.com/support/faqs">https://www.stanleyengineeredfastening.com/support/faqs</a>
29-Sep-2017	LHFPDR2A	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Is there a load limit set for maintainances (Techs standing on the tiles)?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Paragraph 3.5-c of the PFC SRD rev 01 requires base tiles to be able to support the weight of a technician.
29-Sep-2017	LHFPDR2B-1	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	The weld quality/strength is in question, If the some of the studs need to be checked, then shouldn't all the studs need to be checked?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Testing completed and test report is number NSTX-U-REC-080-00. No studs failed in the weld. The design torque is 6 ft-lbs. And the minimum tested strength is 24 ft-lbs (failing in threads).  Failure of tiles is not expected as all components meet requirements. There are no sliding mechanisms in the PFCs.

29-Sep-2017	LHFPDR2 B-2	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	How is failure mode of expected design features accounted in the analysis? (example: If sliding is needed and fails, what is affected?)	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Tile function does not require moving parts. All parts are analyzed for the expected load conditions as defined in the SRD.</p>
29-Sep-2017	LHFPDR2 C	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Will the tile testing include fatigue testing? Will the fatigue tests include expected load inventory?	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Fatigue testing was included in the pin tests and revealed that the designs were marginal. Gasket feature on pin contact points has now been included. See analysis report NSTXU-CALC-11-10-00 (W. Syed).</p> <p>Fatigue testing is being conducted on CSFW tiles (see report NSTX-U-REC-082-00). NSTX-U structural design criteria (1/2 ultimate) is applied to analysis. Load spectrum is applied as per GRD and NSTX-U-RQMT-RD-003-01 (disruptions).</p>
29-Sep-2017	LHFPDR4	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Interface table I.I.I.I.2 (Slide 16 on 02-03_PFC Review of Requirements & Interface Definition_GerhardtS) OBD does not interface with IBD. Interface is with OBD 1/2	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Formal interface documentation is conducted with new ICD system. This is reviewing and updating all tables in SRDs and RDs throughout project.</p>
29-Sep-2017	LHFPDR5	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Revise the CSFW requirement ASAP (Before FDR) taking into account "as-built" tolerance data that show the tile to tile offset in plasma direction is more than 0.01"	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p>

					Completed. The PFC requirements document has been updated with tile to tile alignment to .035". See answer LHFPDR28 above.
29-Sep-2017	LHFPDR6	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Are the location of the welded studs on the casing matching the 3D model? How will the mismatch affect the 0.01" tile alignment requirement? Suggest to design inspection tool/jig to check alignment.
29-Sep-2017	LHFPDR7	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Verify analysis assumption accommodate the thermal gradient of the CS casing during bakeout. The CS temperature > 350deg C to achieve a 350deg C PFC.
29-Sep-2017	LHFPDR8	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Allen head spiral lock will likely strip out where all wrench is inserted due to the higher torque.
					<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The location of the studs does not match the 3D model. The studs misalignment doesn't affect the tile to tile offset in plasma direction. The requirement is updated, and have alignment requirement of +/- .035. In addition, weld stud test report (number NSTX-U-REC-080-00) has shown that grinding and reshooting of studs does not compromise strength.</p> <p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Out of Scope for the PFC design effort. All designs can survive 350C bake-outs. NSTX-U Integration and integrated analysis determine bakeout performance. See calculation report NSTXU-CALC-10-06-00 (H. Zhang).</p> <p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Spiralock Nuts testing completed. @ 8-12 ft-lb Nuts strip out. @7 ft-lb survive 10 times and @ 6 ft-lb survive 12times. Will order enough spares for Nuts and will change to higher torque fastener head (Torx style). See drawing</p>

						C-ED11448. IP will reflect design torque.
29-Sep-2017	LHFPDR9 A	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Are the stress concentration geometry features accounted for? (ie. threads x4 stress   probe threaded into tile). [Langmir probes]	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Thread stresses were evaluated by B. Linn for OBD345 design.</p>
29-Sep-2017	LHFPDR9 B	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Thermal Coef of Expansion differences with probe and tile threaded, what affects?	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Probe plug and tile will be composed of the same material so there will be no CTE-mismatch issues. See drawings 9D11170 and 9D11171. Material call-outs on those drawings will be updated within the PFC Diagnostics scope of work.</p> <p>CTE is the same between probe and tile. See tile and diagnostic drawings which specify material. OBD tile drawings: E-ED1402-4, E-ED1403-4, E-ED1404-7, E-ED1405-5, E-ED1406-8, and E-ED1407-5. Langmuir probe diagnostic drawing E-9D11171.</p>
29-Sep-2017	LHFPDR9 C	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	Check field modifications to tiles are in drawings and checked by analysis	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Field modifications are not planned in these designs. New designs are in use and it is not necessary to re-analyze designs that will not be used. New designs have necessary features for wire access and diagnostic implementations.</p>

15-Nov-2017	HHFPDR0 1	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Diagnostic presentation, slide 11, the blue tile misses innermost cube, the load on the toroidally facing edge needs to be evaluated and shadowed if necessary.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The organ pipe variant is a variant allowing gas feed and optical access with a large cut-out.</p> <p>Heat fluxes are lower in the inner-most corner of IBDH as per SRD. A calculation report of the analysis for this tile is NSTXU-CALC-11-19-00.</p>
15-Nov-2017	HHFPDR0 2	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	<p>Please add figures in NSTX-U-RQMT-SRD-003-00 which directly specify the fishscaling direction by region. (Figures 2.3-1 and 2.3-2 only show fish scaling direction for IBD-H, not IBD-V or OBD. Specifying field direction rather than fishscaling is likely to cause confusion)</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Complete. Fish Scaling figure has been enlarged to show specifically which way the field lines will impact the HHF PFCs.</p>
15-Nov-2017	HHFPDR0 3	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	<p>Halo analysis assumes peaking factor of 2 which is reasonable for typical conditions. However there are scenarios/conditions where the peaking factor at tile surface has been measured to be higher (presumably still within assumed peaking * halo fraction factor).</p> <p>Recommend looking at a few cases / spot-check with higher peaking factor - perhaps up to 5 - or whatever is a reasonable upper-bound from physics database to make sure the analysis assumptions we are using are conservative.</p>	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>We are using loads per Art Brooks' spreadsheet, scaled for tile thickness (calculation number NSTXU-CALC-11-24-00). We are designing to the SRD and RD documents only.</p>
15-Nov-2017	HHFPDR0 4	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Stress concentrations will occur in the castellated tiles due to heat flux. Determine what prior literature and experiments (preferably in	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00

					graphite) can confirm this analysis and plan + execute tests on prototypes as necessary.	HHF testing has been completed at Advanced Research Laboratory. See report NSTX-U-REC-084-00 for details.
15-Nov-2017	HHFPDR0 5	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The tile sample circulated evidenced chipped edges along the interior machined corners and interfaces. Investigate/comment as to the impact of the sharp interfaces created by these chipped edges on fatigue properties and potential crack propagation. Is a different process needed to eliminate this chipping?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Filletts will be included at critical regions where sharp corners occur. Lockbar contact location, where the most critical stresses occur, will not have sharp corners of this kind. This can be seen in drawing E-ED1398.  No special process is expected during manufacturing.
15-Nov-2017	HHFPDR0 6	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Lithium evaporation is aimed at lower divertor. The 0.02" tile gap will most likely be filled with lithium compound over the time. How this will affect tile analysis?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Hand calculations are performed of the new eddy current loads assuming a "completed shorted" surface (i.e. same tile area but no castellations). The calculated eddy currents are analyzed in the base tile analysis and represent "worst case" loads. Calculation report NSTXU-CALC-11-24-00 details this.
15-Nov-2017	HHFPDR0 7	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	For CS-A, slide 6: Regarding the grafoil beneath the CS-A tiles, consider increasing the length of the "U" portion of the grafoil to decrease likelihood of grafoil tearing into 2 pieces.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Agreed. Grafoil length is increased to cover both Row 5 & Row 6 CSA tile (AJ). See drawing E-ED1425 to confirm increased length.

15-Nov-2017	HHFPDR08	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Recommend adding length to grafoil gasket under the CSA tiles where the gasket is a single piece at the bottom of the U-shape to increase gasket survivability	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Agreed. Grafoil length is increased to cover both Row 5 & Row 6 CSA tile (AJ). See drawing E-ED1425 to confirm increased length.
15-Nov-2017	HHFPDR09	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	For the CSAS, the tile shaping was presented as a flattening of a curved surface. This creates a faceted heat flux enhancement. Show that the heat flux is still OK w/ faceting or adjust shaping to be rounded to avoid this. Request guidance from physics as necessary.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Current CSA tile fishscale surface is a curved surface. See drawings E-ED1420 to E-ED1423.
15-Nov-2017	HHFPDR10	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	For the CS-A region: Several FEA results plots show compressive stresses with sharp gradients across a width less than a single element length. The mesh may not be resolving the minimum compressive stresses properly. If it has not been done already, please assess whether these are numerical artifacts or real contact stresses. (See slides #14, 18, 20, 24, etc.)	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Will redo modeling with finer mesh. Analysis result is shown in calculation report NSTXU-CALC-11-21-00.
15-Nov-2017	HHFPDR11	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	HC Rogowski Coils, CS-A R5: Ensure that sufficient clearance exists for both the gas injection tubes and rogowski coil. Prefer to do this in a way which still holds the rogowski coil secure, w/o having too much "slop" at other poloidal angles.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Diagnostic cut out updated to avail enough clearance. See drawing number E-ED1420,ED1421 & Rju_ankita_master_layout.
15-Nov-2017	HHFPDR12	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	For CSA design, the tapped hole on t-bar is all the way through. The pin could end up at different positions during installation. Suggest to machine a stopper feature in	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00

					t-bar so that when bottomed out the pin will end up the same position at all locations.	Done. T-bar is modified to have a hard stop for Pins (AJ). See drawing number E-ED1424.
15-Nov-2017	HHFPDR1 3	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Has the effect of thermal growth of the tile further compressing the graphfoil been accounted?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Yes. See the deformation plot. The grafoil is compressed <1 % of its original thickness so still has enough margin to provide cushioning effect. See calculation report NSTXU-CALC-11-21-00.
15-Nov-2017	HHFPDR1 4	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The CSAS tiles have gaps that are ~0.060" between tiles, corresponding to ~1.5 mm. Section 3.3-d of the PFC requirements says any gap > 1 mm must be approved. Either close gap to below 1 mm (beware of tolerances to prevent tile interaction) or get 'sign-off' on this gap.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  These tiles have overlaps so, there won't be any shine through to casing even though the gap is of .06". The area of the corner gap is comparable to the area of the nut-caps or bolts in all other front-surface mounting design and this is not deemed to be a problem.
15-Nov-2017	HHFPDR1 5	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	IBD-H/IBD-V Frame/Ice Cube Tray: Consider plating (copper/silver) the contact surfaces b/w the frame and the CS Casing, to enhance thermal/electrical contact and minimize galling due to differential thermal expansion.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The window frames on IBDV and IBDH are not intended as the electrical and thermal pathways in this design. Thermal and electrical contact is already maximized with the use of a grafoil gasket between the graphite tile and the metal base plate.  The window frames and HTP and CS casing are all composed of inconel. This eliminates coefficient of thermal expansion differences.  To prevent galling between components, the window frames will be silver plated.

15-Nov-2017	HHFPDR1 6	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The toroidal gaps on the LHF IBDV tiles also appear to be 1.5 mm in violation of 3.3-d (see CSAS CHIT). The HHF tiles have the ring to block line of sight to casing. Assume all gaps should be double checked so I don't keep writing this CHIT.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  All gaps have been reduced to 0.040" (1mm).
15-Nov-2017	HHFPDR1 7	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	IBD-V Frame/Ice Cube Tray: Mechanical fixation of frame shows slotted bolts to allow fine adjustment during installation, but this would require high preloads to develop frictional tractions sufficient to react shearing side loads. Consider adding a few small welds to the frame near the center, to provide a fixed shear reaction point from which the frame can expand outwards.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Slotted bolt access is provided for assembly. In addition, adjacent vertical frames are bolted together to ensure all frames have common motion (i.e. don't open gaps). This is shown in detail in drawing E-ED1435 sheet 2 zone H2. The calculation report for IBDV tiles is NSTXU-CALC-11-19-00.
15-Nov-2017	HHFPDR1 8	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Bolting scheme needs one two directional pin plus a second sliding restraint - More work needed on mounting	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Assumption: this CHIT refers to the IBDH frame mounting scheme to the HTP.  Precise positioning of the frame in the plane of the HTP is achieved with locating pins indicated in drawing E-ED1433 zone D5 and G5. This prevents sliding motion. The adjacent frames are fastened together to prevent relative motion or rotation about the locating pins. Bolts into HTP prevent vertical displacement.

15-Nov-2017	HHFPDR19	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The "ikea" toggle bar works well on the flat plastic prototype tile. Next step should be to prototype a full inconel arched frame with graphite tiles to test full range of tolerances and measure the tension in each pin. Purpose is to verify smooth operation in round condition with brittle graphite tile, in full range of tolerances. Can also use to develop method to extract a tile when fastener galls or welds tight.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Prototype of frame will be tested with graphite but is not believed to be necessary to provide design assurance for the FDR. Pins will be silver plate to prevent galling. Displacement of each pin will be measured to characterize load. Testing result will be reported in appropriate report.
15-Nov-2017	HHFPDR20	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	IBD-V Ikea Connector Prototype: 1. Two tiles on 1 rod may not have even load distribution. Consider checking this with pressure paper. 2. I can rotate the two tiles (about an axis normal to their surface) by hand so that their corners touch. Is this OK? Does tolerance stack need to be investigated to prevent this?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  1. Uneven loading can occur, but does not change the function of the tile. Grafoil back-layer deforms between casing and graphite. Adjustability is included in the belleville stack and pin to fine-tune preloads. This is shown in drawing ED1432 with washer of 0.010" thickness.  2. A grafoil layer (including along the sides of the frame) will prevent rotation. The gap between frame and tile is 0.030" and the thickness of the grafoil on either side is 0.030". Any force will result in compression of the grafoil which resists rotation.
15-Nov-2017	HHFPDR21	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Prototype the two-bar mounting scheme for castellated tiles and consider testing in relevant environments to confirm design (e.g bake, under high heat flux) and demonstrate tolerance build-up for fishscaling.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Expected tolerances associated with tile manufacturing have been used to define the fish-scaling geometries to guarantee no leading edges (MEMO PFC-180706-MAJ-01 and NSTX-U-RQMT-SRD-003-01). The

						interfaces between the tile surface and the back-surface is solely defined by the manufacturing tolerances of the tile and the grafoil. The mounting scheme does not affect this. See also calculation NSTXU-CALC-11-22-00 for a tolerance stack-up calculation.
15-Nov-2017	HHFPDR2 2	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	At the gap between the IBDH and the OBD1, with minimum relative movement between the two tile assemblies, there can be a line of sight hitting the metal fixing rod.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  There is a slight line of site. Last update was moving the rod to be flush with angled part of tile. As requested by outboard team See views supplied below. The view of the lock-bar is mitigated by the depth below the tile surface. The resulting aspect ratio between channel width to depth is well over 2 and this is not expected to be a problem.
15-Nov-2017	HHFPDR2 3	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The IBDH tiles are thicker and could impact cutouts in low heat flux region. For MGI, this should not be an issue. For spectroscopy this may impact FOV. Ensure cutouts are consistent with requirements for these systems.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Optical access geometry was provided to diagnostic physicist and no comments or modifications were given.
15-Nov-2017	HHFPDR2 4	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The gap between the IBDV LHF and the IBDH is not a high aspect ratio gap. The gap is greater than 1 mm (1/16"?) [PFC SRD 3.3d] so it must be evaluated.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The final design of the IBDH tile includes an inboard "shelf" feature that maintains a constant gap between the IBDH and IBDV-LHF tiles of 0.040". This meets the criteria for an acceptable line of sight as per the SRD in section 3.3-d (NSTX-U-RQMT-SRD-003-02).

15-Nov-2017	HHFPDR2 5	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Seems to me that the "Access holes" on the IBDH tiles that were shown will allow large access to the diagnostic wire cavity...like an open barn door. This should be closed off.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  No plasma access to the cavity between IBDH and IBDV-LHF except through gaps less than or equal to 0.040" is possible in the final design. The variant design for the organ pipes now includes a "back wall" that prevents plasma influx.
15-Nov-2017	HHFPDR2 6	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Same as chit #11, only for IBD-H: FEA plots on slide #33 show compressive stresses (after pulse) which looks like the mesh density may not be fully resolving the peak stress (which is a combination of the soak through thermal displacements with the mounting supports preload). If it has not been done already, please assess whether these are numerical artifacts or real contact stresses.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Mesh refinement studies were included in the PDR materials to determine if contact stresses were appropriately resolved (they were).
15-Nov-2017	HHFPDR2 7	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	CASE #1 Requirements for IBDH imply 8.5 MW/m <sup>2</sup> which would not meet surface temperature requirements w/ shaping and perfect coil alignment although are well within stress allowable. Coil alignment requirements need to be specified, and a combination of CASE #1 heat flux requirement needs to be reduced, impact angle needs to be increased and surface temperature requirement needs to be increased.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The SRD revision 01 has reduced heat flux requirements and defined the requirements for analysis as considering axisymmetric heat loads only. The new heat flux requirements and relevant design details (e.g. surface shaping) have been analyzed and each high-heat flux design area includes an analysis report detailing the results (e.g. NSTXU-CALC-11-22-00).
15-Nov-2017	HHFPDR2 8	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The IBDH tiles should not have viewing holes if they are over organ pipes associated with electrical feedthroughs. The diagnostics RD has information	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00

					about how the organ pipes are used.	Access to the organ pipes for electrical feed-thrus is provided by channel-ways cut into the base-tile design shown in drawing E-ED1434.
15-Nov-2017	HHFPDR29	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Please perform a self-check of the global EM model when applied to actual PFC mountings. e.g. Do changes in path resistivities through the bolts or by using a frame with many more holes change the current distributions on a global level. Are the applied global EM BCs still valid in the final configurations?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  A detailed EM analysis was completed for the IBDV (NSTXU-CALC-11-19-00). This calculation did a detailed analysis of the path of the the EM loads through the tiles and mounting hardware/structure.  All design specific PFC EM loads were conservatively estimated by bounding worst case EM paths, along with assuming one solid block of material.
15-Nov-2017	HHFPDR30	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Are studies underway for cleaning dust and debris from castellation gaps, etc.?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  EM Analysis input was calculated with worst case scenarios where the castellation gaps were filled with lithium. Design incorporates worst case in which castellations were removed due to connecting material between the castellations. Lithium will also evaporate away during the run cycle.
15-Nov-2017	HHFPDR31	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Andrei did not shown stress results for metal frame nor the interface with the HTP. Do the interface components (bolted connection?) meet design criteria?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Stress in the frame and hardware components have been analyzed and are presented in reports NSTXU-CALC-11-18-00 and NSTXU-CALC-11-19-00.

15-Nov-2017	HHFPDR3 2	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Are halo current forces in the direction to slide the transition pieces toward the open end of the keyhole if the clamping force is insufficient?	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Halo current loads result in electromagnetic loading that can operate in either direction of the poloidal plane depending on whether the tile is on an upper surface or a lower surface. Analysis of halo loads is included in the final analysis of each tile design.</p>
15-Nov-2017	HHFPDR3 3	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Define a tolerance for the radial vertical step between the IBD-H and IBD-V. If this tolerance is small, and there is not a capability to adjust the height of either the IBD-H or IBD-V (e.g., shimming), this will have implications on the assembly level positioning of the CS within NSTX-U Vessel.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The IBDH design includes a "shelf" feature to make a uniform surface for the IBDV-LHF tiles. See drawing E-ED1434.</p>
15-Nov-2017	HHFPDR3 4	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The target and achievable relative vertical position of the IBDH and the OBD1 tiles (at the bottom and at the top of the machine) needs to be defined.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The design for OBD12 and IBDH make use of the in-vessel positions as determined by metrology (c.f. NSTX-U-REC-085-00). In the case of IBDH, the substrate tolerance is improved by the Heat-Transfer Plate. Discussion with the HTP COG/RE has reached an agreed-to surface profile tolerance of 0.010". In the case of the OBD12 design, the outboard divertor plates have been measured via direct metrology (report NSTX-U-REC-085-00). The design of the OBD12 makes use of unique "Transition Plates" that correct the structure to create an axisymmetric surface as described in the system design document. Tolerances of 0.010" tile-to-tile are expected to be achievable.</p>

15-Nov-2017	HHFPDR3 5	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	ODR1-2, consider add feature to lock transition plate onto copper plate after find the right position of the tile, instead of rely on two bolts at one end in slots. Also how to prevent hardware get loosened over the heat cycles?	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>A locking feature, and backup design, has been developed. This is shown in drawing E-ED1408 sheet 8 (quadrant J-14).</p>
15-Nov-2017	HHFPDR3 6	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The OBD12 multi Keyhole fastening scheme will be a challenge to properly engage in all positions. Recommend building a full size mockup replicating all materials and features to test the ease of installation.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The design was revised to only engage two should screws at once only. The present design is shown in drawing E-ED1408 sheet 1.</p>
15-Nov-2017	HHFPDR3 7	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	CASE #1 Requirements for OBD R1/R2 imply 9.0 MW/m <sup>2</sup> which would not meet surface temperature requirements w/ shaping and perfect coil alignment although are well within stress allowable. Coil alignment requirements need to be specified, and a combination of CASE #1 heat flux requirement needs to be reduced, impact angle needs to be increased and surface temperature requirement needs to be increased.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>SRD revision 01 (and following) have reduced requirements and defined the design target as having axisymmetric heat fluxes. See SRD NSTX-U-RQMT-SRD-003-02 paragraph 4.0-c.</p>
15-Nov-2017	HHFPDR3 8	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Global Thermal Analysis: Emissivity of .8 is very high for lithium coated PFCs. It may be reasonable to assume that lithium "boils off" in divertor regions, but maybe not for lower heat flux area	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>The surface emissivity value to be used for design and analysis is given in the SRD (NSTX-U-RQMT-SRD-003-01 and following) in section 3.1-I. It is defined as 0.7 for all graphite surfaces. No credit is taken for the effect of lithium or lithium</p>

						compounds or other wall-conditioning materials that may reduce the incident power.
15-Nov-2017	HHFPDR39	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Multiple presentations listed temperature requirements for bakeout as 300C - 325C. While the minimum temperature for the bakeout system is 300C there is also a high limit of 350C to accommodate imbalances in the system. Design requirements for components exposed to bakeout should use the 350C as a design point as the operating temperature will on average range between 300C and 350C. Review and ensure that analysis involving bakeout (thermal expansion etc) is based off of the 350C maximum and not the 300C minimum bakeout temperature.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Tile designs have limiting temperature of 1600C surface average at the end of the defined heat loads with edge temperatures of up to 2000C. Both temperatures greatly surpass 350C. Thermal growth of individual tiles is much less than the tile-to-tile gap. A typical CTE is less than 10 microns/m-K with a typical length of 20 cm (~5 inches). At 400 C, the thermal growth, d, is $d=L*CTE*dT=0.02m*10e-6 m/m-K*400K=79e-6 m$ . The typical tile-to-tile gap is 1000e-6 m so thermal growth of the tiles is not a concern. Achievement of bakeout temperature has been analyzed by the Integrated Analysis group and is reported in calculation report NSTXU-CALC-10-6-00.
15-Nov-2017	HHFPDR40	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Consider offsetting LHF IBDV tiles 7.5 deg from HHF IBDV tiles to align center of HHF with clear center and double hold downs away from single T-bar in center of LHF tiles to facilitate wire routing	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Wire routing has been determined with drawing E-ED1324 and all tiles on the center stack casing are compatible with this interface document between the PFC group and Diagnostics.
15-Nov-2017	HHFPDR41	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	For the OBDR1/R2 tiles, it would be very very nice to have two 2D mirnov coils over that poloidal extent, as in the previous design. And it is necessary to orient them so that they do NOT measure toroidal field.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  We will use one Mirnov coil per tile per OBD12 assembly shown in

						drawing E-ED1408 sheet 4. This coil will be oriented to measure the poloidal field.
15-Nov-2017	HHFPDR4 3	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Develop clear list of goals for high heat flux testing of prototypes necessary for the FDR and ensure resources (schedule, \$ and personnel) will allow those to be completed prior to FDR.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Prototyping process defined by RE in January requires COGs to identify needed tests for any prototypes. The definition of a "needed test" is one that cannot be qualified through analysis to the satisfaction of the COG. Following HHF testing of the ORNL prototype (see NSTX-U Year End Report section on F(18-1)), COGs for HHF designs did not deem HHF testing of the prototypes necessary to qualify the performance of the tiles. Cost savings will be reflected in a BCP to the current WAF post-FDR.
15-Nov-2017	HHFPDR4 4	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Consider drafting the oversight plan(s) soon as they help in the procurement planning. It would be a good idea to have generic drafts, not yet including supplier info, ready by the FDR.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Material purchase does not require an oversight plan. Tile manufacturing cannot begin until CDE3a review.
15-Nov-2017	HHFPDR4 5	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	High Heat Flux Test: The HHF testing results show a qualitative sorting of different material's relative performance. However, as compared to pre-testing FEA scoping, ATJ failure occurs right at expectation, but Sigrafine R6510 fails at less than expectation. This may be an indication that we are not meeting the criteria document's requirement of a FOS of 2x on stress.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  In testing by PPPL and ORNL, no mechanical fracturing of the graphite material was ever achieved. Instead, surface ablation, masking (possibly) spall was found when heat fluxes and/or times exceeded those defined in the SRD. These results are reported in NSTX-U-REC-084-00. Analysis of the

						high-heat flux tiles indicates that the surface temperature limit is reached before any stress allowables for all cases in the SRD. The NSTX Structural Design Criteria uses a 2x factor of safety for principal stresses in brittle material so the present design is meeting this requirement.
15-Nov-2017	HHFPDR4 6	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Regarding the sample tests, I recommend computing/tabulating, as best we understand, the internal stresses and likely surface temperatures. ANSYS runs I presume. And then correlate the "damage" observed with proximity to compressive (or other) stress limits.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  This analysis is budgeted in the WAF but developments indicated the COGs would not require these tests to provide design assurance. See answer to HHFPDR43.
15-Nov-2017	HHFPDR4 7	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Keep the IBDV low heat flux tiles the HHF schedule. The design of these tiles are impacted by interfacing and diagnostic routing and we risk being forced into design decisions on HHF tiles that are impacted by a fixed LHF IBDV.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  IBDV LHF tiles have been designed along with the IBDV scope. All PFCs have been integrated into a parallel schedule.
15-Nov-2017	HHFPDR4 8	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	An upper divertor gas injection system (symmetric with and identical to the existing lower divertor gas injection system) should be considered as high priority to address divertor heat flux mitigation by divertor radiation. Additional poloidally distributed divertor gas systems, such as the proposed PFR system, are desirable for physics studies but not required.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Gas injection systems and requirements are defined in the NSTX-U-RQMT-RD-004-00 requirements document "PFC Diagnostics and Fueling."

15-Nov-2017	HHFPDR4 9	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Detail design and analysis need to be performed, in the next project phase, for hardware (i.e. T-Bars, supports), fasteners (i.e. bolts, pins and washers), and welded joints.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Detailed designs of graphite tiles as well as mounting hardware has been performed to reach FDR. Summaries of the designs and associated calculations are given in each FDR presentation which refers to drawings, testing reports, and calculations by number as per the NSTX-U Document Management Plan.</p>
15-Nov-2017	HHFPDR5 2	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	PFC team should craft response on material question raised in EOC (or other) previous recommendation to evaluate R6510 and R6710 based on knowledge to date.	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Material selection was done through material selection peer review. Each PFC COG choose a 1st and 2nd choice material that would help mitigate any graphite procurement difficulties. See MEMO PFC-180628-MAJ-03 for details.</p>
15-Jun-2018	MDSPR01	Material Down Selection Peer Review	1.01		Will the fabrication be able to begin right after the CDE-3a review or will there be a delay in approval?	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Required documents will be completed as to expedite the manufacturing process up to the CDE-3a review. There will be a delay in approval and that is incorporated into the post FDR schedule.</p>
15-Jun-2018	MDSPR02	Material Down Selection Peer Review	1.01		Is the aspect of the material properties being tested now and the actual material properties of the obtained materials being different being looked into?	<p>Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00</p> <p>Additional material will be purchased to accommodate variations. Testing will be done and</p>

						the appropriate material will be used. See report NSTX-U-REC-083-00.
15-Jun-2018	MDSR03	Material Down Selection Peer Review	1.01		Did XTJ ever bid to PPPL and do we understand the reason DIII-D was able to get it?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  XTJ was not chosen by the PFC team for any regions for their material of choice. See MEMO PFC-180628-MAJ-03.
15-Jun-2018	MDSR04	Material Down Selection Peer Review	1.01		Do the vendors use the same ASTM standards as we are using for these tests?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  The Vendors do not use the same ASTM standards as we are using for our tests. The Vendor's use a variety of different standards and many would not give us the details of those standards. The Vendors also stated that they could not guarantee any of the provided values. For details of PPPL-procured testing, see report NSTX-U-083-00.
15-Jun-2018	MDSR05	Material Down Selection Peer Review	1.01		Is this flexural number directly relatable to the design process.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  No. The flexural number is not directly related to the design process. The structural requirements state that the design shall use have tensile, which the PFCs are designed against. See NSTX-CRIT-0001-02 for design criteria used in the PFC program.
15-Jun-2018	MDSR06	Material Down Selection Peer Review	1.01		Does this mean we need to test to failure in the correct stress state?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  CSFW tile testing was completed (see NSTX-U-REC-082-00).

						Prototypes were deemed unnecessary for the other regions. Analysis (see design reports) is within the requirements and the values show acceptable results.
15-Jun-2018	MDSR07	Material Down Selection Peer Review	1.01		is it fair to say that the head pop was a tensile failure.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Yes, the head pop shows a lower tensile strength than the actual tensile strength. This can be used as an acceptable value since it is a lower value. Another round of testing was done and the test concluded appropriately.
15-Jun-2018	MDSR08	Material Down Selection Peer Review	1.01		Heat flux should be interpreted as pure normal heat flux?	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Heat flux values are defined as axisymmetric with a given angle of incidence to a surface in the PFC SRD (NSTX-U-RQMT-SRD-003-02 paragraph 4.0-c.).
14-Feb-2017	VVIHPP14	Vacuum Vessel & Internal Hardware DVVR	1.1.1.6	PFCs - Integration	Passive plate disruption analysis doesn't include the tiles. As you bend the plates, this could create stress-concentrations around the tile bolts. Could have low-cycle fatigue in the tiles and mounting structures.	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
21-Apr-2017	POLARPER31	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Regarding the 'small tile' option with a single bolt on each tile, it is important to build in a keyway groove or equivalent structure in the back plate that engages with the tiles to keep the tiles from rotating about the bolt – lesson learned from C-Mod inner wall tiles.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Tile down selection review was completed and the small tile option was not selected. Castellated tile geometry was selected. (NA)

21-Apr-2017	POLARPER34	Polar Region Design Integration Peer Review	1.1.1	PFCs - High Heat Flux	Regarding the 'small tile' option: Consider castellated design of smallish tiles instead of a full array of separate very small tiles.	Closed per NSTX-U-REC-089-00 NSTX-U Chit Resolution Report - Plasma Facing Components (PFCs) NSTXU-PFC-CRR-001-00  Tile down selection review was completed and the small tile option was not selected. Castellated tile geometry was selected. (NA)
29-Sep-2017	LHFPDR3	Low Heat Flux -- Plasma Facing Components PDR	1.1.1	PFCs - Low Heat Flux	PFC performance & requirements must consider/asses tile to field alignment as well as tile to tile alignment.	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
15-Nov-2017	HHFPDR42	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Look into terminal strips or connections with feeds to the other side built into IBDV frames that can be built into frames to allow for easy in vessel connection/repair	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
15-Nov-2017	HHFPDR50	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	The cooling plate and other components (that require cooling/heating fluids) design shall comply with Mech-015 to ensure their safety as pressurized components.	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
15-Nov-2017	HHFPDR51	PFC High Heat Flux PDR	1.1.1	PFCs - High Heat Flux	Procedure shall be developed to explain technical and configuration priorities for assembly, installation and testing.	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
15-Aug-2018	PROJPDR26	Project PDR	1.01	1.1	How the Grafoil under the HHF tiles will react to pre-loads + heating is not understood. Testing should be done to make sure the tiles will maintain the proper pre-loads and positioning.	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report

15-Aug-2018	PROJPDR 33	Project PDR	1.01	1.1	Supplier of graphite is unwilling to guarantee material properties. However, they will supply test data with each provided piece of material. If they are willing to share historical data on these values with us (e.g. ~35+ most recent reports), we can construct statistically significant confidence intervals for the true mean & std dev of each of the measured properties. Though short of a guarantee, it will be sufficiently reliable and should ameliorate the uncertainty which is complicating our design process.	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
28-Sep-2018	PFCPEMP FDR01	PFCs-PE MP FDR	1.01.01	1.1.1.1	Please ensure that the high vacuum outgassing test of the purchased graphite will be also included in the test plan.	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
28-Sep-2018	PFCPEMP FDR02	PFCs-PE MP FDR	1.01.01	1.1.1.1	Review the numerous procurements and determine which ones require Statements of Work to ensure that suppliers understand and agree to all technical and QA requirements, and that all steps are taken during the manufacturing and delivery process to are compliant with project needs.	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
28-Sep-2018	PFCPEMP FDR03	PFCs-PE MP FDR	1.01.01	1.1.1.1	Calculation 11-10 section 3.1 mentions "PPPL material database." No reference is provided for this information. What properties were used in this analyses? This comment applies to other calculations as well. the types of materials used was stated, but the relevant material property information was not provided.  RBC: ANSYS material properties used in calculations are included in the digital	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report

					<p>archive. Link has been made through dashboard. This is the analysis group database used within the PFC group.</p> <p>RBR: Concur - PFC group will generate a new NSTX-U-REC that has the material database. CALCS that reference the "material database" will be taken to rev. 01 with comment to new REC.</p>	
28-Sep-2018	PFCPEMP FDR04	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>The CSA tiles nearest to the centre-tube have a sharp internal angle of about 140 degrees, at the thinnest point of these "not quite L-shaped" tiles. Wouldn't it be a good idea to radius that internal corner by a few cm, to improve its margin against unforeseen extreme loads, achievable at negligible cost?</p> <p>RBC: Consider</p>	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
28-Sep-2018	PFCPEMP FDR05	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>Calculation 11-11 shows the summary of the tile loads which can be directly seen from the subsequent figures. The summary loads include Halo forces and eddy current moments. Are there no halo moments and eddy current forces?</p> <p>RBC: This is a labeling issue. nodal solutions are imported directly. Reject</p>	RBC: This is a labeling issue. nodal solutions are imported directly. Reject
28-Sep-2018	PFCPEMP FDR06	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>As the pre-load is the most significant source of stress on the tiles (quoting the presenter - mechanical stresses at the fixtures decrease when tiles are heated), consider carry out pre-load tests to support analysis results.</p>	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report

					RBC: Design team to provide rationale of omitting prototype recommendations of down-selection committee	
28-Sep-2018	PFCPEMP FDR07	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>Calculations make reference to PFC-180613-AK-01. This appears to be a procedure for doing some of the PFC FEA. (1) I could not find this reference in the dashboard. (2) Has this procedure been vetted / checked?</p> <p>RBC: PFC team will confirm this MEMO has been filed with NSTX-U document management system. If this is analysis guidance, the process is vetted in the "Calculation Check" process.</p>	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
28-Sep-2018	PFCPEMP FDR08	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>We witnessed in testing that the rod(pin) bends and could potentially crack the tile. The solution of adding the graphoil bushing is a good option; but it helps to be tested to see if it sets.</p> <p>RBC: Either memo with the rational for not testing or repeat of test Consider</p>	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
28-Sep-2018	PFCPEMP FDR09	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>Is there a concern on the nut coming loose? Any preventative/locking measure? I noticed the thread fit on the stud is rather loose. How about a tighter fit thread on the nuts?</p> <p>RBC: These are "spirolock" nuts that prevent backing out. Reject</p>	RBC: These are "spirolock" nuts that prevent backing out. Reject

28-Sep-2018	PFCPEMP FDR10	PFCs-PE MP FDR	1.01. 01	1.1.1. 1	<p>Slide 12 of Bob's presentation on the OBD-R12 tile assemblies shows four shoulder screws to attach the transition plate to the OBD structure, only two of which (at the end) have marginal access for a modified hex-key to tighten them. The other two are intended to have welded-on Belleville washers to provide inhibition of rattling when the heads were slid along the key-hole slots. We discussed the possible (I would say "probable") need for a wedge feature on the key-hole slot but it occurs to me that the weld will constrain the deformation of the Belleville washer, which is undesirable. Use a wedge plus a spring washer of some different type with a threaded hole so it is trapped on the screw without welding?</p> <p>RBC: PFC Team will evaluate prototype transition plate when it is completed, including alternative schemes such as this proposed. Result will be filed with REC or MEMO.</p>	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
28-Sep-2018	PFCPEMP FDR11	PFCs-PE MP FDR	1.01. 01	1.1.1. 1	<p>Someone (Steve R?) noted that the copper backing plates of OBD-R12 might not be flat. The TF coils of Compass had this problem, due to residual stresses near the surfaces of the rolled plate from which they were machined. The cure was to make several light cuts on each side, but this required very many rejigging cycles in the machining of each TF conductor.</p> <p>RBC: Not cutting R12 copper plate Reject</p>	RBC: Not cutting R12 copper plate Reject

28-Sep-2018	PFCPEMP FDR12	PFCs-PE MP FDR	1.01. 01	1.1.1. 1	<p>NSTXU-CALC-11-31-00 assumes the HTP can be shimmed to within 0.003-0.005". This is not currently in the installation plan (HTP surface flatness of 0.010" was previously discussed with HTP COG). Calculation thus indicates that one of three things is required: A) The tile fish scale should be redone to the expected HTP value, or B) the HTP COG should concur that the required surface flatness can be delivered, or C) the reassembly WAF should be revisited to ensure shimming in the IP is consistent with this requirement.</p> <p>RBC: PFC team and integration group will discuss this action to determine the best path forward.</p>	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report
28-Sep-2018	PFCPEMP FDR13	PFCs-PE MP FDR	1.01. 01	1.1.1. 1	<p>In slide 11 of Andrei's talk on IBDH, the 90 degree rotated tie-bar design is shown (similar to an IKEA furniture locking cam ring). Depending on the preload applied by the Belleville stacks, this might need a large torque to make the initial rotation - but once vacuum tribology and the occasional halo current has gone through the pull-down pins, they might get welded to the tie-rods. What would then be the recovery method to disassemble these components? Can you use some mismatch of alloys (maybe Monel against Inconel?) to avoid the welding effect?</p> <p>RBC: PFC team plan is to utilize silver coating to avoid galling. Redundant</p>	Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report

28-Sep-2018	PFCPEMP FDR14	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>If CFC is available it can be used in HHF PFC region, and than pulse power and duration can be increased significantly.</p> <p>RBC: This CHIT would significantly change the design. SRD r02 requirements are met with SGL R6510 (first choice material). In addition, there are fabrication concerns for the fine surface features. Reject</p>	<p>RBC: This CHIT would significantly change the design. SRD r02 requirements are met with SGL R6510 (first choice material). In addition, there are fabrication concerns for the fine surface features. Reject</p>
28-Sep-2018	PFCPEMP FDR15	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>Add thermocouples where the casing bakeout thermal analysis shows critical strains and or temperature limits</p>	<p>Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report</p>
28-Sep-2018	PFCPEMP FDR16	PFCs-PE MP FDR	1.01.01	1.1.1.1	<p>Consider adding thermocouples where the thermal analysis shows critical strain differentials or temperature limits</p>	<p>Closed per NSTX-U-REC-174-00 NSTX-U Chit Resolution Report</p>