



National Spherical Torus eXperiment Upgrade

Team Meeting 3/16/2022

NSTX-U Team Meeting, 3/16/22

Stefan Gerhardt for the NSTX-U Team

Last Edited: 3/16/22, 2:00 PM

High Level Thoughts

- Project is going well
 - Current CPI (Proposed Revised Baseline): 0.98
 - Current SPI (Proposed Revised Baseline): 0.99
 - *Thanks to the team for meeting these cost/schedule goals while respecting the overriding priorities of safety and quality*
- Adverse findings on the existing bundle have resulted in our pausing work on it.
- Energetically moving on new bundle procurement/fabrication
 - major activity involving a team from engineering, project management, quality, and procurement
- Preparing for a DOE review in the spring

Outline

- Existing Bundle Disposition
- New Bundle Progress, IPR, Project Schedule
- Balance of Project

Decision to Remove OH Taken in Late 2021

- In late 2021, there was an accumulation of evidence that the source of the insulation resistance drop was on the outer surface of the TF bundle.
 - There were no solutions on the table which would provide the expected level of assurance for reliable operations.
- It became apparent that we would need to remove the OH coil to diagnose and (hopefully) remedy the condition on the TF coil

OH Removal in 2022



Acknowledge Chuck King, Charlie Sands, and Joe Bartzak for their relentless work on this sectioning



Safety, quality, and schedule - in that order - successfully managed to get a very challenging task completed w/o incident

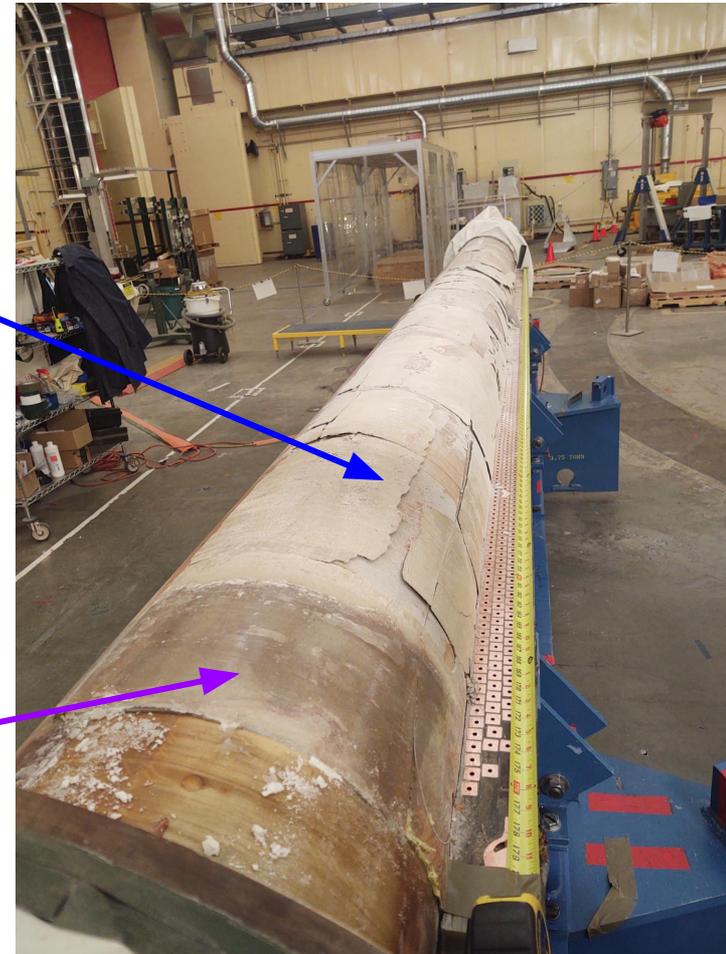


Aquapour Contamination Between TF and OH



Loose "Pure"
Aquapour

Hardened
Aquapour/Resin
Material



Cleaning the Bundle Surface

Magnet after Cleaning Loose Aquapour



Sanding the Aquapour/Resin material and "near resin"

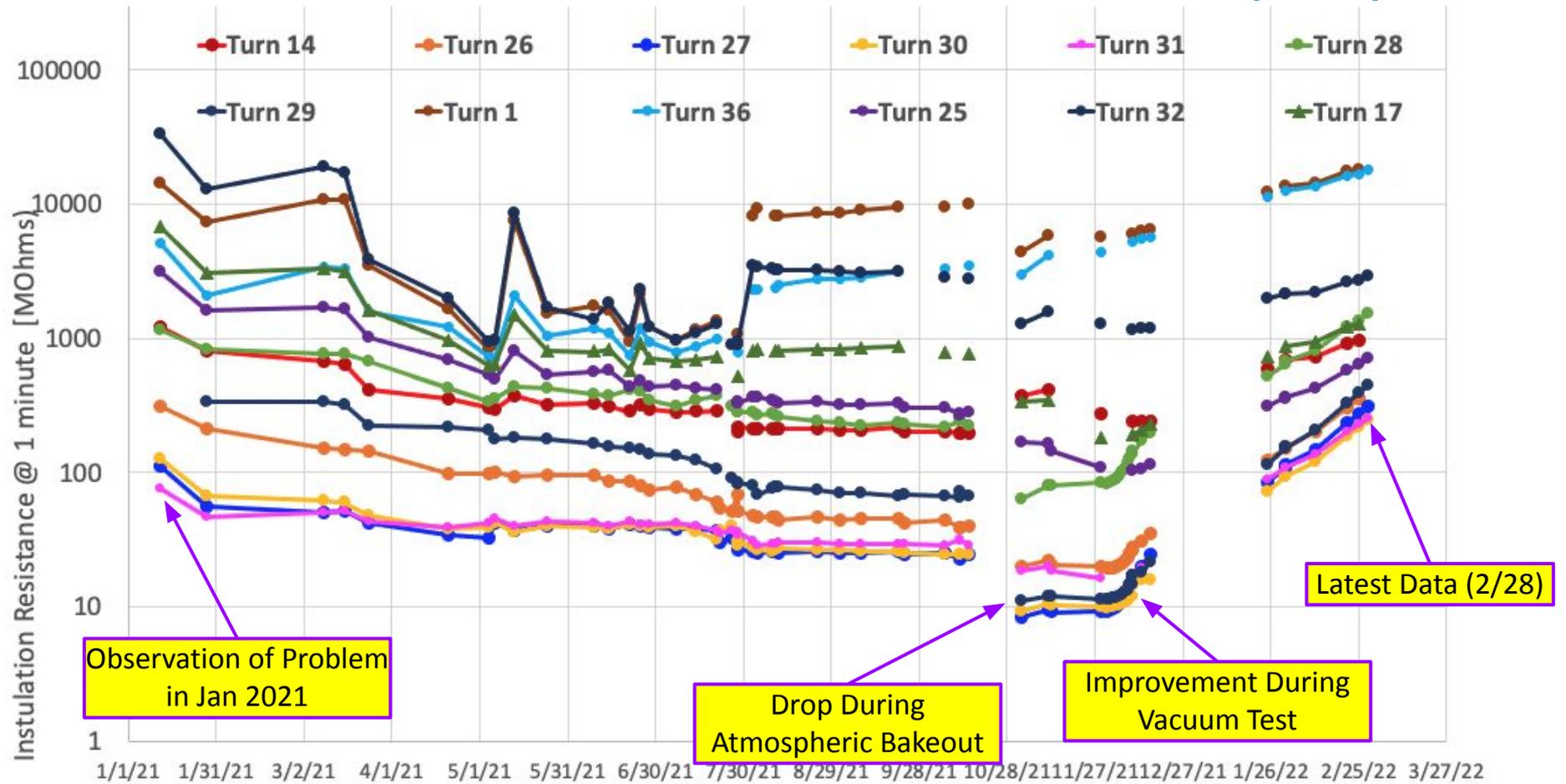


Fully Sanded and Cleaned Toroidal Field Bundle



“All But One Grounded” Testing - 2021 and 2022

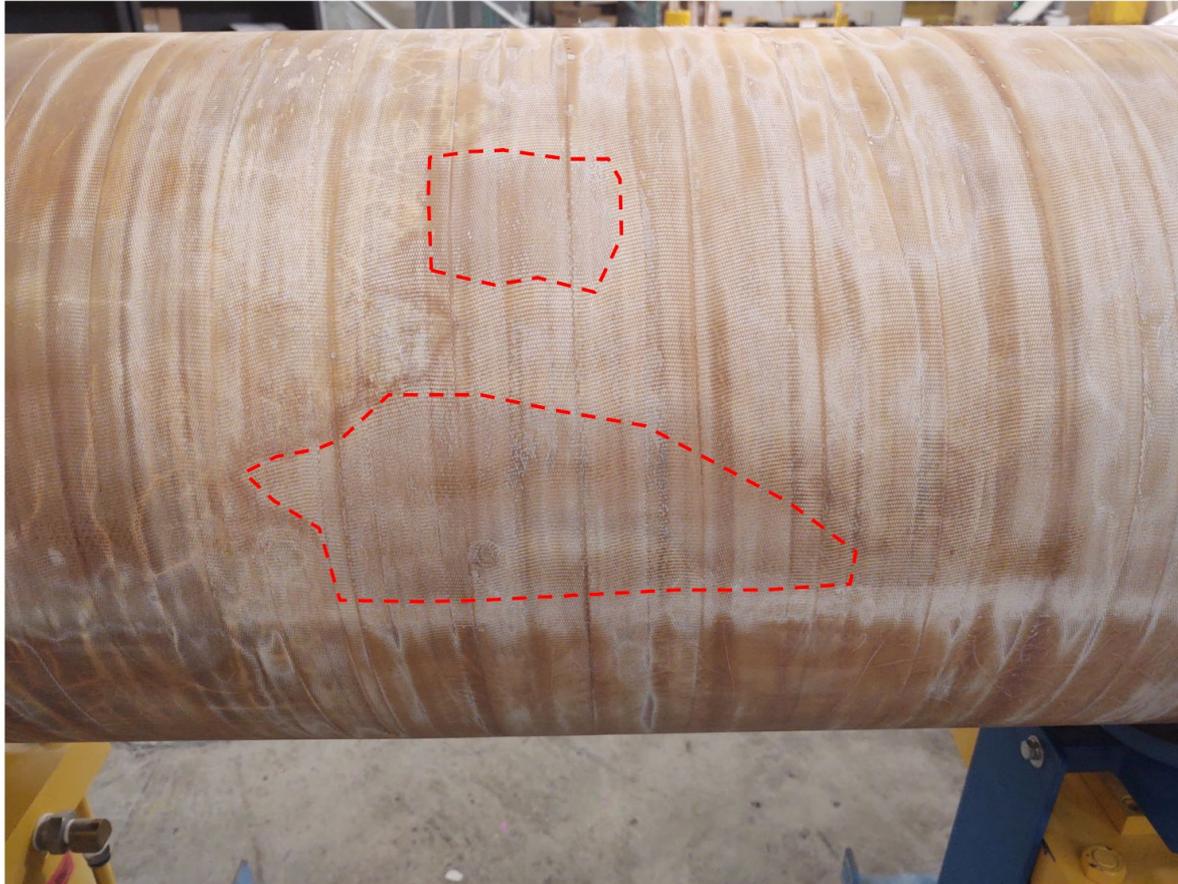
OH Removal and Cleaning



Found areas with hollow insulation on the outer surface

Bundle
Top

Bundle
Bottom



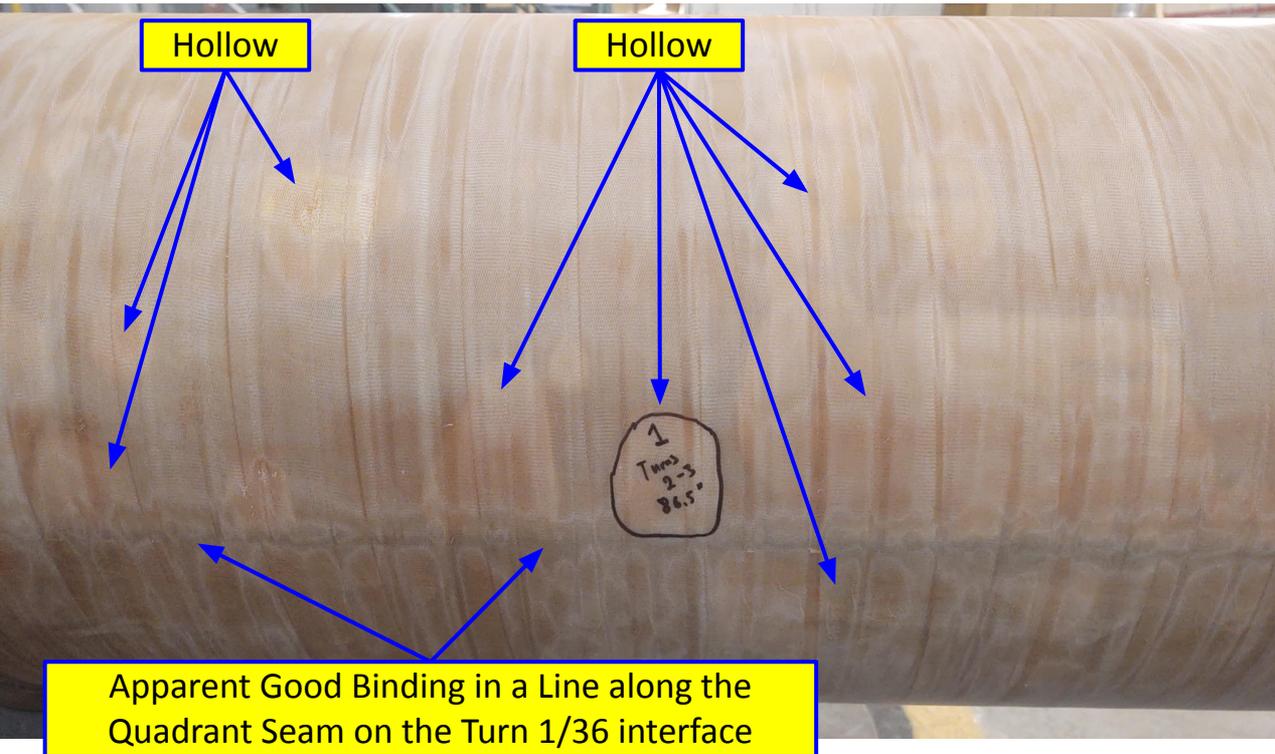
Turn 1
Quadrant Seam →
Turn 36

167"
From
Bottom

149"
From
Bottom

Have Started to Examine the Underside of these “Blisters” - Patch #1

- Hollow patch 86” from the bottom, along turns 2-3, was the first to be examined...excavated to see how deep it is.
- Loose layer is down to the TF quadrant

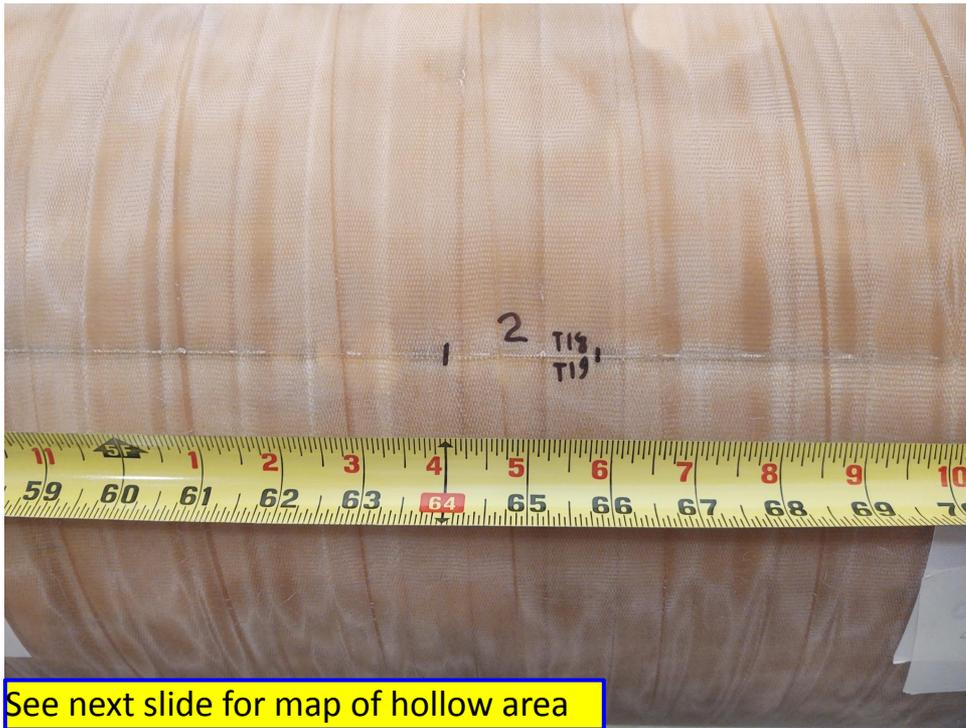


Sanded Down Hollow Region to Reveal Quadrant Turn Insulation Underneath



Have Started to Examine the Underside of these “Blisters” - Patch #2

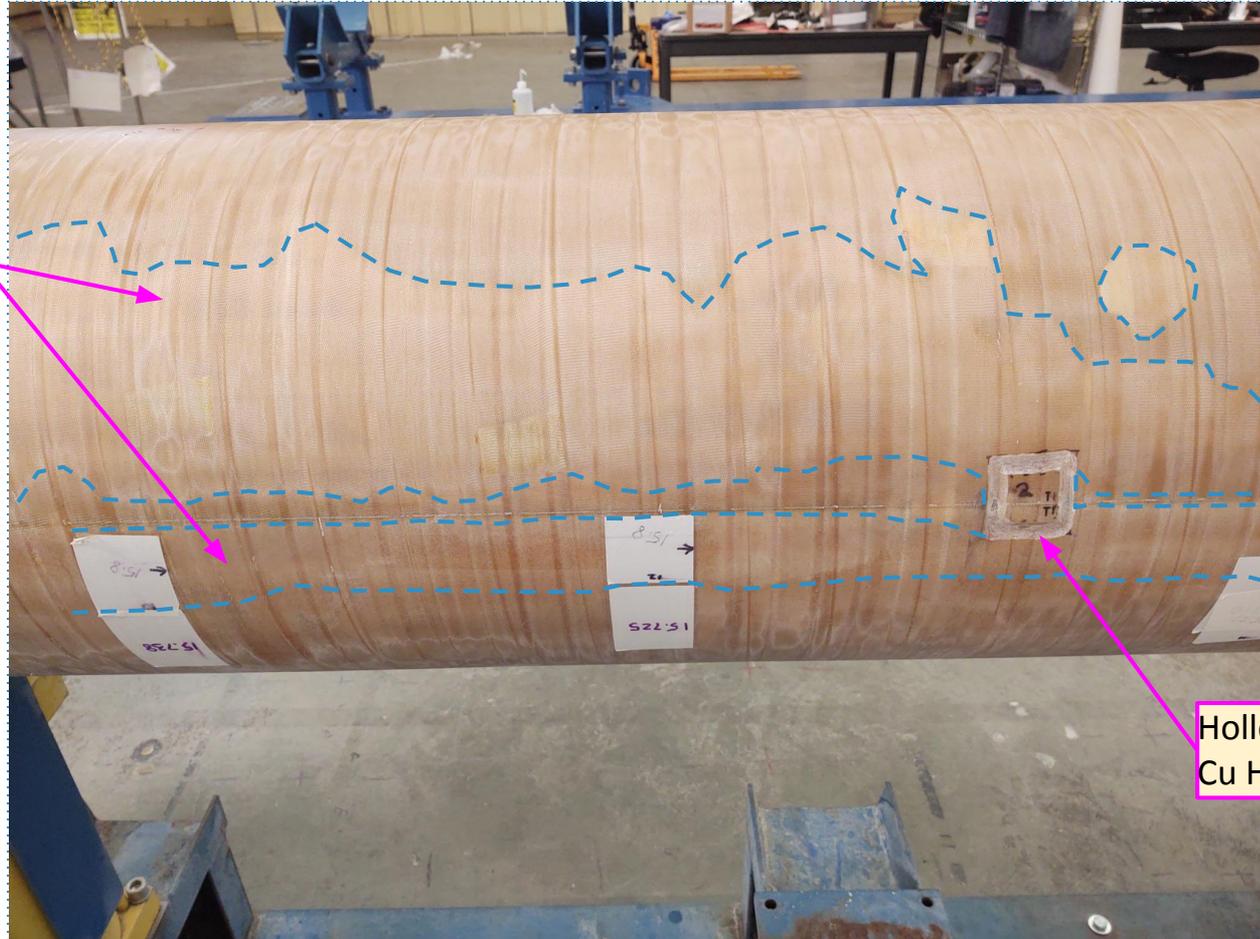
- Hollow material above 18/19 Quadrant Seam
- Picked a point of hollowness 65” from bundle bottom flags



- Sanded with Intent to Remove a Piece of Ground Wall
- Got to bottom of hollow layer, cut last fibers with knife, saw Cu
- Separation of insulation from Cu apparent



Excavated Patch #2 is Part of a Much Larger Hollow Region



Unclear How Deep These Hollow Regions Are

Turn 18

Turn 19

Hollow Down to Cu Here

Work on the Existing Bundle is Presently Paused

- Observations
 - Hollow areas further called into question the quality of the vacuum pressure impregnation
 - Continuing excavations were at significant risk of doing irreparable harm - very well could end up exposing turn Cu in many places
- Decision made to (Project, Engineering, DOs office) to pause excavations on the bundle and direct near-term focus on the new-bundle activity
 - Will reopen forensics in consultation with new bundle vendor - supports our goal of having the highest quality new bundle
 - Bundle is in safe controlled storage and forensic or repair actions can be restarted as desired



2021 and 2022 Activities on Existing Bundle Addressed in Two Reports

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PPPL



DOC - DOCUMENT

REPORT: ACTIVITIES IN 2021 DIAGNOSING THE
TF INNER-LEG BUNDLE TURN INSULATION

NSTXU_1-1-3-3-1_DOC_103

Rev. 2

Work Planning #: **12/17/2021**
Effective Date: **12/17/2021**
Prepared By: **Stefan Gerhardt**

Reviewed By	Stefan Gerhardt, Preparer	12/17/2021 09:27:29 AM
Approved By	Steve Raftopoulos, Responsible Engineer	12/17/2021 09:48:01 AM

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P.O. BOX 451 PRINCETON, N.J. 08543

Images are
links - click
as you like if
you want to
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PPPL



DOC - DOCUMENT

Activities in 2022 Diagnosing the TF Inner-Leg
Bundle Turn Insulation

NSTXU_1-1-3-3-1_DOC_104

Work Planning #: **03/14/2022**
Effective Date: **03/14/2022**
Prepared By: **Stefan Gerhardt**

Document Admin: Kathleen Lukazik

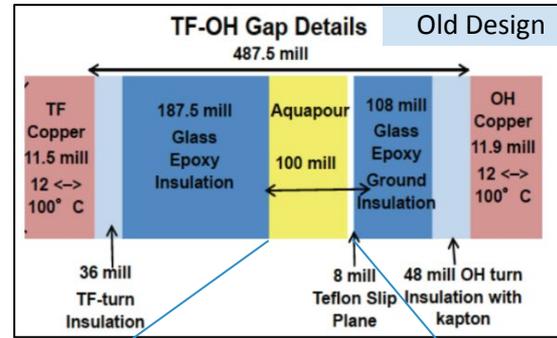
Reviewed By	Stefan Gerhardt, Preparer	03/14/2022 09:28:10 AM
Approved By	Steve Raftopoulos, Responsible Engineer	03/14/2022 10:11:10 AM

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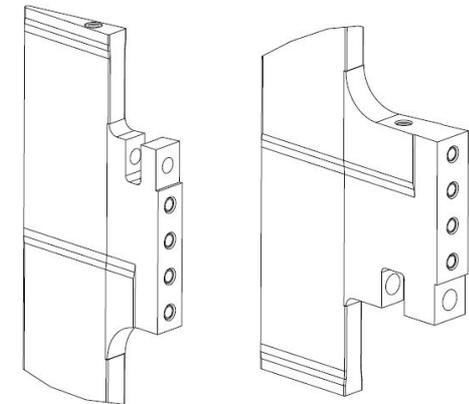
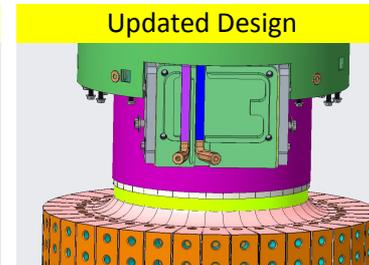
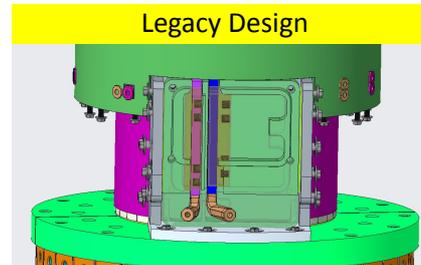
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- Existing Bundle Disposition
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We are Moving Forward Aggressively on the New Bundle - Engineering

- New bundle engineering developing targeted design changes to address known issues
 - Eliminating Aquapour
 - Modest conductor shape changes to reduce insulation thermal stresses
 - Changes to the OH lead block to improve fabricability
 - Embedded cooling hole in TF conductor*
- PDR 3/3 with external reviewers from NHMFL, FNAL, UKAEA



“Scalloping” - slight thinning of the TF Conductor cross sectioning in order to thicken the insulation and reduce stresses



Aggressively Moving Forward on Procurement

- Three phase contract for the Prime Fabricator:
 - Phase 1: Vendor support for Final Design
 - Phase 2: Vendor long lead
 - Phase 3: Vendor fabrication
- Vendor bids in, evaluation committee has made recommendation, in process of final review and award - targeting late March or early April
 - Until that award, the information is business confidential and embargoed
- Long lead procurements
 - Bids in hand for OH Cu - 700' lengths which eliminate many braze joints
 - In process of getting bids for TF conductors*
 - Have identified likely vendors for welding/machining TF conductors - includes vendor who did it last time.

Vendors bid on the full job now, can adjust their bid at the starts of Phase 2 and Phase 3.

Cost and Schedule Review This Week

- PPPL-called review in advance of the DOE review
- Prime vendor information is embargoed, so this is based on PPPL internal estimates - will update with vendor information in the coming weeks
- Chaired by Kem Robinson
 - Technical, quality, and Project Controls expertise (LBNL, FNAL, etc)
- Success in this Review supports a DOE review for a new Project baseline - likely late April or early May.

- Shows receipt inspection on bundle in early December 2023

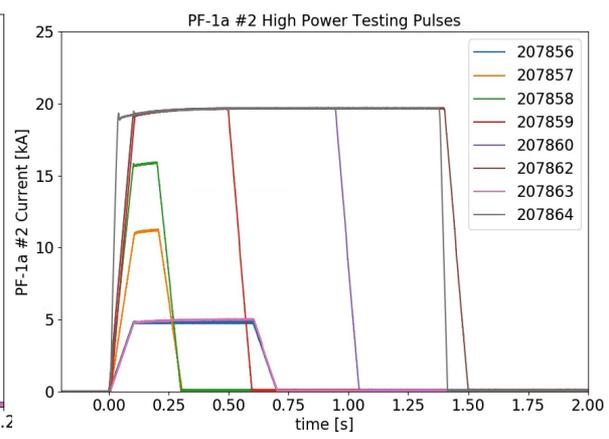
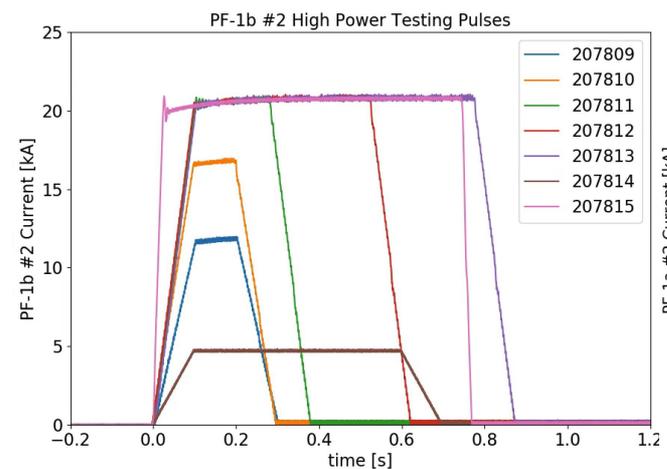
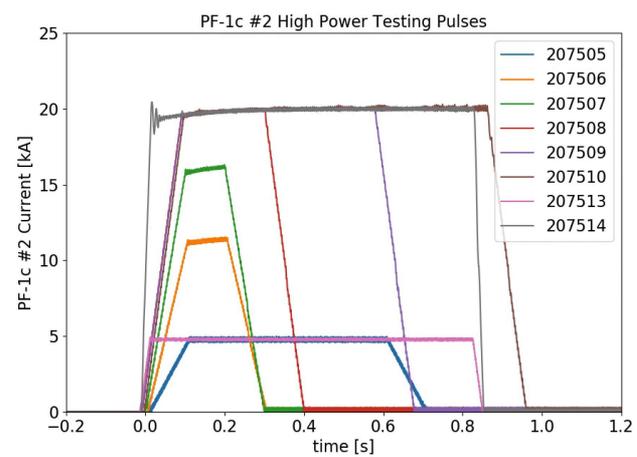
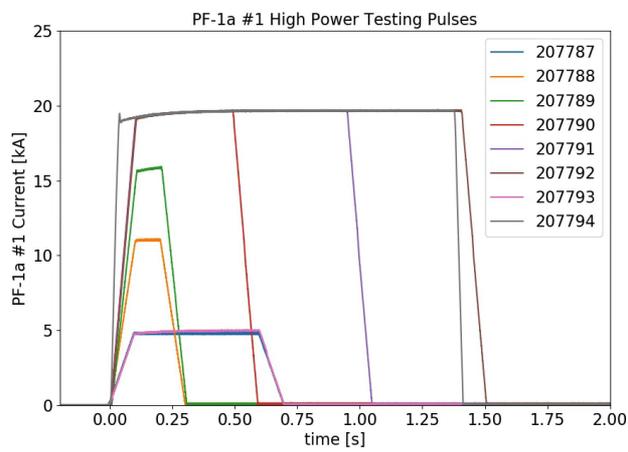
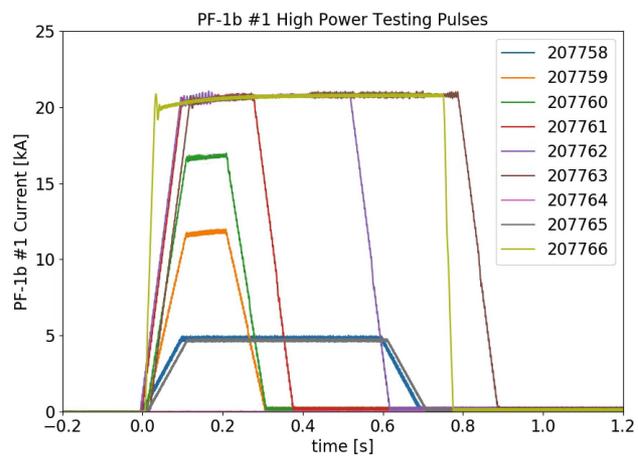
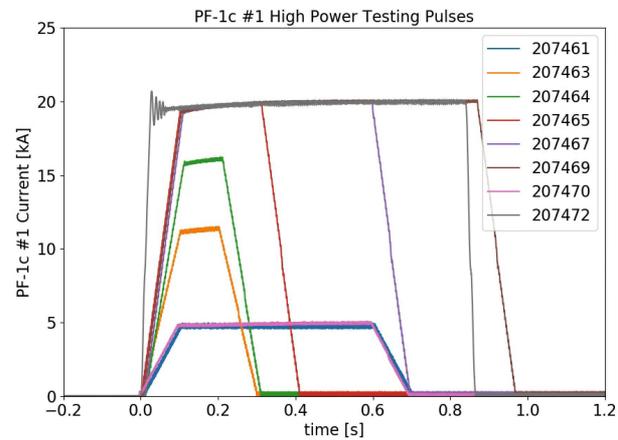
Task Name	Start	Finish	2021				2022				2023						
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4			
Rates (FY22)																	
4026 FAB NEW TF/OH BUNDLE	11/15/21	12/07/23															
BEGIN 4026	11/15/21	11/15/21															
Cost through FEB 2022																	
4026 LOE support and Project Deliverables	11/16/21	03/22/22															
TF/OH LL PROCUREMENT	11/16/21	12/16/22															
OH Raw Conductor - Extrusion	11/16/21	07/15/22															
OH Raw Conductor - Processing	03/14/22	12/16/22															
TF Raw Bars - Procurement	11/16/21	09/22/22															
TF Conductor Assemblies - Procurement	11/16/21	12/05/22															
TF/OH Prime Contractor - Procurement	11/16/21	09/13/22															
TF/OH ENGINEERING	11/16/21	06/30/22															
OH Raw Conductor Material	11/16/21	01/28/22															
TF Raw Bars	11/16/21	02/04/22															
TF Conductor Assembly	11/16/21	03/11/22															
TF/OH Gap/Aquapor Elimination	11/16/21	04/13/22															
TF/OH PDR	11/16/21	03/17/22															
TF/OH FDR	04/07/22	05/27/22															
TF/OH Prime Contractor Phase1 Execution (Detailed Design)	03/31/22	05/26/22															
FERMI Lab Technical Support	02/11/22	06/30/22															
TF/OH FABRICATION	07/11/22	12/07/23															
Phase 2 Fabrication	07/11/22	01/13/23															
Phase 3 Fabrication	09/14/22	11/23/23															
PPPL Work Upon Bundle Arrival	09/06/23	12/07/23															
FINISH ALL: 4026 (Deliver to 5015)																	

Upcoming IPR and Project Schedule

- The Recovery project needs to provide to the DOE a new baseline cost and schedule this spring
 - The complete Project schedule will be defined there.
 - Final schedule contingency will be defined there as well.
- In the legacy schedule, we had ~11 months of work between assembling items on the TF/OH bundle and first plasma
 - Machine assembly, bakeout, commissioning
- *We are developing schedule mitigation methods to reduce that duration, reduce risk, and improve readiness for operations*
 - For instance, complete fit-up of PFCs, mock-up installation of the casing in order to fit up bus work, getting more diagnostic work done.
 - The specific schedule improvements from these are being developed and will be presented at the IPR

-
- Existing Bundle Disposition
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Completed High Power Testing of Inner-PF Coils



5 of 6 Coils Installed in Supports

PF-1c #1 in Reentrant Enclosure



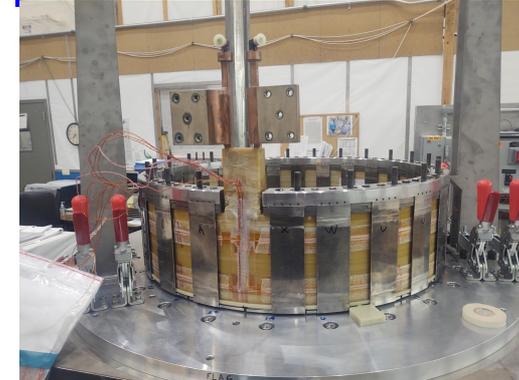
PF-1c #2 in Reentrant Enclosure



PF-1a #1 Slings



PF-1a #1 Slings



PF-1a #2 in Slings



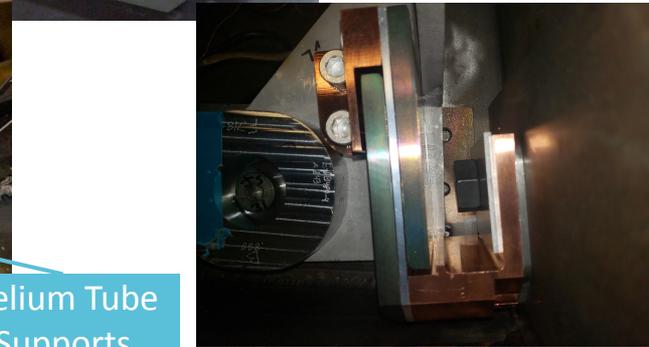
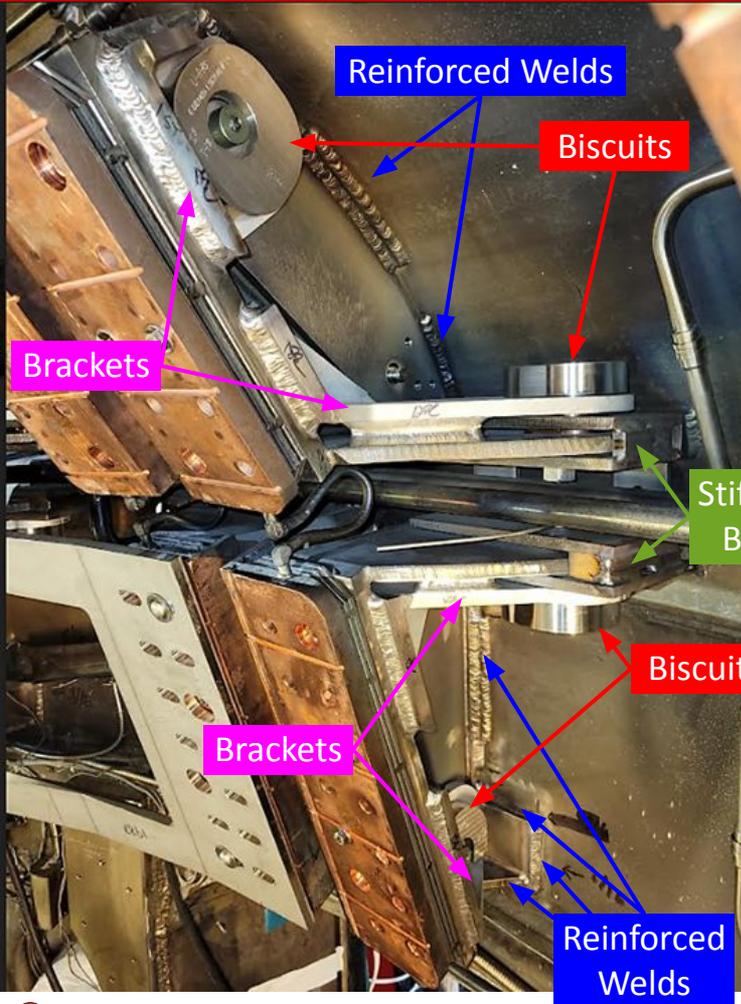
PF-1b #2 in Slings



One bay w/ a complete set of new welds, brackets, "biscuits" & toroidal blocks
Biscuits are 100% done,

Passive Plate Job is Final Phase

- Reinforce welds to vessel - **DONE**
- Install Stiffening Blocks in Existing Brackets - **DONE**
- Install reinforcement brackets - **DONE**
- Install Biscuits - **DONE**
- Install Helium tube support Bracket - **DONE**
- Install shunts - ongoing
- Fabricate Passive plate-back stiffeners - ~60% done



CS Casing Continues to Make Progress

- Heating/Cooling features fully installed
 - Had an emergent issue this year on pinning the heat transfer plate
 - Resolved by switch to a tapered pin design
- Now preparing to weld the bellows assemblies.
- Final step will be to shoot studs onto the casing exterior
 - Studs support tile installation
- Delivery late spring in present schedule



Heat Transfer Tubing
Inside the Casing



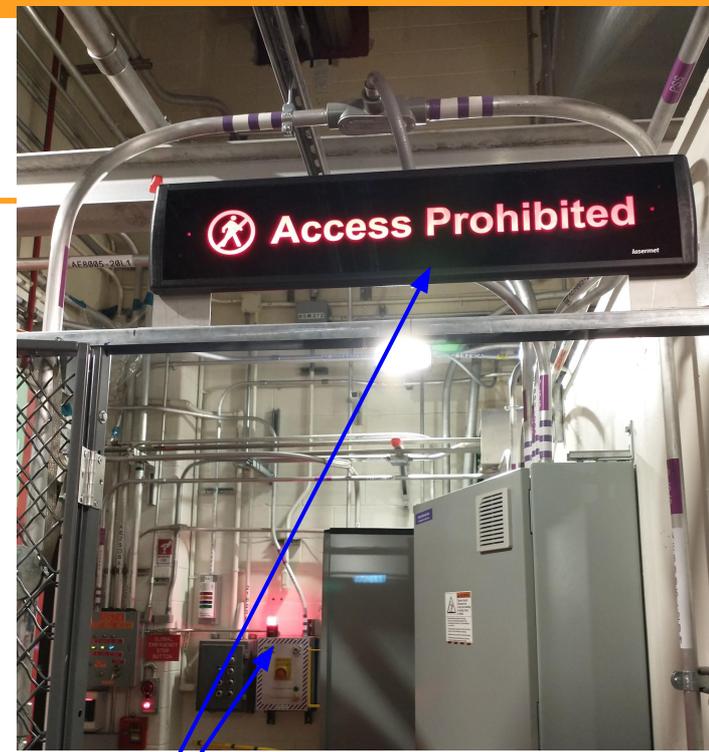
Pinning the Heat
Transfer Plate



Bellows Assembly
Ready to be Welded

Other Highlights

- Completed refurbishment and upgrade of 13.8 kV breakers
 - Have a fail-safe trip mechanism
- New access control system (PSS-SIS) fully installed
 - Now wrapping up testing - safety system experts on-site today to give the work a check-up
- Completed first shifts and tilts of the PF-4U and PF-5U coils
 - Shifted to be centered and “flat” in the redefined global coordinate system
 - Now checking their positions while preparing to shift/tilt the lower coils.



New Marquee, New E-Stop and Search and Station

Custom Fixtures for Shifting Coils



Summary

- Paused work on existing bundle in order to prioritize the best possible new bundle.
 - Can restart work on the existing bundle as desired.
- Moving forward with energy on the new bundle design and procurement.
- Making strong progress on the balance of the Project
- IPR in early spring to set a new baseline.

Backup