



National Spherical Torus eXperiment Upgrade

CS Casing

WBS 1.01.02.06 & 1.01.02.07

NSTX-U Recovery Project FDR – March 17-19, 2020

Mike Viola - Cognizant Engineer

Last edit: 3/8/20

Outline

1. Overview

2. Scope

3. Requirements and Interfaces

4. Analysis/Prototyping

5. Chit Closure

6. Procurement, Fabrication, Installation, and Test

7. Risk - Project Risks and Design FMECA

8. Quality, Environmental, Safety, and Health

9. Summary

Overview - WBS 1.01.02.06 & 1.01.02.07

WBS Title	CS Casing	WBS #	1.01.02.06
Project Cog.	M. Viola	Assoc. Proj. Man.	G. Swider
Design Scope	Design new Centerstack casing; design & fabricate new Inner-PF coil supports, upper & lower vacuum boundary components, ceramic break assembly, & outer Skirt. Perform structural integrity assessment of all structures included in the load path to the test cell floor.		
Technical Impact of Scope	Enables reliable high vacuum; supports coils over full range of EM loads, supports inner plasma facing components.		
Design Status	FDR completed on 12/28/2018 as part of MCS scope: review link chits and calculations handled as part of the MCS design close out drawings: link SoW/Tech Spec: link		
Fabrication Status	Fabrication of components has started		
Installation Status	Once CS casing arrives, the PFC assembly will begin		

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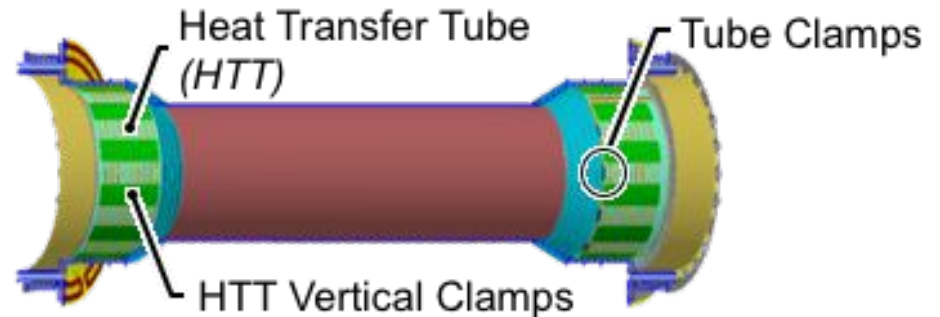
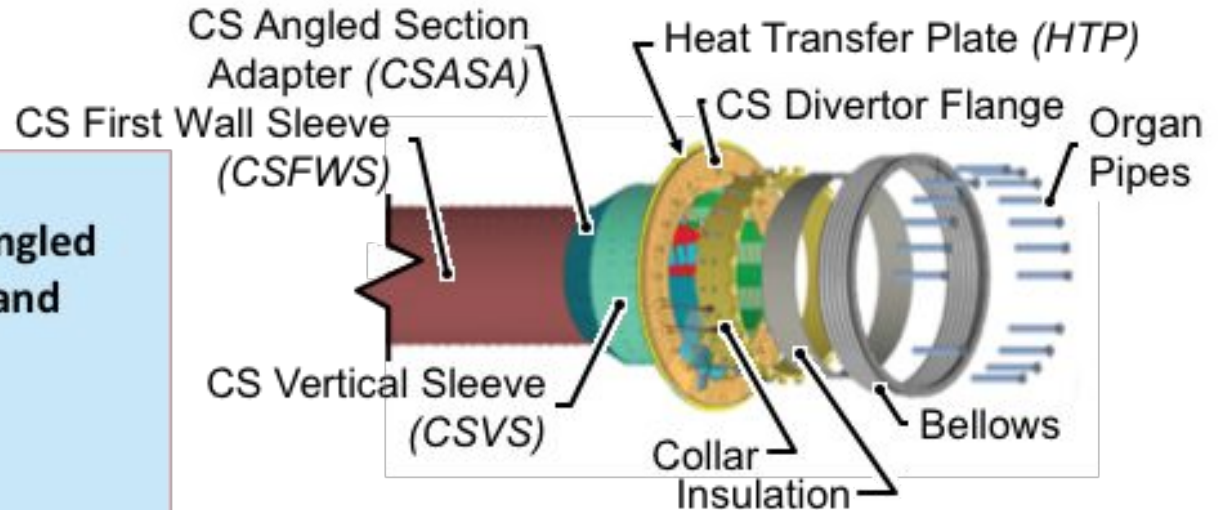
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Center Stack Casing - Scope

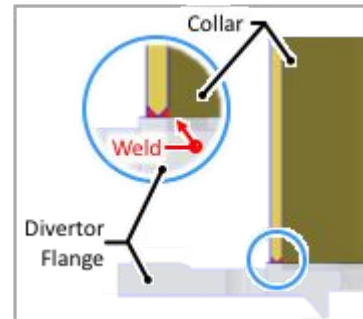
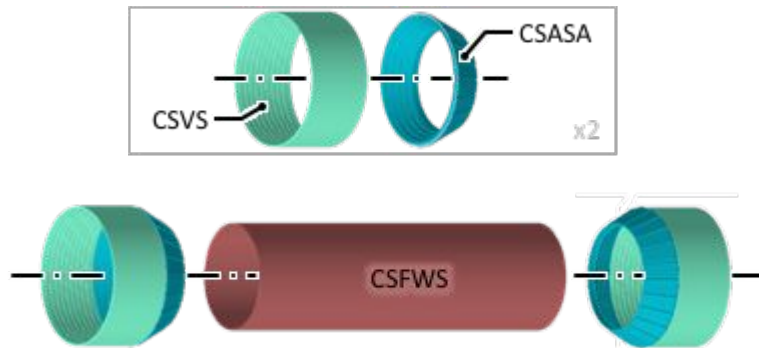
Center Stack Casing:

- Integration of First Wall, Angled Section, Vertical Divertor, and Horizontal Divertor
- Organ pipes,
- Integrate collar
- Maintain vacuum and accommodate thermal growth via bellows
- Integration of Heat Transfer Plates and Heat Transfer Tubes
- Install studs on Vertical Target and First Wall



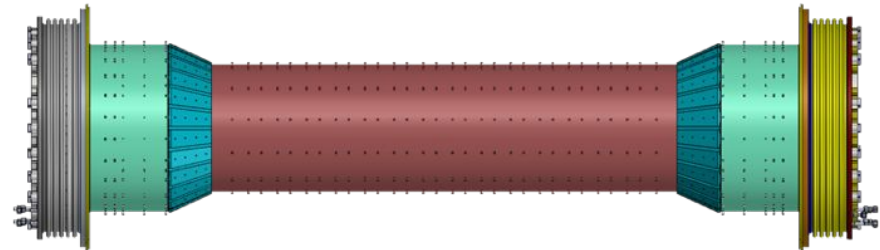
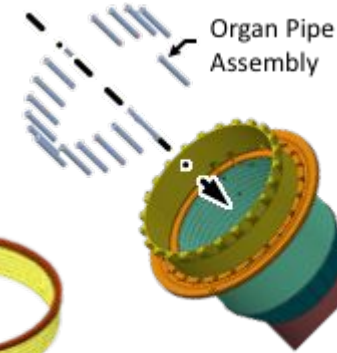
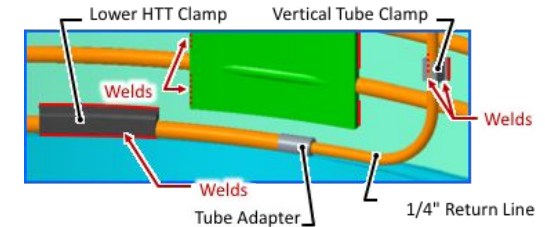
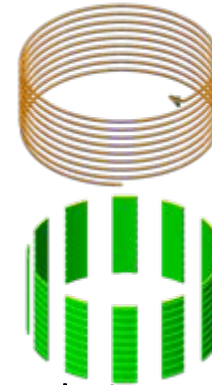
Casing Assembly - 1

1. ✓ CSFWS(x1), CSASA (x2) and CSVS (x2) were forged parts with extra thickness
2. ✓ ID of CSFWS was pre-machined
3. ✓ Assemble (weld) CSFWS (x1), CSASA (x2) and CSVS (x2)
4. ✓ Weld Divertor Flange Assembly to each CSVS
5. Post Machine Welded Assembly
6. Perform Ultrasonic Weld Inspection (UT) and Vacuum Leak Testing (LT).



Casing Assembly - 2 Install PPPL supplied components

1. Install the HTT and HTT stub weldments
 - Perform weld inspection (WI) and leak test (LT)
2. Weld all HTT clamps (WI)
3. Install Organ Pipes (WI) (LT)
4. Weld HTP feedthrus to the divertor (WI) (LT)
5. Align and install the HTP assemblies using bolts and pins and weld the tube adapters to feedthroughs (WI) (LT)
6. Install HTP Stub weldments. (WI) (LT)
7. Weld bellows assembly to divertor flange. (WI) (LT)
8. Machine pockets and install all PFC Studs (E-DC11204)
9. Perform a final Metrological Surveys



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} See talk by Mark Smith,
this session

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Procurement, Fabrication, Installation, and Test

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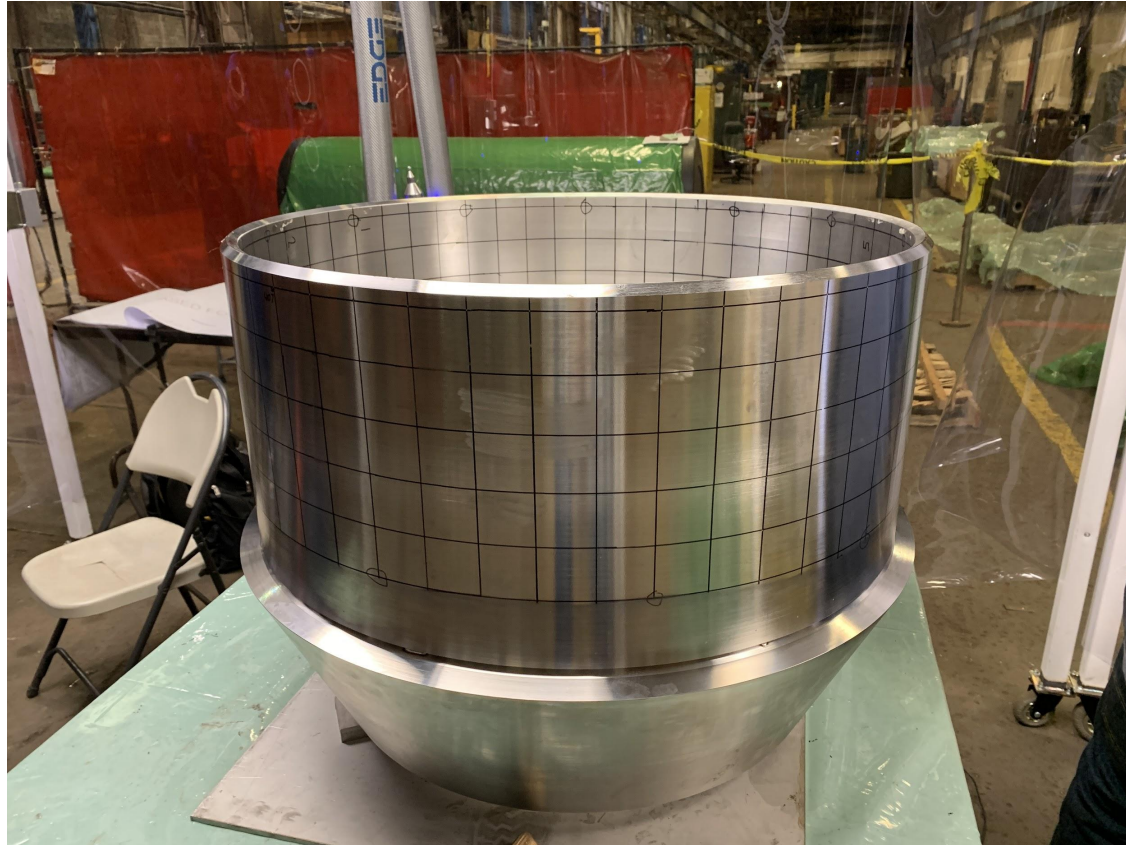
Fabrication Status

- Fabrication is proceeding with great attention to quality.
 - PPPL collaborated with TEAM Inc who sent their best Title III inspector to observe the forging UT inspections. He advised that “they were the best forgings he has seen.”
 - PPPL hired a CWI and senior fabrication engineer to provide additional oversight of the fabrication process.
- Schedule delays were caused by:
 - Late delivery of the forgings from Italy due to forging delays and use of single best machinist for machining of forgings.
 - HOLTEC sole reliance on their best Inconel TIG welder and their best QA Romer arm operator which caused single shift work with extremely careful oversight of weld distortion.

Main parts were forged by IBF in Italy

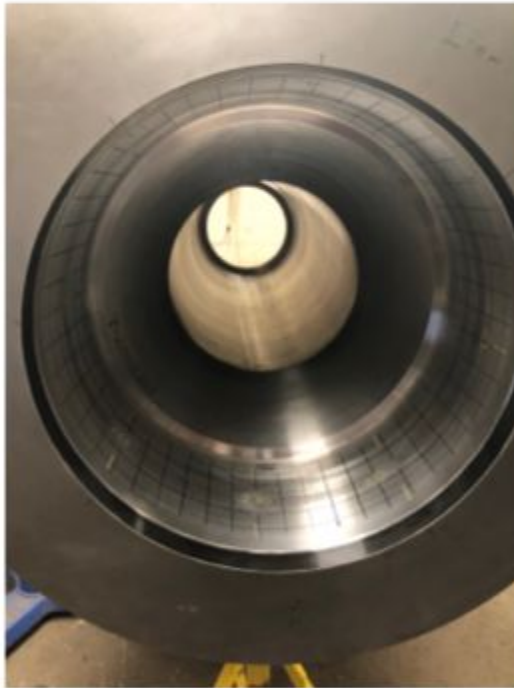


All casing parts were tacked together with great precision.



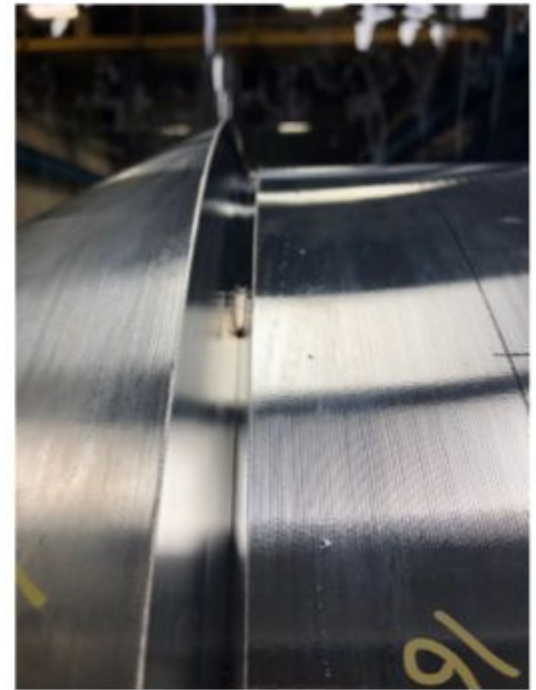
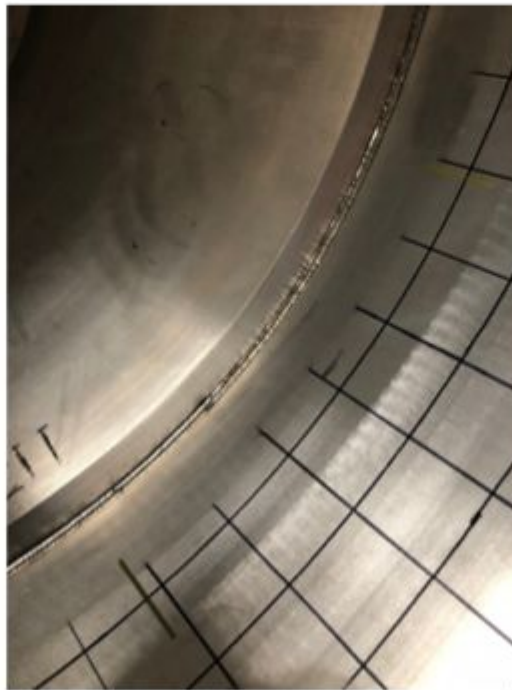
CSC fully tacked together

Inner and Outer



Welding Vertical Sleeve to Angled Section

ID welded first then OD background to smooth metal then welded



Angled Section to First Wall done from OD

ID

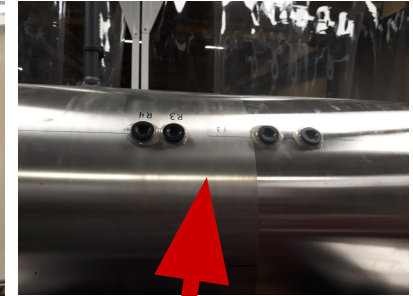
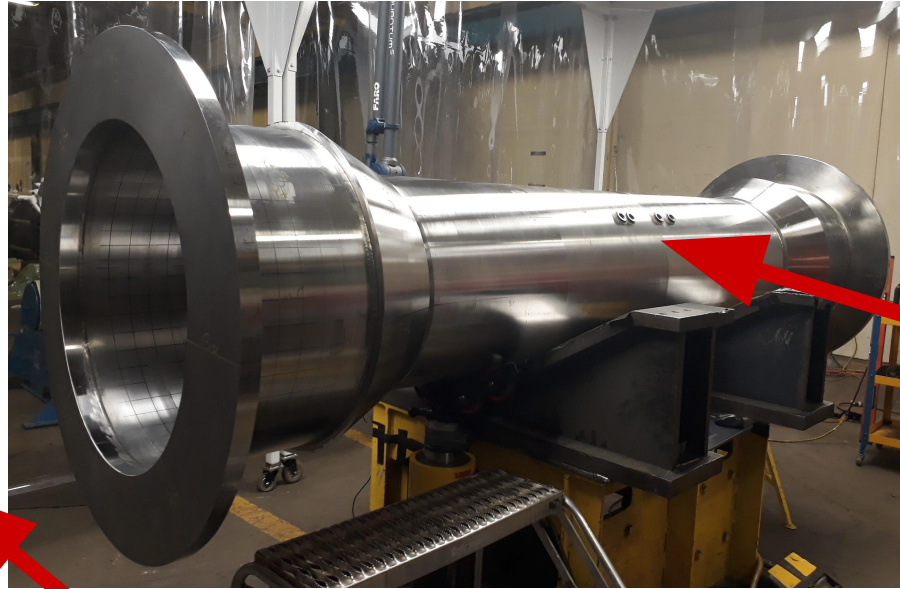
OD

All welding from OD



Milled out after welding

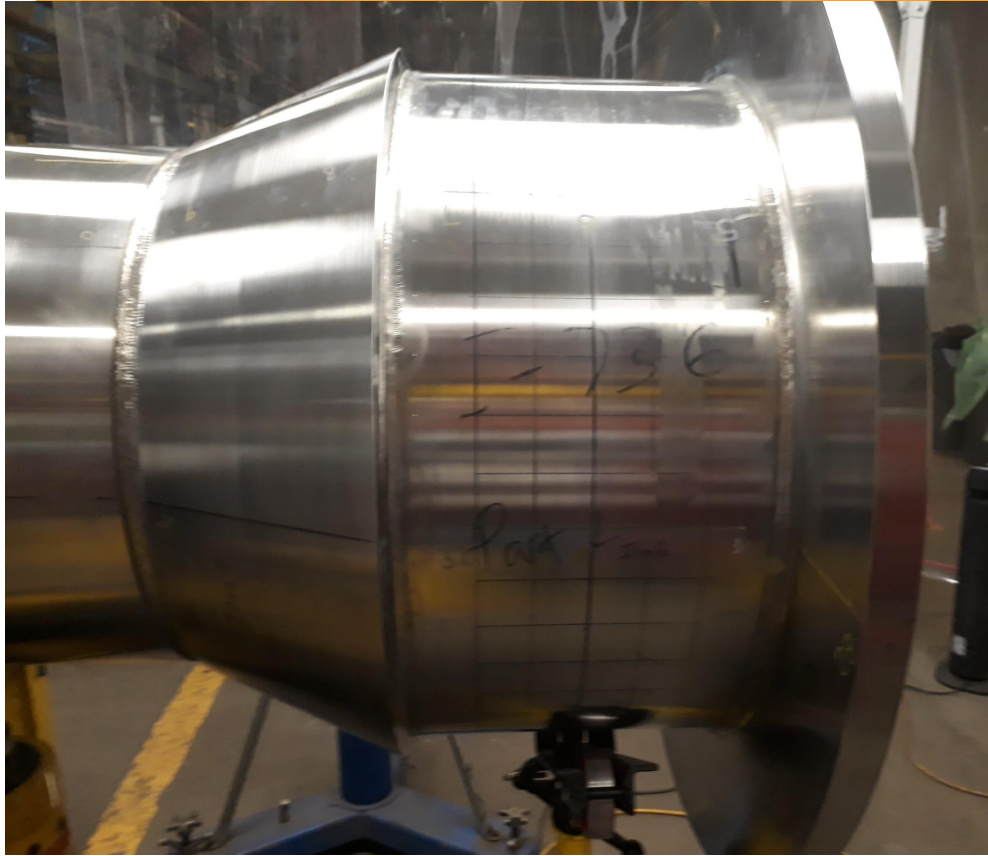
Welding of each end section to First Wall



Reference pucks
for FARO arm
measurements.

Tacks broken then end section
repositioned to accommodate
accumulative and predicted distortion.

Completed Lower Section Weldment



First Wall Sleeve to
Angled Section Adapter to
CS Extension Sleeve to
Diverter Flange

Outside and inside surfaces
have extra material for final
machining.

NCRs are generated by fabricator and processed through our system.

NCR Item	NCR Number	Description of the Issue
First Wall Sleeve	#3016101H-1	Item 1 of IBF P.O. 117028, POLI 1, DWG 11647 has the following feature OOT: The .010" cylindricity of the inside diameter was found to be .024". This Item from DWG 11647 becomes Item 8 from client DWG EDC11210 (first wall sleeve).
Angled Section Adapter	#3016101H-2 Rev 1	While machining the weld bevel prep on the large end of the Item (angled section), a false cut was applied in the area where the "land" of the bevel was to exist. Rev. 1: Following inspection of the item per component machining DWG 11711, dimensions were found OOT but would not affect the joint.
Angled Section Adapter	#3016101H-3	The Angled Section Adapter has dimensions found out of tolerance. Overlaying the as-built dimensions of this item with the model reveals that there is no effect on form or function of this item as there is excessive stock of material. The weld bevel prep on the large end of the cone is larger in diameter than anticipated; however, it will not affect the welding fit up. Accept as is.

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Project Risks are Actively Being Managed

Risk	Score (1-81)	Open/Retired	Risk Retirement Event
If the existing center stack casing welds cannot be qualified in current design	35	RETIRED	FDR completion
If there is CSC Distortion due to modifying the casing welds	35	RETIRED	Shipment of CSC to site
If there is CSC Distortion due to continuous welds or the HTT clamp welds	35	OPEN	End of fabrication for CSC
If the trial fit up of the CSC, due to the CSC as-built condition, cannot be installed per alignment requirements	28	RETIRED	Post fit-up
If the CS casing is damaged during shipment	20	OPEN	Receipt at PPPL
If all CSC drawings are not released for fabrication prior to the beginning of this fabrication scope	20	RETIRED	Award of CSC fabrication contract

Project Risks are Actively Being Managed

Risk	Score (1-81)	Open/Retired	Risk Retirement Event
If the suppliers find the CSC design is not readily able to be fabricated	20	RETIRED	CSC Contract let
If CSC work scope is not managed by dedicated COG by OCT 1, 2018	18	RETIRED	
If raw materials for the CSC are not readily available	16	RETIRED	Award of contract
If deformation of CSC occurs from new continuous welds	12	RETIRED	Receipt of CSC
If components do not fit as designed	12	OPEN	Completion of assembly testing
If suppliers agree that CSC design cannot be fabricated	9	RETIRED	FDR for casing

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Quality Assurance and ESH

QA

- PPPL QA supplier qualification audits occurred prior to start for fabrication.
- PPPL QA & PPPL Engineering for on-site Manufacturing Readiness Review.

Fabrication Oversight

- Resident PPPL Engineering representative, in concert with the QA Representative, coordinated the scheduling local subcontracted QA Engineers to assure on-site QA presence as needed during fabrication.
- PPPL representatives stop work when required to resolve quality issues, NCRs and safety issues.

ESH

- HOLTEC provides an introductory video for all visitors and has an excellent safety record.

Quality Assurance for the CSC Fabrication

- Review of Tech Spec, Oversight Plan, QA Plan, and Manufacturing, Inspection and Test Plan (MIT) prior to start of fabrication.
- Manufacturing Readiness Review (MRR) - Review of documents and material certs, review of tooling and fixtures, drawings, manufacturing plans, QA plans (specific to the project) personnel qualifications, process flow, and schedule.
- Qualification of Holtec – verification that Holtec has an effective Quality Assurance program that meets contractual requirements.
- Provided 2.5 weeks of oversight (witness points and hold points) at Holtec during the fabrication.
- Review and document nonconformances (NCRs and DDRs) and corrective action reports (CAR).
- Review and document Holtec inspection reports and travelers.
- Receipt inspection at PPPL.

Safety for the CSC Fabrication

- The HOLTEC safety program is robust.
 - Visitors first watch a safety orientation video.
 - Visitors must wear safety shoes,
 - hearing and
 - eye protection at all times.
 - All visitors have stop work authority.

Summary

- Requirements have been met via a combination of analysis and testing.
- Interfaces are considered in the design and documented in the ICDs.
- All chits related to the inner-PF replacement job are closed.
- Risks have been retired except for distortion due to welding, final fit-up of components and damage due to shipment. Full time oversight and mitigation steps are in place.
- The HOLTEC safety program is robust.