Status of 650MHz Cryomodule Development Efforts at RRCAT
&
Other Technological Developments

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Cryomodule Model

1. The Model is complete

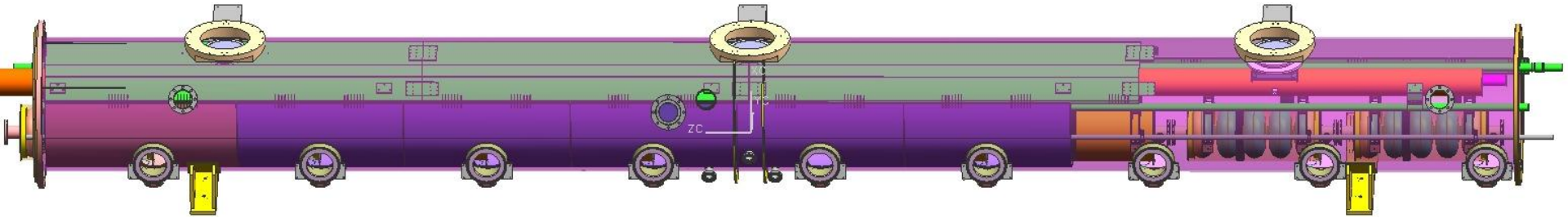
- The model considers separate HGR pipe and 2K two phase pipe .

- The diameter as of now considers a vacuum vessel of diameter 46 inches.

- Thermal shields have been modeled after analysis has been made on ANSYS.

- The cavity support system has been taken to be of modified type but can be modified whenever needed.

Cryomodule 2-D Drawings



2. The 2-D Drawings have begun considering these factors

- The 2D drawings are in progress fro Vacuum vessel.

(This work is at present stalled, as cryogenic piping is being finalized) .

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Analysis Completed

1.Thermal Contraction Calculations for entire Type IV cryomodule
- Completed

2. Static Heat Load in Cryomodule
- Completed

3. Steady State & Transient Thermal Analysis For 70K Thermal Shield.
- Completed

4. We have completed vacuum vessel design note in a format such that it does not take much time to convert it to a larger vessel.
- Completed

Vacuum Vessel : Preliminary Design Note Parameters

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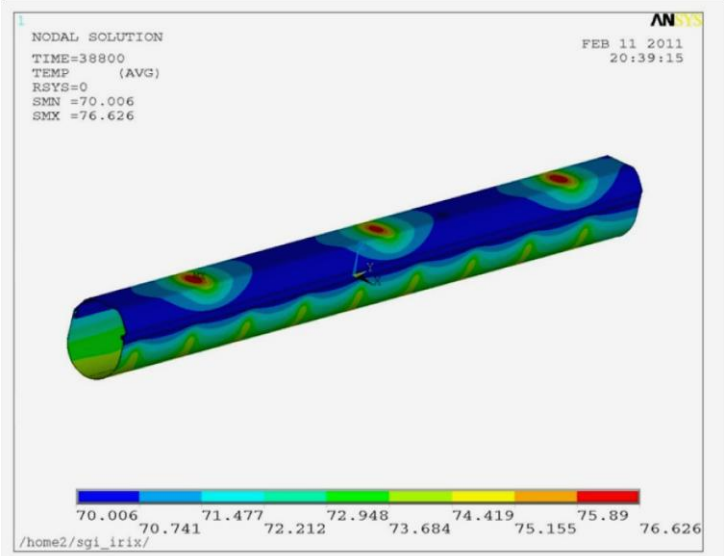
Preliminary vacuum vessel of Cryomodule	Designed value	Remark
Diameter of Steel Vessel*	46 inch	Necessary as cavity size is 400mm
Overall Length of Vessel	472.44 inch	Minor adjustments may be made This figure is as per present lattice.
Nominal Thickness of Vessel	0.375 inch	Does not change for 46inch diameter

- Prepared a preliminary design note on FNAL template.
- Verified with ASME Boiler and Pressure Vessel Code Sec.VIII Div1,(2004)

Steady State & Transient Thermal Analysis For 70K Thermal Shield



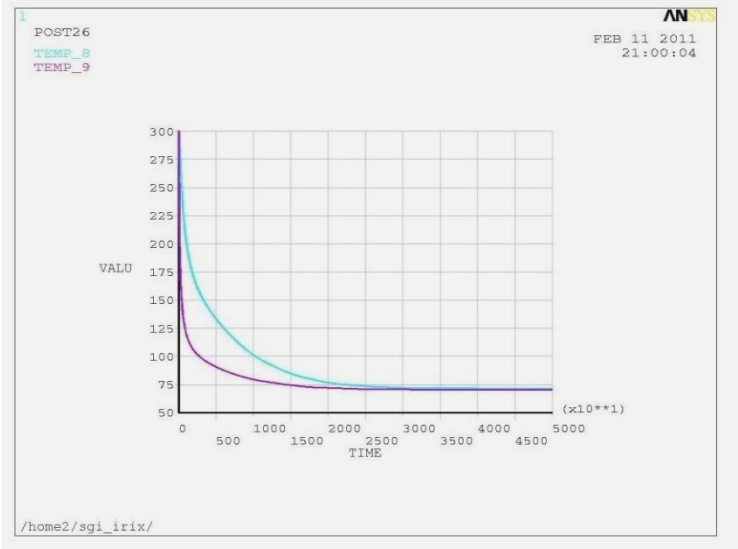


Fig: Temperature Plot of steady state thermal analysis

1. **Mass flow rate- 24 gm/sec**
2. **Convection heat transfer coefficient- 200 W/m2K**
3. **Heat load:**

   Through support post: 10 watt per support post
   Through coupler input: 2 watt per coupler

A. Cool down reached in 10.7 Hour

B. Max temperature gradient is found to 40 K at finger weld region

C. Fig. shows the temperature plot of 70 K thermal shield after 10.7 hours

RRCAT Efforts to Evaluate Feasibility of Laser Welding for SCRF Cavity Fabrication

Alternate SC Cavity Fabrication Technology Development (ACFT)

Pending Patent Appl. No 1177/MUMNP/2011

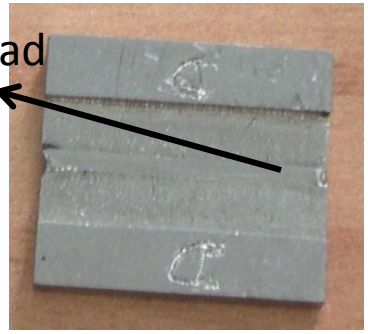
RRCAT has undertaken a project to develop a SC cavity fabrication technique which uses Laser welding instead of Electron beam welding.

Objective : Reduce cost & obtain repeatable performance. Minimize chemical processing.

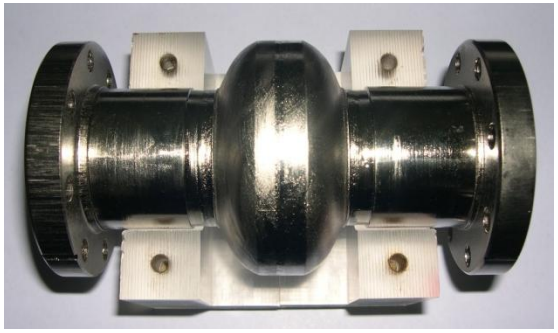
Advantages:

- Large difference in capital and operating cost. (Rs.11cr Vs. Rs.50 Lakhs)
- Energy deposited is 6 times less, so lesser shrinkage and lesser distortion.
- High vacuum not necessary . Inert gas can be used (using ultra pure helium).
- Many joints in single setting as optical fiber is used. Debris removal by gas stream.

Development Effort at Cryomodule Engineering Lab & SSLD, RRCAT



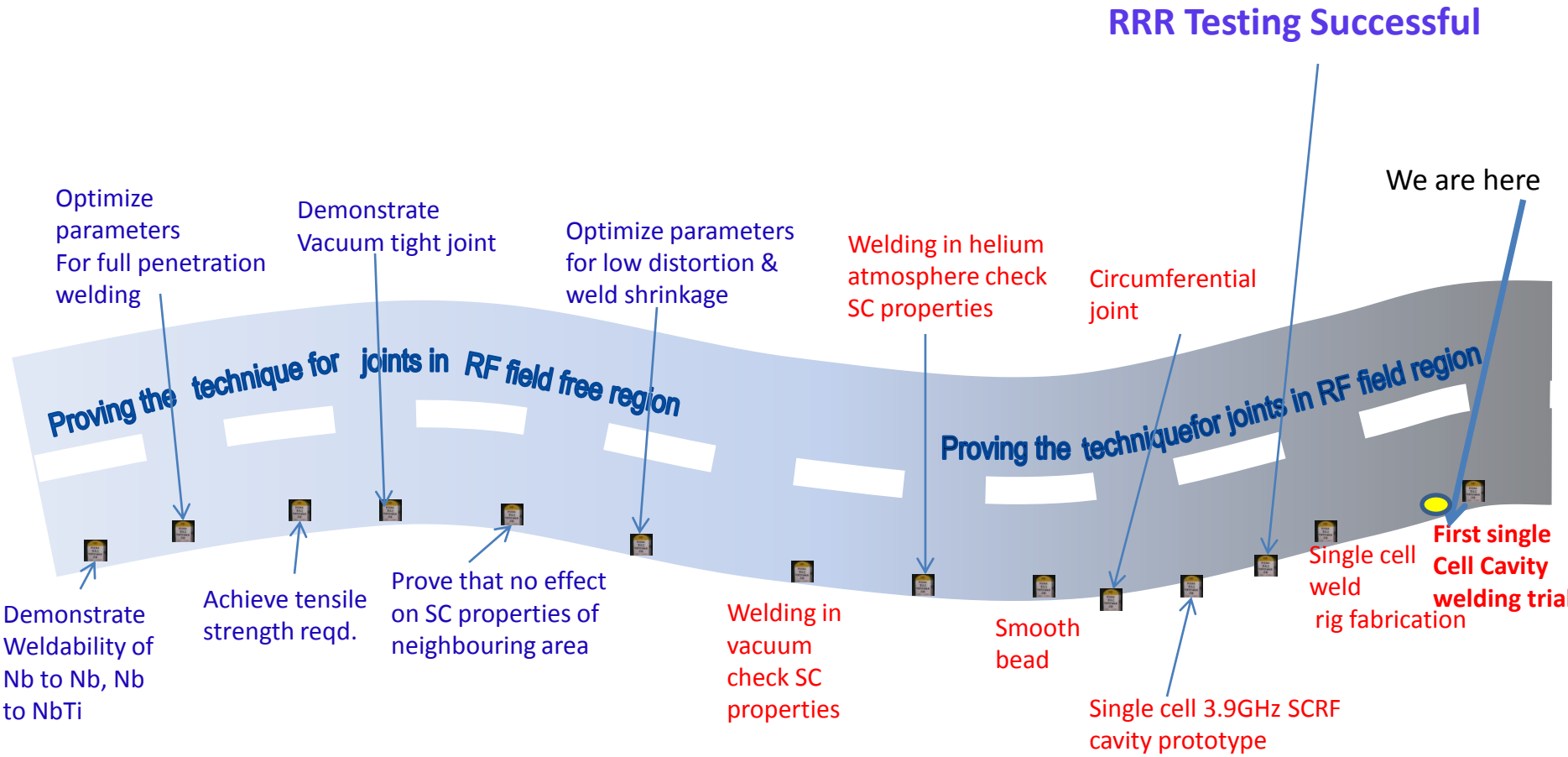
Flat Sample



Laser Welded 3.9GHz SCRF cavity

1.3 GHz SCRF Cavity Single cell

Roadmap Followed



Infrastructure

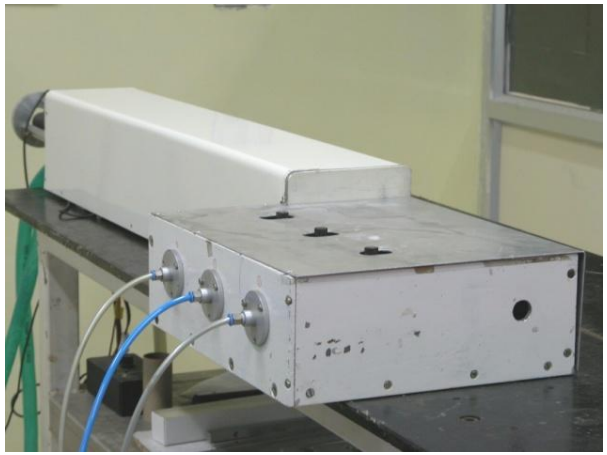
Trials in Experimental Chamber

Final Welding in Welding Rig Developed for this purpose

Technology Development Effort

4 Step Development Plan

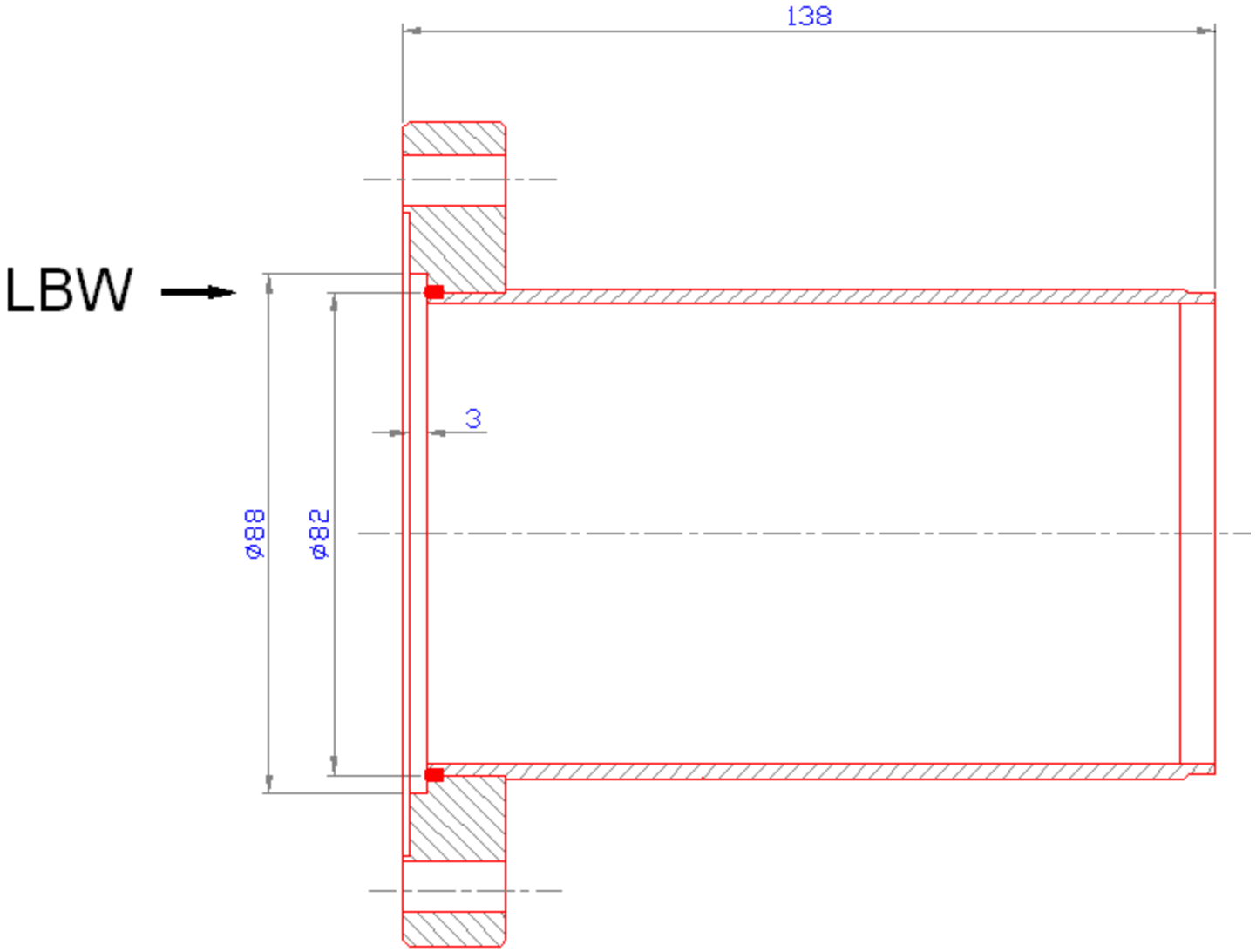
- ✓ Weld flat Samples and optimize parameters for all joints. Check mechanical properties and SC properties . Weld ring samples- **COMPLETED**
- ✓ Develop Experimental Chamber and Fixtures. Fabricate a small prototype cavity to validate methodology. - **COMPLETED**
- ✓ Develop Final facility for single cell SCRF cavity. **– COMPLETED**
- ✓ Fabricate first prototype of single cell cavity in high RRR Niobium.- **IN PROCESS**

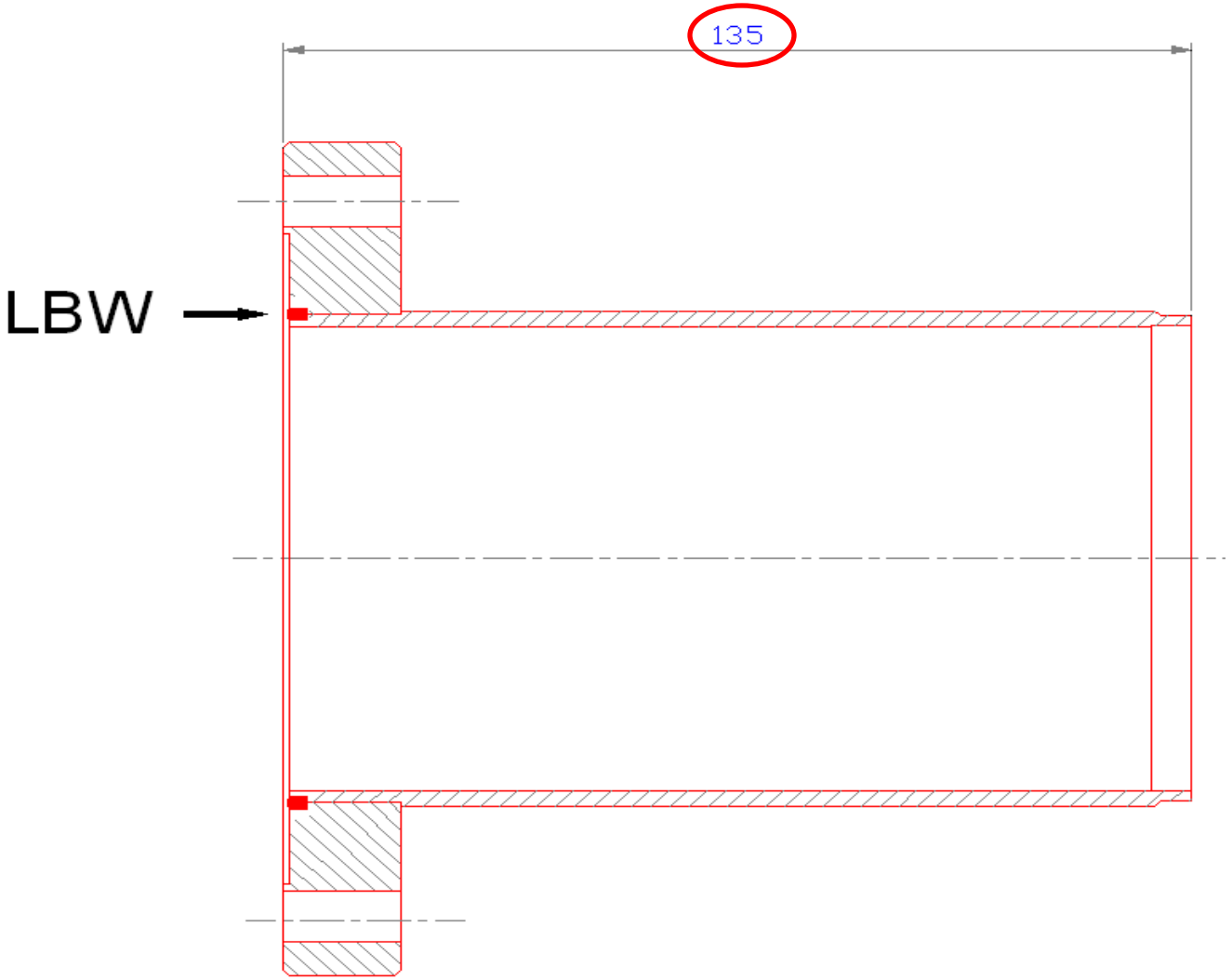


Indigenously developed Laser System By SSLD,RRCAT for this task

Laser welded half cells of SC Cavity at CMEL,RRCAT

In this option we can remove the defective weld metal completely by turning and again weld it in similar fashion , The difference will be the 3 mm step which will be formed in this NbTi flange





In this option we can remove the defective weld metal completely by turning and again weld it in similar fashion with the pipe length shortened. For this we will have to take a new NbTi flange.

The difference will be that the beam pipe will have shorter length on both sides by about 3+3=6mm

Thanks For Your Patience