Fermilab

Fermi National Accelerator Laboratory
Technical Division
Headquarters
P.O. Box 500 Mail Stop 316
Batavia, IL 60510
Phone: (630)840-4641

November 13th, 2008

To: Pier Oddone or Director's Designee
From: Giorgio Apollinari - TD Head
Subject: Request for Director's exception for the 3.9 GHz Helium Vessel for Cavity #7 (pressure vessel IND-112)

The vessel described in the attached engineering note is an exceptional vessel and requires a Director's exception for full compliance with FESHM Chapter 5031 (Pressure Vessels). The 3.9-GHz dressed cavity has materials and complex geometry that are not conducive to complete design and fabrication as a helium vessel following the ASME boiler and pressure vessel.

Specific areas of exception to the ASME code include:

1. The use of Nb and NbTi, not explicitly allowed by the code.

2. A calculated stress in the Nb cavity at the iris with worst case tuning extension (0.5 mm) and internal pressure at room temperature of 82.4 MPa vs 60 MPa allowable. This stress is self-limited by the tuner and results at worst in an offset of the neutral tuning position.

3. Partial penetration welds in Ti and between NbTi and Ti, justified by the need to avoid burning through the material.

4. Weld procedure specification (WPS), procedure qualification record (PQR), and welder performance qualification (WPQ) not performed, or initiated after completion of the work.

5. Incomplete testing of bulk and weld affected zone material. No X-ray or ultrasonic inspections of welds due to access difficulty. As mitigation, samples were welded, cut, polished, and photographed in order to establish degree of weld penetration.

The project began many years ago as Superconducting RF R&D, and the helium vessel falls below the size (6 inches diameter) which would bring it into the scope of the ASME Boiler and Pressure Vessel Code. The design was developed at first strictly for cavity performance goals, not with ASME code in mind. The decision to review this vessel per ASME code came rather late in the project. The 0.8 factor taken on allowable material stress per FESHM 5031 is intended exactly for this issue, to mitigate incomplete code-specified information. However, we show that the vessel is safe at a level that is similar to the Code, as recommended by the DOE's Federal Register for contractors on Worker Safety and Health Program (10CFR851) and in accordance with FESHM 5031.

With this memo, we request a signature from the Director or designee for this exceptional vessel engineering note.

Giorgio Apollinari

FERMILAB
AD/Cryogenic Department

October 28, 2008

To: Giorgio Apollinari

From: Jay Theilacker and Terry Tope
3.9 GHz Cavity Engineering Note Review Committee

Subject: 3.9 GHz Cavity #7 Engineering Note Review

Enclosed you will find the subject engineering note signed by the review committee. Since it falls into the exception vessel category, you will need to prepare justification in accordance to the requirements step 7 Extended Engineering Note for Exceptional Vessels of FESHM 5031TA to take to the Director for approval.

This engineering note only applies to testing in the Fermilab horizontal test cryostat. A new analysis will need to be prepared which addresses the 3.9 GHz cryomodule operation in FLASH. Subsequent 3.9 GHz cavity engineering notes should continue to reference the cavity #5 note in order to limit its content to exceptions as well as cavity specific information or changes.

FERMILAB
Technical Division

Pressure Vessel Engineering Note For the 3.9-GHz Helium Vessel, Cavity #7 (short version referencing cavity #5)

Authors: M. Wong, G. Galasso, Harry Carter, Tom Peterson, Phil Pfund, Dan Olis, Tug Arkan	Date: 24 Oct 2008

Table of Contents

General introduction – exceptional vessel

This engineering note for dressed cavity #7 references the note for cavity #5 where the information is almost identical. For the same reasons as Cavity #5, Cavity #7 is an exceptional vessel. Starting with the Extended Engineering Note on page 8, only the differences from cavity #5 are detailed here. Specifically, the highlighted test details the differences. The non-highlighted next is identical to its counterpart in the Cavity #5 note.

PRESSURE VESSEL ENGINEERING NOTE

PER FESHM CHAPTER 5031

Prepared by: Mayling Wong, Germano Galasso, Tom Peterson, Phil Pfund, Harry Carter, Dan Olis, Tug Arkan

Preparation date: 24 October 2008

1. Description and Identification

   Fill in the label information below:

This vessel conforms to Fermilab ES&H Manual Chapter 5031

Vessel Title 3.9-GHz Helium Vessel, Cavity #7

Vessel Number IND-114

Vessel Drawing Number 5525.000-ME-440598 (Rev. B)

Maximum Allowable Working Pressures (MAWP):
- Internal pressure Warm 2.0-bar (29.0 psia)
- Internal Pressure Cold 2.0 bar (29.0 psia)
- External Pressure 1.0-bar (14.5-psia)

Working Temperature Range -457 ^{O}F - 100 ^{O}F

Contents Superfluid helium

Designer/Manufacturer FNAL

Test Pressure (if tested at Fermi) Acceptance Date:______ ←**Document per Chapter 5034 of the Fermilab ES&H Manual**

2.3 bar

19 PSIG, Hydraulic ______ Pneumatic X

Accepted as conforming to standard by Apollinari Giorgio

of Division/Section TD Date: 11/21/08 ←**Actual signature required**

NOTE: Any subsequent changes in contents, pressures, temperatures, valving, etc., which affect the safety of this vessel shall require another review.

Reviewed by: [signature] Date: 8.28.08

Director's signature (or designee) if the vessel is for manned areas but doesn't conform to the requirements of the chapter.

[signature] Date: 11/20/08

[signature] Date: 11/20/08

ES&H Director Concurrence

Amendment No.:	Reviewed by:	Date:

Lab Property Number(s): ____________
Lab Location Code: Meson Detector Building (obtain from safety officer)
Purpose of Vessel(s): LHe containment for nine-cell 3.9-GHz superconducting Radio frequency cavity
Vessel Capacity/Size: 3.4-L Diameter: 5.5″(140mm) Length: 19.9″(505.92mm)
Normal Operating Pressure (OP) 0.02-bar (0.25-psia)
MAWP-OP = 28.75 PSID

List the numbers of all pertinent drawings and the location of the originals.

Drawing #	Location of Original
5525-ME-440598 Rev B	IDEAS FERMI TDM
5520-ME-426450 Rev F	IDEAS FERMI TDM
5520-ME-426321 Rev B	IDEAS FERMI TDM
5520-MB-426252 Rev C	IDEAS FERMI TDM

(Above are the top-level drawings, see Appendix B, “drawing tree”, in the design note)

2. Design Verification

Is this vessel designed and built to meet the Code or “In-House Built” requirements?
Yes ___ No X

If “No” state the standard that was used ASME Code, Section VIII, Div 1 and Div 2 with finite element analysis and reference to published mechanical data for niobium and NbTi (where code data were not available)

Demonstrate that design calculations of that standard have been made and that other requirements of that standard have been satisfied.

Skip to part 3 “system venting verification.”

Does the vessel(s) have a U stamp? Yes_____ No X . If "Yes", complete section 2A; if "No", complete section 2B.

A. Staple photo of U stamp plate below.
Copy "U" label details to the side

Copy data here:
____
____
____
____
____
____

Provide ASME design calculations in an appendix. On the sketch below, circle all applicable sections of the ASME code per Section VIII, Division I. (Only for non-coded vessels)

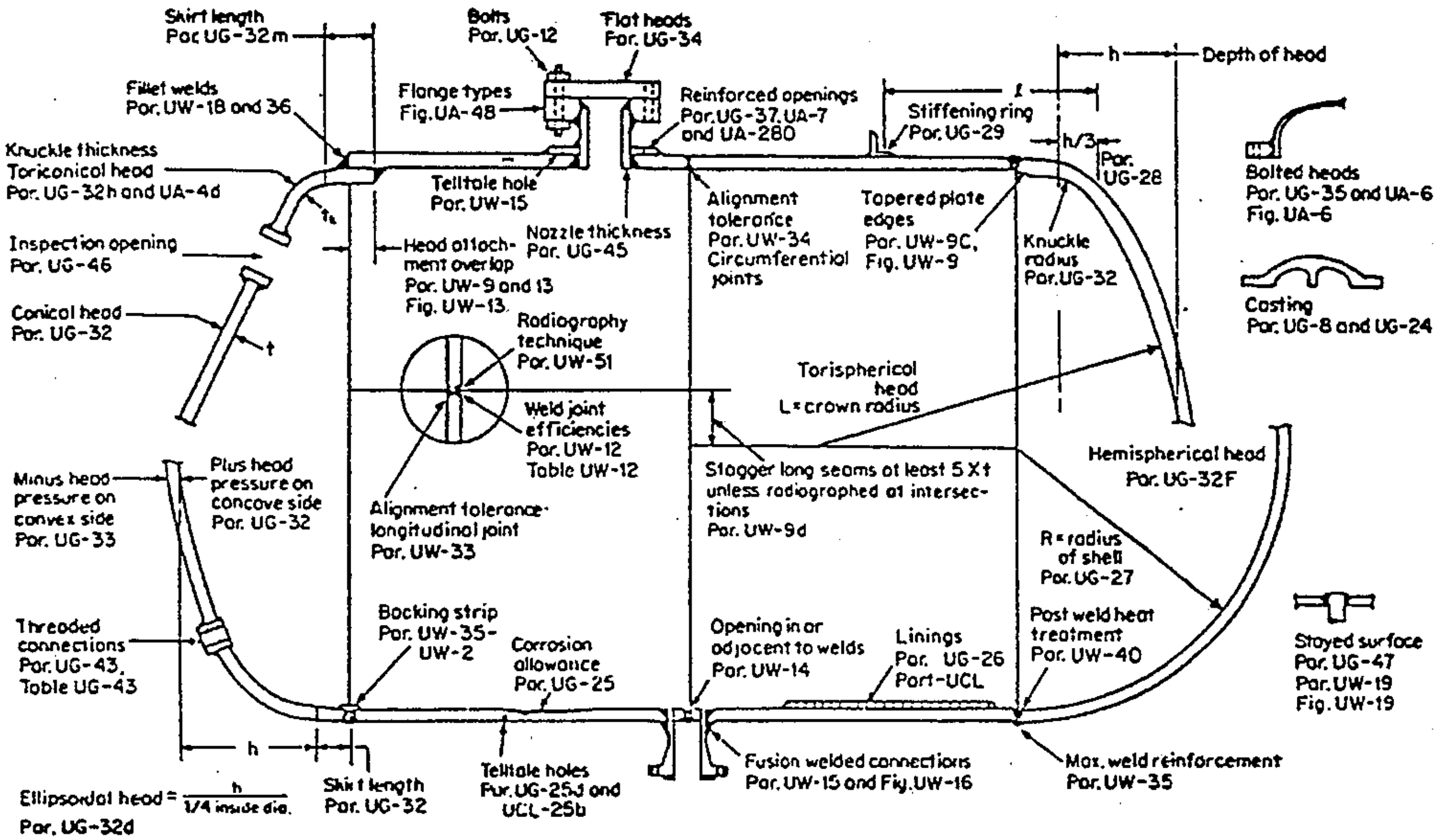


Figure 1. ASME Code: Applicable Sections

2B.

Summary of ASME Code

Item	Reference ASME Code Section	CALCULATION RESULT (Required thickness or stress level vs. actual thickness calculated stress level)
(see Design Note)		
________	________	________ vs ________
________	________	________ vs ________
________	________	________ vs ________
________	________	________ vs ________

3. System Venting Verification (See Figure A4 for vent system schematic - drawing 4906.320-ME-440302)

Does the venting system follow the Code UG-125 through UG-137?
Yes X No___

Does the venting system also follow the Compressed Gas Association Standards S-1.1 and S-1.3?
Yes X No_____

A "no" response to both of the two proceeding questions requires a justification and statement regarding what standards were applied to verify system venting is adequate.

List of reliefs and settings:

Manufacturer	Model #	Set Pressure	Flow Rate	Size
BS&B	LPS	12-psig	2188-SCFM air	3-inch
Hylok 700	CV5-F12N-25		Cv=5.2	3/4"

4. Operating Procedure

Is an operating procedure necessary for the safe operation of this vessel?
Yes_____ No X (If "Yes", it must be appended)

5. Welding Information

Has the vessel been fabricated in a non-code shop? Yes X No ______
If "Yes", append a copy of the welding shop statement of welder qualification (Procedure Qualification Record, PQR) which references the Welding Procedure Specification (WPS) used to weld this vessel.
See "Welding Information" Section in Appendix A

6. Existing, Used and Unmanned Area Vessels

Is this vessel or any part thereof in the above categories?
Yes_____ No X

If "Yes", follow the requirements for an Extended Engineering Note for Existing, Used and Unmanned Area Vessels.

7. Exceptional Vessels

Is this vessel or any part thereof in the above category?
Yes X No _

If "Yes", follow the requirements for an Extended Engineering Note for Exceptional Vessels.

Appendix A – Extended Engineering Note

Introduction

The 3.9 GHz "dressed cavity", cavity #7, is a niobium superconducting radio frequency (RF) cavity surrounded by a helium vessel which will be filled with liquid helium (so liquid helium surrounds the niobium RF cavity) at temperatures as low as 1.8 K. The cavity will be performance tested in the Horizontal Test Stand (HTS) at the Meson Test Area at Fermi National Accelerator Laboratory (Fermilab) before being installed in a cryostat with three other 3.9 GHz dressed cavities. The cryostat with four dressed cavities will be shipped to DESY, in Hamburg, Germany, to be installed in the FLASH-linac (former TTF2-linac). This document summarizes how the helium vessel for cavity #8 follows the requirements of the FESHM 5031 [ref 1]. This document and supporting documents for the 3.9 GHz helium vessel engineering note and also for the 3.9 GHz cryomodule may be found at:

http://ilc-dms.fnal.gov/Workgroups/CryomoduleDocumentation/3rd-Harmonic-Cryomodule-for-DESY/

Cavity #7 is the fourth dressed cavity that will be tested in HTS. The designs of the dressed cavity are almost identical to Cavity #5. The only difference is in one part of the helium vessel design. The difference is detailed in the "Vessel Description" of Appendix A of this engineering note. The fabrication of Cavity #7 follows almost the exact the same procedure as the fabrication for Cavity #5. Several steps in the welding procedure differ in an effort to optimize the fabrication process. How the fabrication for Cavity #7 differs from Cavity #5 is detailed in the section titled "Welding Information" of Appendix A of this engineering note.

…

Exceptional Vessel Discussion and Extended Engineering Note Summary

Reason for Exception

The 3.9-GHz dressed cavity as a helium vessel has materials and complex geometry that are not conducive to complete design and fabrication following the ASME Code [ref 2]. Parts of the vessel are made of niobium and an alloy that is 45% niobium/55% titanium. Neither of these materials is approved in the Code.

However, we show that the vessel is safe at a level that is similar to the Code, as recommended by the DOE's Federal Register for contractors on Worker Safety and Health Program [ref 3] and in accordance with FESHM 5031. Since the vessel design and fabrication cannot exactly follow the guidelines given by the Code, the vessel requires a Director's Exception. (The page numbers in Table A1 refer to the pages in the Cavity #5 engineering note.)

Table A1 – Specific areas of exception to the ASME code

Location or procedure	**Reference**	**Explanation for exception**
Niobium material	pg 17	Used for its superconducting properties, not explicitly allowed by the code
Calculated stress in Nb cavity at the iris.	pg 41	Worst case tuning extension (0.5 mm) with internal pressure at room temperature (82.4 MPa vs 60 MPa allowable). This stress is self-limited by the tuner and results at worst in an offset of the neutral tuning position.
Niobium-Titanium material	pg 19	Used for compatibility in welding with niobium and titanium, a transition between the two metals
Partial penetration welds in Ti and between NbTi and Ti	pp 79 - 85	Care not to burn through the material
Weld procedure specification (WPS), procedure qualification record (PQR), and welder performance qualification (WPQ) were either not performed, or initiated after completion of the work	pp 74	The 0.8 factor taken on allowable material stress per FESHM 5031 is intended exactly for this issue, to mitigate incomplete code-specified information.
Incomplete testing of bulk and weld affected zone material	pp 74	See note above regarding 0.8 factor.
No X-ray or ultrasonic inspections of welds (Div 2 requires 100% radiography, plus 10% ultrasonic testing on welds.)	pg 74	Access difficulty. Samples were welded, cut, polished, and photographed instead in order to establish degree of weld penetration.

…

Fabrication

Detailed welding information is included in this engineering note. A fabrication procedure, associated material specifications, and welders' certifications are compiled in a second document with the file name "Cavity-7-Matl_Weld_Certs.doc".

...

Pressure Test

The dressed cavity was pressure tested to 2.3 bar, 1.15 times the MAWP of 2.0 bar.

...

Vessel Description

...

A complete drawing tree is shown in Figure A1. The top level and second level assembly drawings are copied in the following figures for reference here. A complete set of drawings is at:

http://ilc-dms.fnal.gov/Workgroups/CryomoduleDocumentation/3rd-Harmonic-Cryomodule-for-DESY/DressedCavityDrawings/ and is also archived at:

http://tdserver1/project/TDarchivedDrawings/drawings/

The design of Cavity #7 is almost the same as for Cavity #5. The drawings shown in Figure A1 have been updated to reflect the changes. The only design change for Cavity #7 is the thickness of the bellows cuff design (drawing MB-457115) at the bellows-to-shell joint in the helium vessel. The thickness of the cuff is 2-mm. The cuff design allows for a full penetration TIG weld of the bellows assembly to the helium vessel shell. The joint detail is shown in Figure A29 (weld #7, #8).

...

3.9 GHz Cavity #7 Drawing Tree

Dwg. No.	Rev.	Description
440598	C	Vertical Helium Vessel Weld Fixture
426450	H	Helium Vessel Weldment Style C
426277	A	Flange, RF Cavity, Helium Supply
426278	C	Tube, Helium Vessel Supply
426257	E	Flange, Vessel Tuner Stepped Ring
457114	C	Bellows Weldment
457116	A	Backing Ring, Bellows
457115	A	Cuff, Bellows
457113	-	Bellows
426250	D	Shell, Helium Vessel
426258	E	Flange, Helium Vessel Tuner Ring
426251	G	Shell, Helium Vessel, Helium Supply Side
426262	D	Flange, Helium Vessel Drain
426260	A	Pin, Helium Vessel Invar Connection
426321	B	Cavity Weldment
426332	C	End Tube w/o MC, Fabricating Process
426335	-	Conical Flange "B" Weldment
426329	A	End Cell
426336	A	End Cap, Vessel, Small
426354	-	Flange, Niobium, Tube End
426358	A	End Tube w/o MC Port
426178	A	Flange RF Cavity, NW40
426334	A	Flange, CF Pickup Antenna
426333	-	Tube, Pickup Antenna
426286	A	Formteil
426328	B	Flange, HOM Coupler
426582	-	HOM Coupler
426330	A	Dumbbell Weldment, Full
426182	-	Mid Cavity Weldment
426183	A	Mid Cell
426323	C	End Tube w/MC, Fabricating Process
426324	-	Conical Flange "A" Weldment
426325	-	End Cap, Vessel, Large
426354	-	Flange, Niobium, Tube End
426329	A	End Cell
426357	A	End Tube w/ MC Port
426328	B	Flange, HOM Coupler
426582	-	HOM Coupler
426327	A	Flange, Main Coupler
426353	A	Tube, Main Coupler
426178	A	Flange, RF Cavity, NW40
426286	A	Formteil
426252	C	Flange, Vessel End, Stepped

Figure A1. Dressed cavity #7 drawing tree

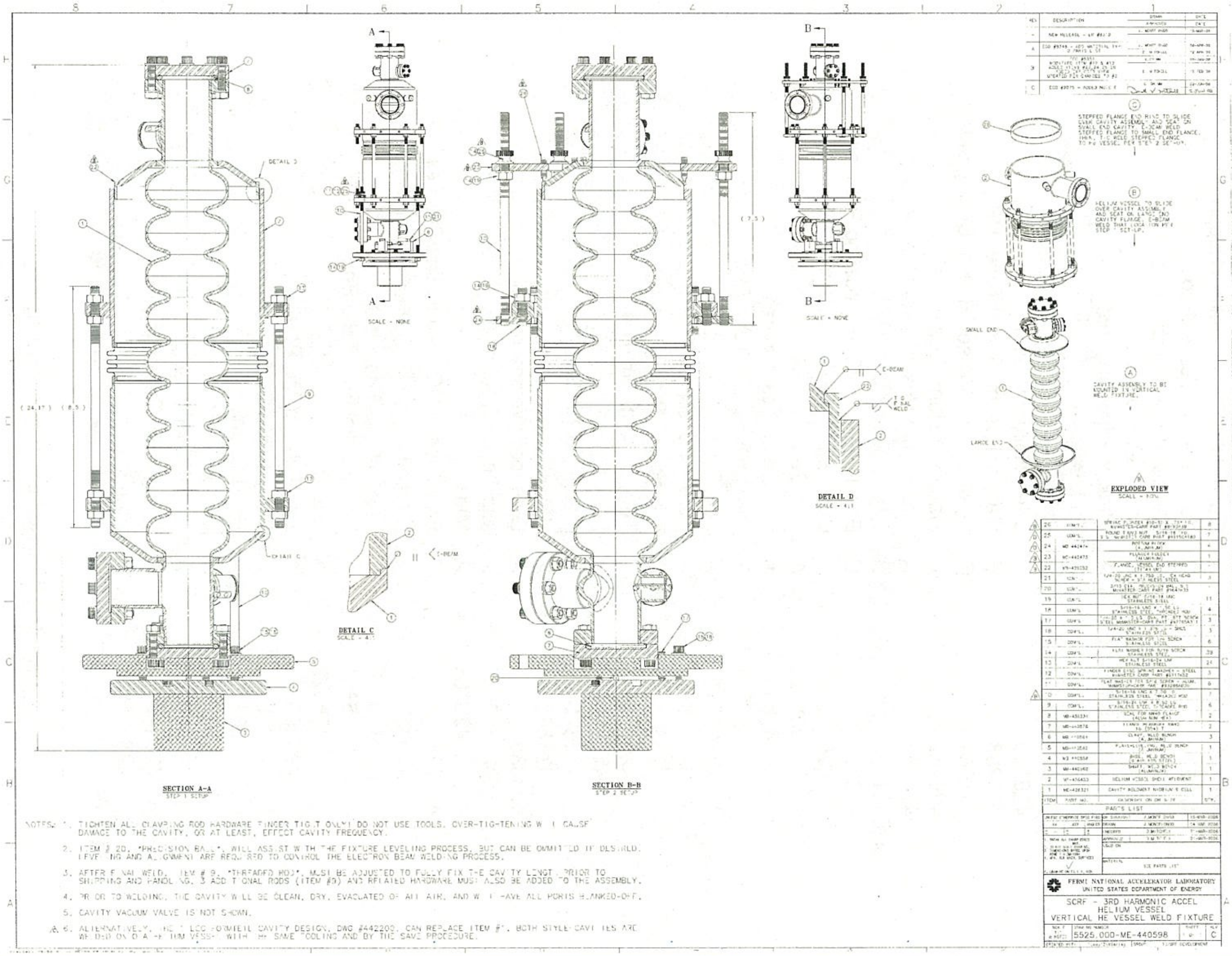


Figure A2 – Helium Vessel for the 3.9-GHz Cavity, assembled in the welding fixture (Drawing 5520.000-ME-440598)

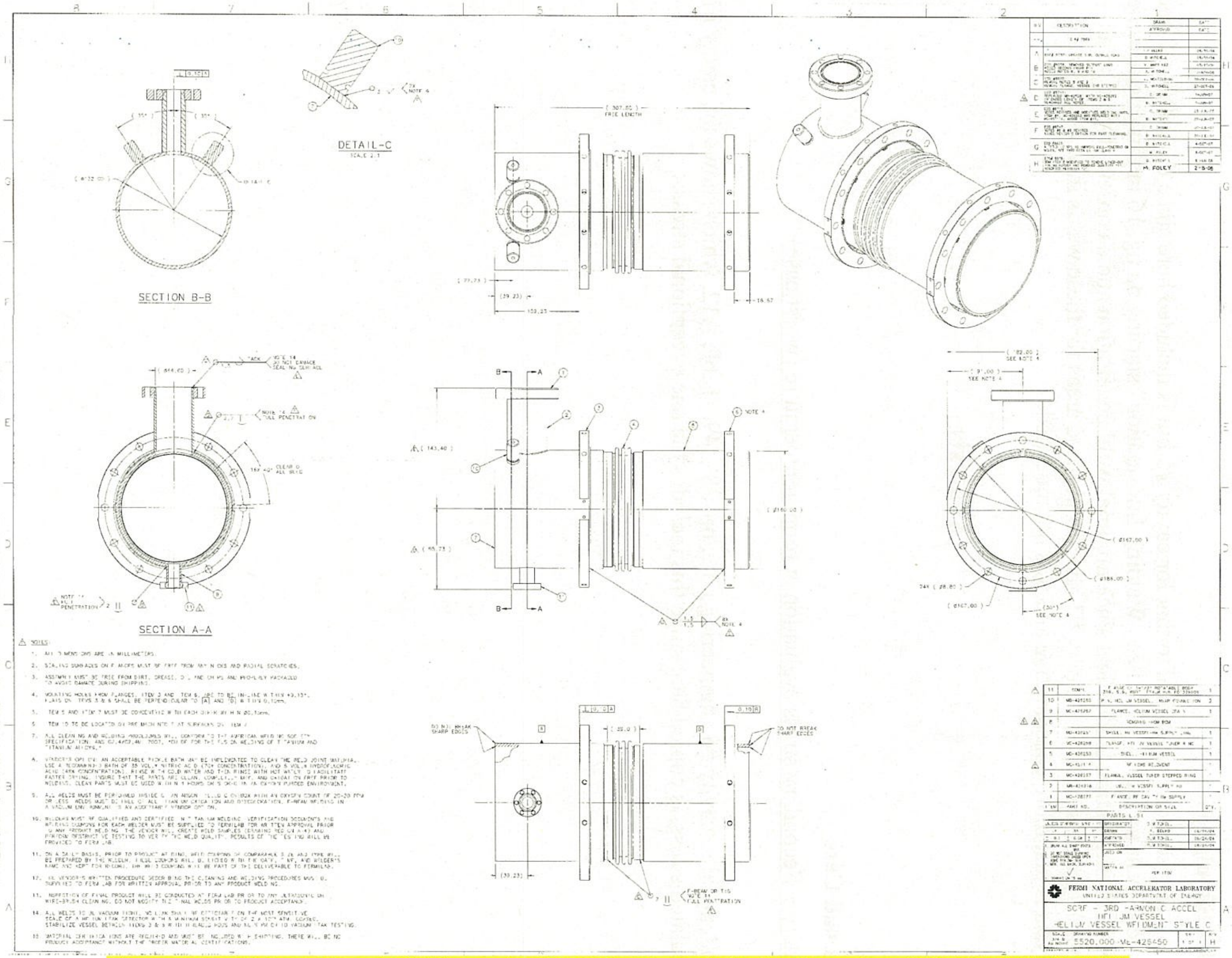


Figure A4 – Helium Vessel Weldment for 3.9-GHz Dressed Cavity (Drawing 5520.000-ME-426450)

…

Welds Simulation

This section is identical to that for cavity #5 but is included here since the welds # 7 and 8 are different for cavity #7. (See "Welding Information" starting on pg. 16 in this engineering note.) The simulation is identical since minimal weld penetration and a conservatively small joint area are assumed. For cavity #7, the actual fused areas for these welds increased, so the analysis is just more conservative and was not modified.

…

Analysis

…

2nd Load Case

Primary + Secondary stress evaluation at room temperature (worst case)

All identical to cavity #5 engineering note, pp. 38 – 49. Table A12, which shows the cavity iris calculated stress, is copied here since this includes the one exceptional stress.

…

Table A12 -2nd Load Case: Niobium Cavity. Linearized Stress Intensity summary

SCL	Component and Evaluation Region	Material	Stress Category and Value Linearized Stress Intensity [MPa]		Acceptance Criteria [MPa]
J	Cavity: Cavity/Nb-Ti Joint Weld Region	Nb RRR	P_M+Pb+Q	11.22	≤ 3·S=60
Y	Cavity: Cavity/Nb-Ti Joint Weld Region	Nb RRR	P_M+Pb+Q	11.31	≤ 3·S=60
Z	Cavity: End Cells Region	Nb RRR	P_M+Pb+Q	20.81	≤ 3·S=60
D	Cavity: Mid Region- Iris	Nb RRR	P_M+Pb+Q	82.43	≤ 3·S=60
F	Cavity: Mid Region- Equator	Nb RRR	P_M+Pb+Q	25.59	≤ 3·S=60

...

Welding Information

All welds were designed, welded, and qualified as per Cavity #5 except those highlighted in Tables A24-1 and A24-2. …

Table A24-1 - 3rd harmonic dressed cavity #7 weld summary

Weld No.	Weld description	Drawing or reference	Type of weld	How qualified and other notes
1	Nb cavity end cell to Nb tube end flange, input coupler end	MD-442202	e-beam	Parameters developed based on microscopic or metallographic analysis of cut, etched and polished weld samples. Welded at Sciaky.
2	Nb cavity end cell to Nb tube end flange, non-input coupler end	MD-442201	e-beam	Same as above. Welded at Sciaky.
3	NbTi large conical end cap A to Nb tube end flange, input coupler end	MD-442202	e-beam	Same as above. Welded at Sciaky.
4	NbTi small conical end cap B to Nb tube end flange, non-input coupler end	MD-442201	e-beam	Same as above. Welded at Sciaky.
5	Nb end tube to Nb conical flange A, coupler end	MD-442202	e-beam	Same as above. Welded at Sciaky.
6	Nb end tube to Nb conical flange B, non-coupler end	MD-442201	e-beam	Same as above. Welded at Sciaky.
7	Ti bellows to Ti tube	MC-457114	TIG	Same as above. Welded at Hi-Tech.
8	Ti bellows to Ti tube	MC-457114	TIG	Same as above. Welded at Hi-Tech.
9	NbTi conical end piece to Ti cylinder, coupler end	ME-440598 detail C and "He_vessel to cavity weld.ppt"	e-beam	Same as weld numbers 1 - 6 above. Welded at Sciaky.
10	NbTi conical end piece to Ti spacer ring, non-coupler end	ME-440598 detail D and "He_vessel to cavity weld.ppt"	e-beam	Same as weld numbers 1 – 6 above. Welded at Sciaky.
11	Ti spacer ring to Ti cylinder, non-coupler end	ME-440598 detail D and "He_vessel to cavity weld.ppt"	TIG	Welded by Dan Watkins, Fermilab, in the A0 glove box. WPQ and PQR from Alloy Weld Inspection Company.

The following information explains the welding procedure of the helium vessel for cavity #7 for weld numbers 7 – 11 (in Table A24-1):

All the parts for this specific helium vessel were machined and TIG welded at Hi-Tech.

There are three welds connecting the helium vessel to the cavity: an EB weld joining the bottom of the vessel to the large conical end cap (weld #9), an EB weld joining the titanium slip ring to the small conical end cap (weld #10), and a TIG fillet weld joining the vessel to the slip ring (weld #11). We are not allowed to do full penetration EB welds because the RF people want to avoid any NbTi or Ti vapor deposition on the half-cells. They believe it will negatively affect heat transfer to the liquid helium in the vessel.

The two EB welds were done at Sciaky. In the Power Point presentation you will see pictures of the cut, etched and polished weld samples performed using the same weld parameters. The TIG weld was done at Fermilab by Dan Watkins. You will also see pictures of the preliminary weld samples Dan produced in the Power Point presentation. His WPQ is provided.

Weld #11, where there is a final fillet weld joining the titanium spacer ring to the titanium cylinder, is a complete circumferential weld. The procedure for Cavity #7 to arrive at the weld is slightly different than for the same weld in Cavity #5. The weld was built up in increments, then allowed to cool so that the frequency spectrum can be monitored. The additional steps of cooling the weld and monitoring the frequency spectrum were taken for Cavity #7 and were not done for Cavity No. 5. The final resulting weld is the same for both cavities.

Table A24-2 below lists the welds that are different between Cavities 7 and 5.

Table A24-2 – Summary of Differences in the Welds of Cavities #5 and #7

Weld No.	Description	Cavity No. 5	Cavity No. 7
7	Ti bellows to Ti tube	E-beam weld at Sciaky – 75% penetration	TIG weld at Hi-Tech – full penetration
8	Ti bellows to Ti tube	E-beam weld at Sciaky – 75% penetration	TIG weld at Hi-Tech – full penetration
9	NbTi conical end piece to Ti cylinder, coupler end	Welds later certified by radiographic analysis, tensile and bend tests performed on weld samples via Packer Engineering (pending).	No radiographic analysis. Weld procedure is the same as for Cavity #5.
11	Ti spacer ring to Ti cylinder, non-coupler end	For final fillet weld, weld in increments around circumference, working towards a complete weld	For final fillet weld, weld in increments around circumference, allow part to cool, monitor frequency spectrum, repeat to work towards a complete weld

Weld documents are available at:

http://ilc-dms.fnal.gov/Workgroups/CryomoduleDocumentation/3rd-Harmonic-Cryomodule-for-DESY/helium-vessel-engineering-note/

These include:

"Helium Vessel to Cavity." This PowerPoint file by Mike Foley describes the helium vessel weld setup and process. Weld samples are also shown.

"Fermilab Welder Performance Qualification (WPQ)." The final closure titanium TIG weld was performed by Dan Watkins.

"Procedure Qualification Record (PQR) for GTAW / Manual Process for Fermilab". The final closure titanium TIG weld was created at Fermilab.

"Procedure Qualification Record (PQR) for Electron Beam Welding process at Sciaky." The niobium cavity was welded at Sciaky. Also, the NbTi / Ti welds were created at Sciaky.

"Procedure for TIG Welding Helium Vessels to 3.9 GHz 3rd Harmonic Cavities." The procedure details the steps in making the final three welds to attach the cavity to the titanium shell.

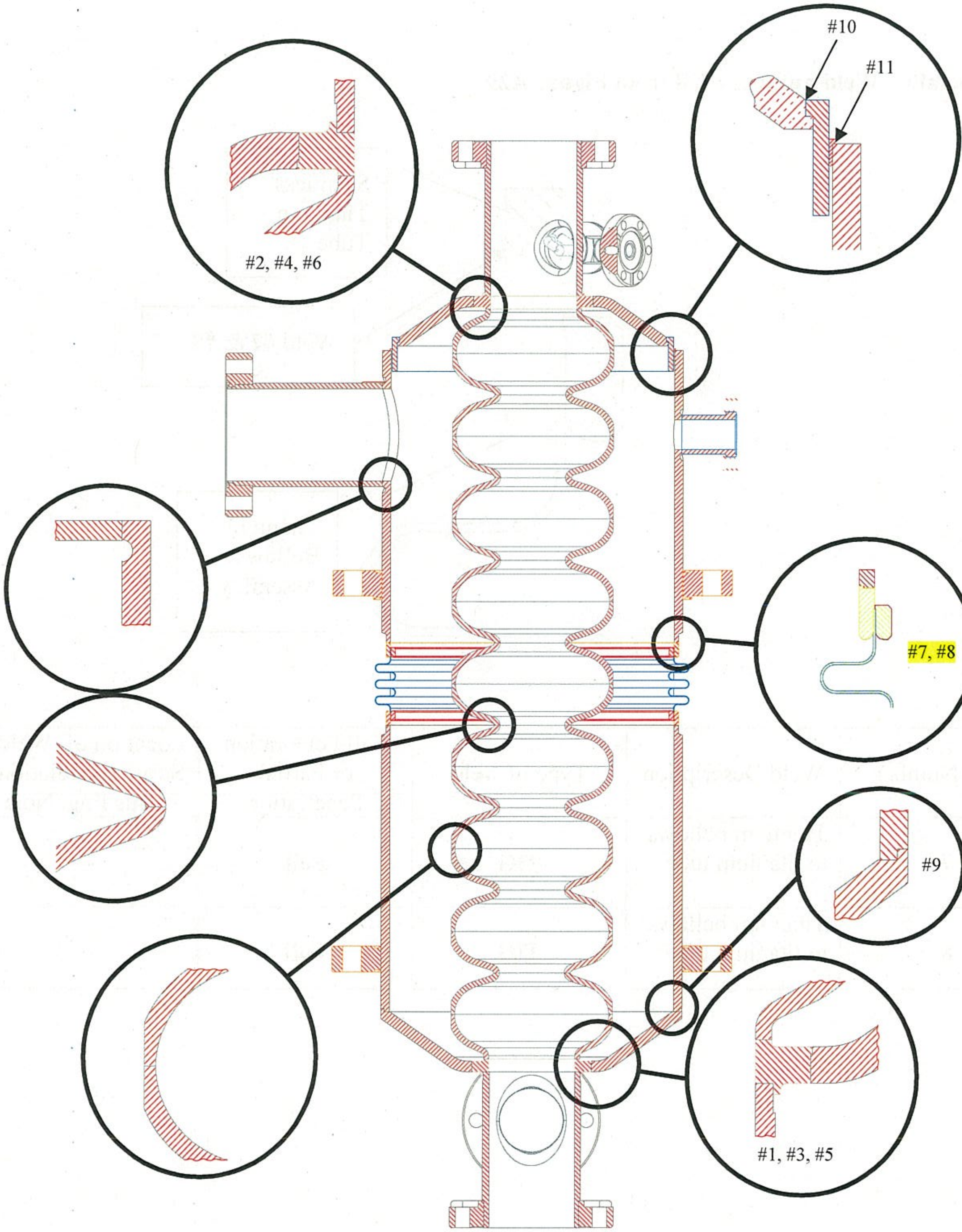
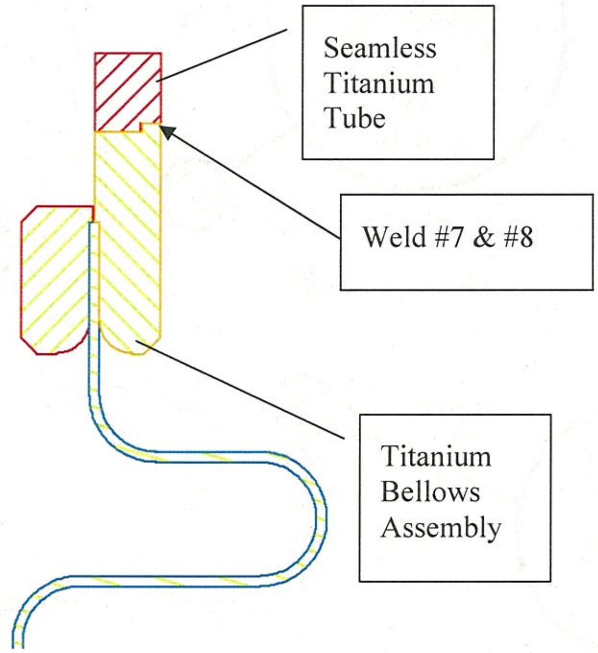


Figure A29 - Welds forming the Cavity #7 Helium Vessel Pressure Boundary

…

Weld Details: Weld numbers 7, 8 from Figure A29



Weld Number	Weld Description	Type of weld	Full Penetration or Partial Penetration	Location of Weld Stress Calculation in this Eng. Note
7	Titanium bellows to titanium tube	TIG	Full	-
8	Titanium bellows to titanium tube	TIG	Full	-

…

Appendix B – 2.3 bar Pressure Test

Pressure test results for Cavity 7.

Fermilab

Date: 13 Nov 2008

EXHIBIT B

Pressure Testing Permit*

Type of Test: [ ]Hydrostatic [x] Pneumatic

Test Pressure 33.5 psig **Maximum Allowable Working Pressure** 29 psid

Items to be Tested

Dressed 3.9 GHz cavity #7 in HTS cave at Meson Lab. Cavity at atmosphere, so test condition is atmospheric pressure inside cavity and outside helium vessel. 2.0 bar differential MAWP implies 2.3 bar differential pressure test which is 33.5 psig pressure test.

Location of Test Meson Lab, HTS cave **Date and Time** 17 Nov 2008 1:30 p.m.

Hazards Involved

Helium pressure of 2.3 bar (33.5 psi) differential (atmosphere inside cavity and outside helium vessel) within approximately 4 liter volume.

Safety Precautions Taken

Helium vessel is inside of the HTS cave, in which no personnel will be permitted while pressurizing the vessel above its 2.0 bar MAWP. Procedures follow FESHM 5034, Pressure Vessel Testing.

Special Conditions or Requirements

35 psig relief valve on supply gas line. Relief cannot be valved off.

See attached sketch for test flow schematic.

Qualified Person and Test Coordinator Dept/Date Tom Peterson (TD, SRF) Tom Peterson 17 Nov 2008

Division/Section Safety Officer Dept/Date Richard Ruthe TD ES&H 11/17/08 [signature] AD ESH 11-17-08

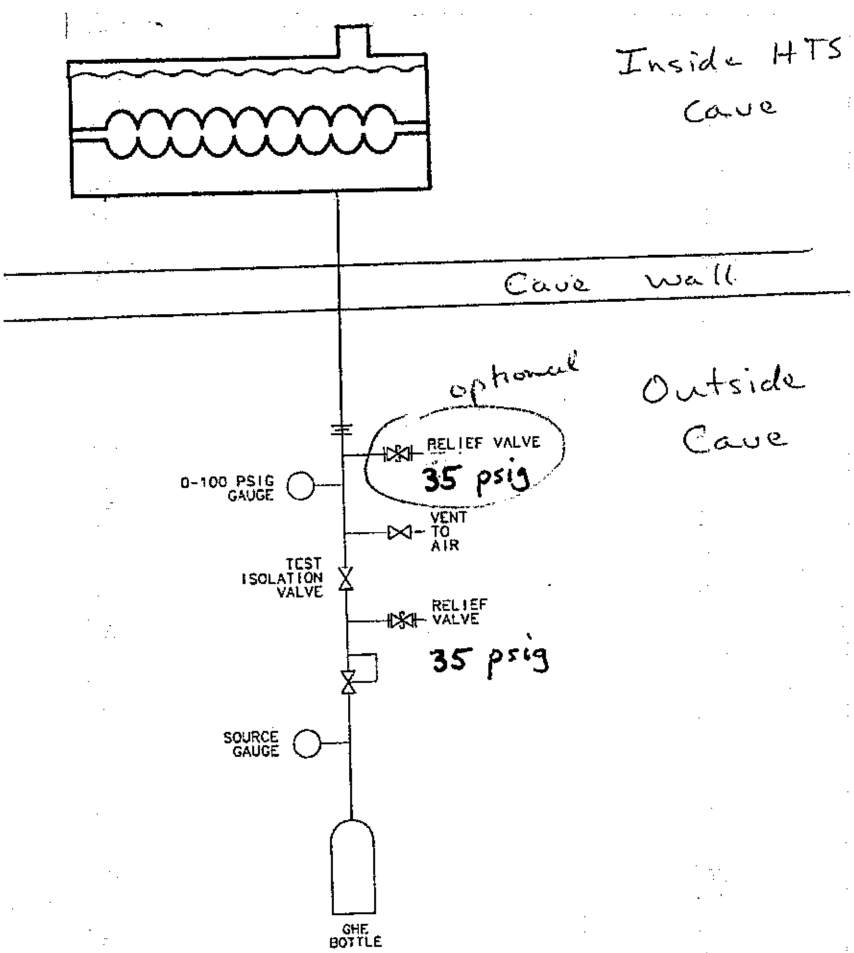
Results

Followed detailed pressure steps per procedure. Each RF test was about 5 min. Held pressure, visual inspection OK.

Witness R. Ruthe [signature] (Safety Officer or Designee) **Dept/Date** TD ES&H 11/17/08 AD/ESH 11-17-08

- Must be signed by division/section safety officer prior to conducting test. It is the responsibility of the test coordinator to obtain signatures.

Test Procedure
See attached sketch for test flow schematic and detailed procedure below that.
Following paragraph 8.3 of Section VIII, Div 2 of the ASME pressure vessel code, the general procedure is:
The pressure in the vessel shall be gradually increased to not more than half the test pressure (which means not more than 17 psig). Then increase pressure in steps of 2 to 3 psi until the final test pressure of 33.5 psig is reached. Then back the pressure off to the MAWP of 29 psig and stop. Verify that no leaks occur by watching the system pressure for 3 minutes. Reduce pressure to half of the test pressure (to 17 psig), then enter the cave for a visual inspection of the vessel.
Note 1: since this vessel and test are a joint TD and AD effort, safety officers from both TD and AD will witness the test.
Note 2: the pressure test will also include an RF frequency measurement before, during, and after pressurization to check for any permanent deformation of the cavity.



Dressed cavity pressure test in HTS cave

Detail for the pressure test steps.

Pressure tests and pressure hold at the MAWP follow the general guidelines presented in ASME pressure vessel code, Section VIII, Div 2, Part 8-3. The table below shows the pressure levels for each pause and what should be done at that pressure. Total time for the test, not including setup and tear-down time, will be about 20 minutes.

Pressure (psig) (psig equals differential pressure for this test)	Dwell time (minutes)	Activity at pressure
0	--	Baseline RF test
8.0	As needed	RF check
16.0	As needed	Snoop line fitting, RF check
19.0	~1	
24.0	As needed	RF check
28.0	~1	
31.0	~1	
32.0	As needed	RF check
33.5	~1	Peak test pressure of 1.15 x MAWP
29.0	3.0*	Test pressure hold point*, RF check
17.0	As needed	Visual inspection of vessel, RF check
0	--	RF check

*The pressure hold point of 29 psig is the MAWP. Dwell time is set long enough to assure us that pressure is not dropping.

Appendix C – Cavity processing information

The bare niobium cavity #7 was processed and baked as described in the tables below, excerpted from Allan Rowe's spreadsheet, "SCRF 3rd Harm Cavity Processing Chart.xls".

Cavity # 7													
		Vacuum Leak Check	Degrease / Ultrasonics	Average Ultrasonic Thickness Measurements (mm)									
Step	Date	He sensitivity <1e-10 Torr-l/s	Micro90/US (YES / NO)	Caret 1	Caret 2	Caret 3	Caret 4	Caret 5	Caret 6	Caret 7	Caret 8	HOM1 Top Hat	HOM2 Top Hat
Leak check		Yes											
Degrease			Yes										
Measurements				2.430	2.640	2.650	2.620	2.680	2.600	2.610	2.300	0.930	0.980
Outside Etch	11/26/07			2.430	2.630	2.650	2.610	2.670	2.590	2.610	2.300		
Degrease	11/26/07		No										
Inside Etch	11/29/07			2.370	2.560	2.600	2.530	2.620	2.530	2.560	2.240	0.890	0.940
Degrease	11/29/07		Yes										
Degasification	12/01/07												
Degrease	12/03/07		Yes										
Inside Etch	01/15/08			2.340	2.520	2.580	2.500	2.620	2.500	2.550	2.230	0.870	0.920
HPR	02/04/08												
HPR	02/05/08												
Vert Test	02/07/08												
HPR	02/14/08												
HPR	02/15/08												
Vert Test	02/28/08												
Measurements	03/07/08			2.320	2.490	2.570	2.500	2.620	2.500	2.550	2.210	0.870	0.930
Degrease	10/06/08		Yes										
Inside Etch-Ti	10/20/08											0.860	0.920
HPR	10/20/08												
HPR	10/21/08												
			Estimated Thickness	2.3	2.47	2.55	2.48	2.6	2.48	2.53	2.19	0.86	0.92

Cavity # 7

Step	BCP Etching											Cavity Weight
	Target Removal (µm)	Averaged Removal (um)	Etch Time (min.)	Achieved Etch Rate (um/min)	Weight Removed (g)	Input Coupler (Top/Bottom)	DI Water Resistivity (Mohm)	BCP Volume Used (liters)	Avg. BCP Temp (C)	Max BCP Temp (C)	Rough Rinses	Grams
Leak check												
Degrease												
Measurements												4187.5
Outside Etch	20	5.00	20	0.3	25.5	NA	16.5	13.3	10.7	11.5	10	4162
Degrease												
Inside Etch	80	56	60	0.9	80.9	bottom	16.5	13.3	11.8	12.2	10	4081.1
Degrease												
Degasification												
Degrease												
Inside Etch	20	21	15	1.4	23.5	bottom	17	13.3	13.5	14.2	10	4057.6
HPR												
HPR												
Vert Test												
HPR												
HPR												
Vert Test												
Measurements												4057.6
Degrease												
Inside Etch-Ti	20	20	15	1		bottom	16.5	13.3	13	13.1	10	
HPR												
HPR												
	140	117										

Cavity # 7

	Hydrogen Bake Out					High Pressure Rinse			
Step	Plateau Time (hr.)	Plateau Temp. (°C)	Max Tot. Pressure (Torr)	Beginning H2 Pressure @ 800C (Torr)	End H2 Pressure after 2hrs (Torr)	No. of Passes	UPW Bacteria Count (CFU/liter)	TOC (ppb)	UPW Resistivity (Mohm)
Leak check									
Degrease									
Measurements									
Outside Etch									
Degrease									
Inside Etch									
Degrease									
Degasification	2.3	822	2.50E-08	3.80E-05	1.50E-06				
Degrease									
Inside Etch									
HPR						26	52	12	18.2
HPR						26	52	12	18.2
Vert Test									
HPR						26	3	6	18.2
HPR						26	3	6	18.2
Vert Test									
Measurements									
Degrease									
Inside Etch-Ti									
HPR						26	13	16	18.2
HPR						26	13	16	18.2