

Design and Implementation of a Cryogenic Loading Capability on the Spectrometer for Materials Research at Temperature and Stress - SMARTS

T. Woodruff and R. Vaidyanathan

University of Central Florida

B. Clausen, T. Sisernos, D. Brown and M.A.M. Bourke

Los Alamos National Laboratory



University of Central Florida

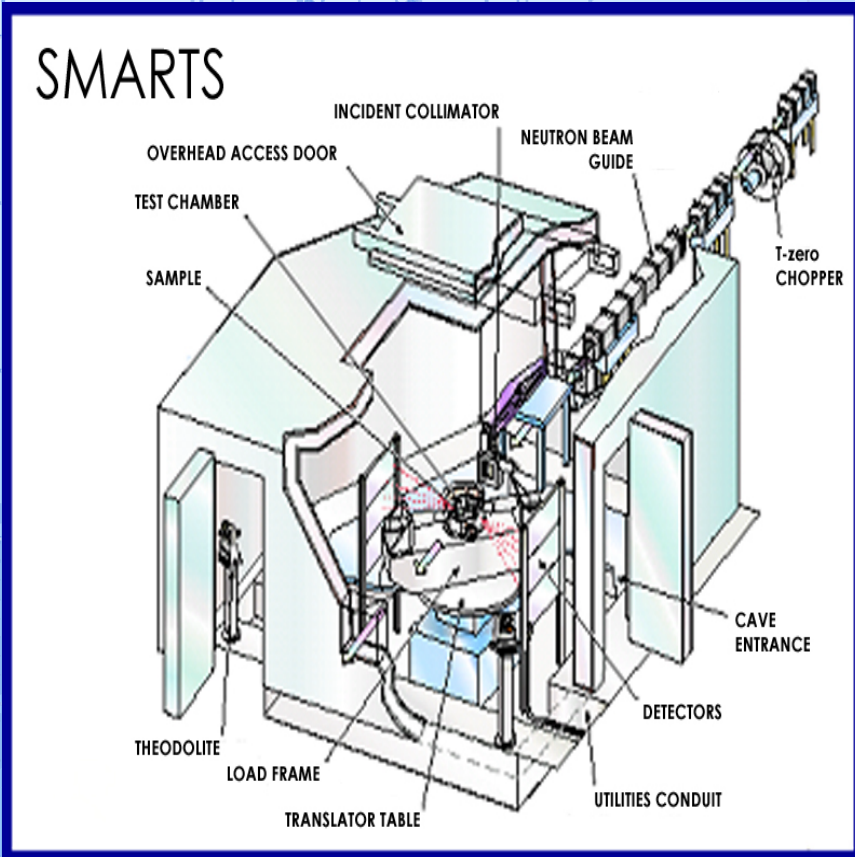
4th International Workshop on Sample Environments at Neutron Scattering Facilities

50	01	REVISED	REVISED PAPER IMAGE
50	02	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	03	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	04	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	05	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	06	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	07	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	08	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	09	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	10	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	11	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	12	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	13	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	14	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	15	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	16	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	17	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	18	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	19	1999-199-100-100 (100)	REVISED PAPER IMAGE
50	20	1999-199-100-100 (100)	REVISED PAPER IMAGE

Spectrometer for **M**Aterials **R**esearch at Temperature and **S**tress



University of Central
Florida



Current Capabilities

- Spatially resolved measurements
- *In situ* loading capability
 - Tensile and compressive loading
 - Applied forces up to 250 kN
- High temperature measurements
 - Test temperatures up to 1800°C
- No low temperature loading capability!

NO.	DESCRIPTION	REVISIONS
01	REVISIONS	REVISIONS
02	REVISIONS	REVISIONS
03	REVISIONS	REVISIONS
04	REVISIONS	REVISIONS
05	REVISIONS	REVISIONS
06	REVISIONS	REVISIONS
07	REVISIONS	REVISIONS
08	REVISIONS	REVISIONS
09	REVISIONS	REVISIONS
10	REVISIONS	REVISIONS

UNIVERSITY OF CENTRAL FLORIDA
MMA&S DEPARTMENT

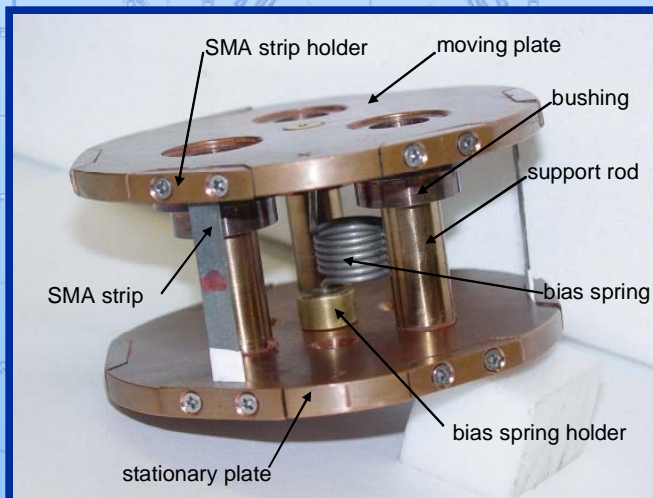
TEST CHAMBER

KCC3101A

Motivation for a Cryogenic Capability



The Future of Mars Plans for NASA's Next Decade of Red Planet Probing



- ❖ NASA project at UCF to fabricate low temperature shape memory alloys for actuator applications
- ❖ Thermal conduction switch for Mars
- ❖ Seals, valves, fluid-line repair and self-healing gaskets
- ❖ Deformation involves stress induced transformation and twinning
- ❖ *In situ* studies during loading of stress induced transformation and twinning in low temperature shape memory alloys
- ❖ General – behavior at low temperatures
 - ❖ phase transformations, e.g., steel
 - ❖ twinning, e.g., Zr
 - ❖ Cu-Nb conductors

4. ENTIRE ASSEMBLY MUST BE LEAK TIGHT. MAXIMUM ALLOWABLE LEAK RATE = 1.0×10^{-2} SIMPSON/SEC.

REV	DESCRIPTION	DATE	BY	CHKD
01	ISSUED FOR FABRICATION	01/15/06	J. J. KELLY	
02	REVISION TO DRAWING	01/15/06	J. J. KELLY	
03	REVISION TO DRAWING	01/15/06	J. J. KELLY	
04	REVISION TO DRAWING	01/15/06	J. J. KELLY	
05	REVISION TO DRAWING	01/15/06	J. J. KELLY	
06	REVISION TO DRAWING	01/15/06	J. J. KELLY	
07	REVISION TO DRAWING	01/15/06	J. J. KELLY	
08	REVISION TO DRAWING	01/15/06	J. J. KELLY	
09	REVISION TO DRAWING	01/15/06	J. J. KELLY	
10	REVISION TO DRAWING	01/15/06	J. J. KELLY	
11	REVISION TO DRAWING	01/15/06	J. J. KELLY	
12	REVISION TO DRAWING	01/15/06	J. J. KELLY	
13	REVISION TO DRAWING	01/15/06	J. J. KELLY	
14	REVISION TO DRAWING	01/15/06	J. J. KELLY	
15	REVISION TO DRAWING	01/15/06	J. J. KELLY	
16	REVISION TO DRAWING	01/15/06	J. J. KELLY	
17	REVISION TO DRAWING	01/15/06	J. J. KELLY	
18	REVISION TO DRAWING	01/15/06	J. J. KELLY	
19	REVISION TO DRAWING	01/15/06	J. J. KELLY	
20	REVISION TO DRAWING	01/15/06	J. J. KELLY	

100% INSPECTION REQUIRED

DATE: 01/15/06

TIME: 10:00 AM

LOCATION: 1000

REVISION: 01

REVISION: 02

REVISION: 03

REVISION: 04

REVISION: 05

REVISION: 06

REVISION: 07

REVISION: 08

REVISION: 09

REVISION: 10

REVISION: 11

REVISION: 12

REVISION: 13

REVISION: 14

REVISION: 15

REVISION: 16

REVISION: 17

REVISION: 18

REVISION: 19

REVISION: 20

REVISION: 21

REVISION: 22

REVISION: 23

REVISION: 24

REVISION: 25

REVISION: 26

REVISION: 27

REVISION: 28

REVISION: 29

REVISION: 30

REVISION: 31

REVISION: 32

REVISION: 33

REVISION: 34

REVISION: 35

REVISION: 36

REVISION: 37

REVISION: 38

REVISION: 39

REVISION: 40

REVISION: 41

REVISION: 42

REVISION: 43

REVISION: 44

REVISION: 45

REVISION: 46

REVISION: 47

REVISION: 48

REVISION: 49

REVISION: 50

REVISION: 51

REVISION: 52

REVISION: 53

REVISION: 54

REVISION: 55

REVISION: 56

REVISION: 57

REVISION: 58

REVISION: 59

REVISION: 60

REVISION: 61

REVISION: 62

REVISION: 63

REVISION: 64

REVISION: 65

REVISION: 66

REVISION: 67

REVISION: 68

REVISION: 69

REVISION: 70

REVISION: 71

REVISION: 72

REVISION: 73

REVISION: 74

REVISION: 75

REVISION: 76

REVISION: 77

REVISION: 78

REVISION: 79

REVISION: 80

REVISION: 81

REVISION: 82

REVISION: 83

REVISION: 84

REVISION: 85

REVISION: 86

REVISION: 87

REVISION: 88

REVISION: 89

REVISION: 90

REVISION: 91

REVISION: 92

REVISION: 93

REVISION: 94

REVISION: 95

REVISION: 96

REVISION: 97

REVISION: 98

REVISION: 99

REVISION: 100

Investigation of Weld Repair on Space Shuttle Flowliners



SPACEFLIGHT NOW

The leading source for online space news

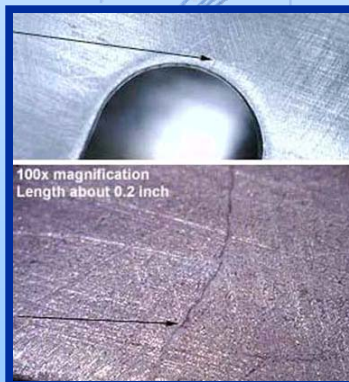
HOME ■ PLUS ■ CURRENT MISSION ■ NEWS ARCHIVE ■ LAUNCH SCHEDULE ■ MISSION REPORT

Hunt for cracks moves to shuttle Endeavour

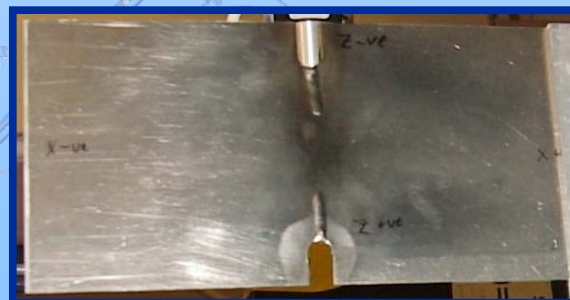
BY WILLIAM HARWOOD

STORY WRITTEN FOR CBS NEWS "SPACE PLACE" & USED WITH PERMISSION

Posted: July 9, 2002



100x magnification
Length about 0.2 inch



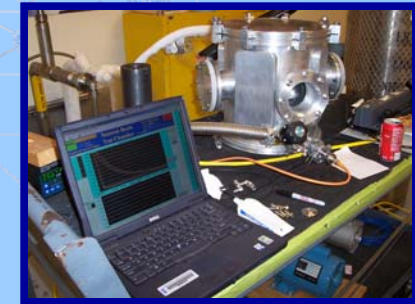
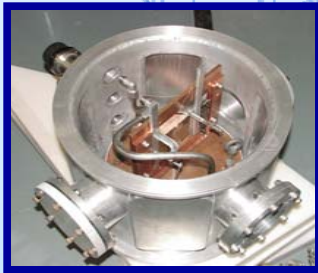
Discovery main propulsion unit
Flow liner crack \approx 5mm length



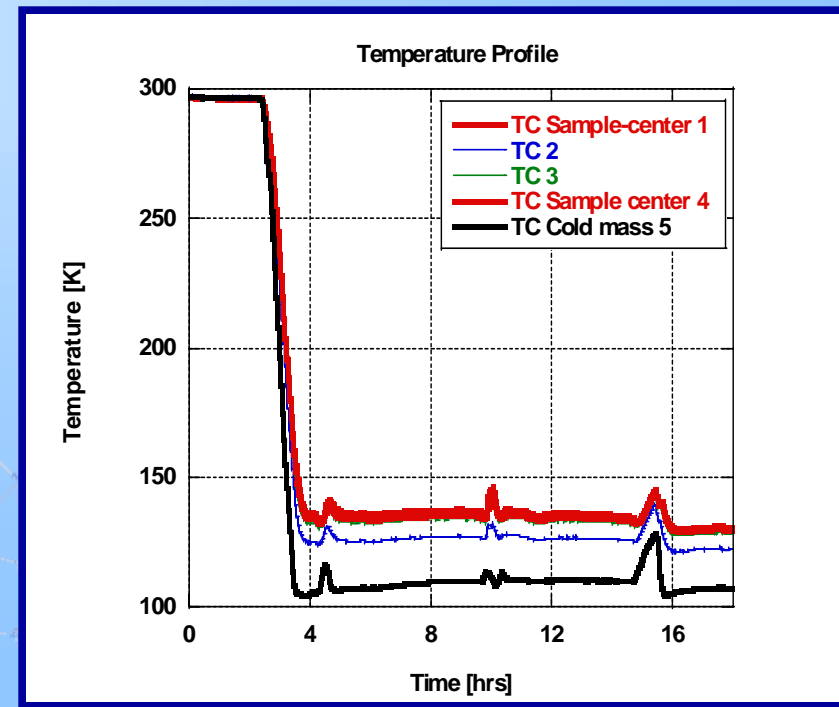
- NOTES:
1. ALL DIMENSIONS AND TOLERANCES ARE IN INCHES.
 2. DIMENSIONS TO CENTER UNLESS OTHERWISE SPECIFIED.
 3. MAINTAIN A TIGHT FIT ON ALL INTERNAL CHANGES SURFACES.
 4. ENTIRE ASSEMBLY MUST BE LEAK TIGHT. MAXIMUM ALLOWABLE HELIUM LEAK RATE = 1.0×10^{-3} SIM-PSI/SEC.

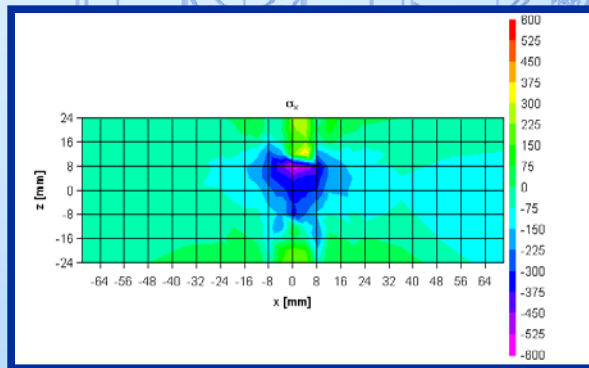
REV	DATE	BY	CHK	APP	DESCRIPTION
1	07/10/02				
TITLE: MEDIUM CHAMBER PART NUMBER: KC3101A					

Initial Cryogenic System - Performance

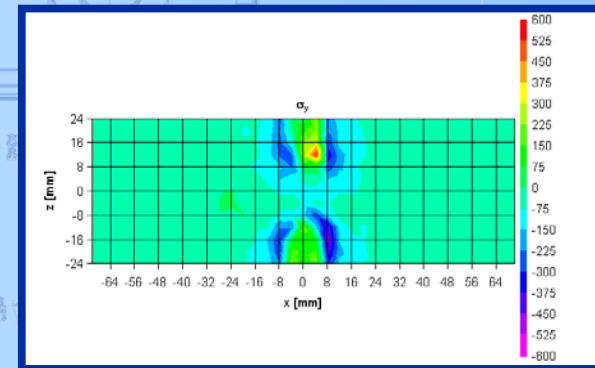


- ❖ Required an average LN2 flow rate of 27 L/hr
- ❖ Required 3.5 hours to reach a steady state sample temperature
- ❖ Obtained a steady state sample temperature of 135 K
- ❖ Temperature gradient across sample at steady state was 8 K





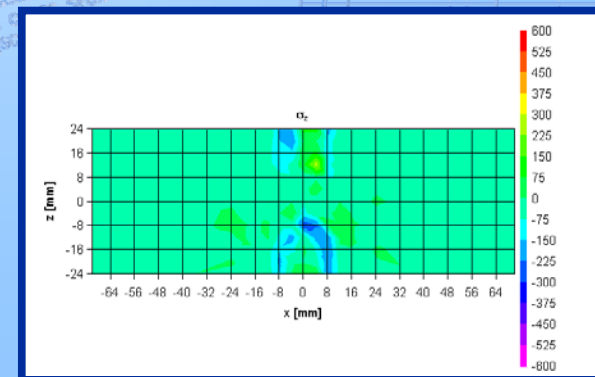
Residual Normal Stresses in x-direction



Residual Normal Stresses in y-direction

Residual Weld Stress Mapping

- Diffraction patterns allowed determination of d-spacing throughout flowliner weld coupons at low temperatures
- d-spacings were converted into strains and then to stresses



Residual Normal Stresses in z-direction

NOTES:

1. ALL DIMENSIONS AND TOLERANCES ARE IN INCHES.
2. DIMENSIONS AND TOLERANCES APPLY
3. MATERIAL IS THE SAME TO BE USED
4. ENTIRE ASSEMBLY MUST BE LEAK TIGHT. MAXIMUM ALLOWABLE RELAY LEAK RATE = 1.0×10^{-3} SIMPSON/SEC.

NO	DATE	REVISION	DESIGNED BY	DESIGNED BY
01				
02				

NO	DATE	REVISION	DESIGNED BY	DESIGNED BY
01				
02				

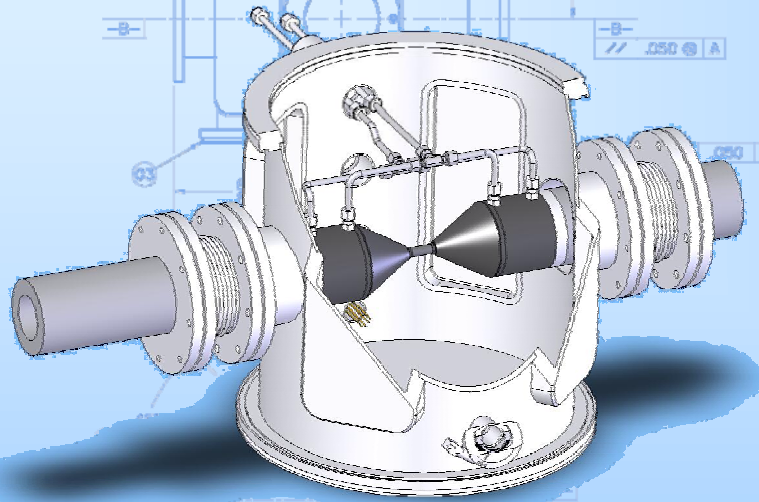
NO	DATE	REVISION	DESIGNED BY	DESIGNED BY
01				
02				

NO	DATE	REVISION	DESIGNED BY	DESIGNED BY
01				
02				

WELD CHAMBER

KCC3101A

Latest Cryogenic Loading Capability



Cooling System Modifications

- New flow-through compression platens were designed to utilize internal convective cooling
- Vascomax push rods were replaced with 17-4PH stainless steel design because of the lower cost and relatively low thermal conductivity
- New platen attachment method was developed to insulate compression platens from the high temperature load frame using Macor® ceramic

Vacuum System Modifications

- Same vacuum chamber was utilized
- New vacuum feed throughs were designed to allow wiring of a strain gage

NOTES:
1. ALL DIM. ARE IN INCHES.
2. DIMENSIONS APPLY AFTER MILLING AND FINISHING.
3. MAINTAIN A 1/16" RADIUS ON ALL INTERNAL CHANGES SURFACES.
4. ENTIRE ASSEMBLY MUST BE LEAK TIGHT. MAXIMUM ALLOWABLE HELIUM LEAK RATE = 1.0×10^{-7} SIM-PSI/SEC.

NO.	QTY.	DESCRIPTION	REFERENCE PART NO.
10	1	17-4PH-100-1/2" DIA. Q102	17-4PH-100-1/2"
11	1	17-4PH-100-1/2" DIA. Q103	17-4PH-100-1/2"
12	1	17-4PH-100-1/2" DIA. Q104	17-4PH-100-1/2"
13	1	17-4PH-100-1/2" DIA. Q105	17-4PH-100-1/2"
14	1	17-4PH-100-1/2" DIA. Q106	17-4PH-100-1/2"
15	1	17-4PH-100-1/2" DIA. Q107	17-4PH-100-1/2"
16	1	17-4PH-100-1/2" DIA. Q108	17-4PH-100-1/2"
17	1	17-4PH-100-1/2" DIA. Q109	17-4PH-100-1/2"
18	1	17-4PH-100-1/2" DIA. Q110	17-4PH-100-1/2"
19	1	17-4PH-100-1/2" DIA. Q111	17-4PH-100-1/2"
20	1	17-4PH-100-1/2" DIA. Q112	17-4PH-100-1/2"
21	1	17-4PH-100-1/2" DIA. Q113	17-4PH-100-1/2"
22	1	17-4PH-100-1/2" DIA. Q114	17-4PH-100-1/2"
23	1	17-4PH-100-1/2" DIA. Q115	17-4PH-100-1/2"
24	1	17-4PH-100-1/2" DIA. Q116	17-4PH-100-1/2"
25	1	17-4PH-100-1/2" DIA. Q117	17-4PH-100-1/2"
26	1	17-4PH-100-1/2" DIA. Q118	17-4PH-100-1/2"
27	1	17-4PH-100-1/2" DIA. Q119	17-4PH-100-1/2"
28	1	17-4PH-100-1/2" DIA. Q120	17-4PH-100-1/2"
29	1	17-4PH-100-1/2" DIA. Q121	17-4PH-100-1/2"
30	1	17-4PH-100-1/2" DIA. Q122	17-4PH-100-1/2"
31	1	17-4PH-100-1/2" DIA. Q123	17-4PH-100-1/2"
32	1	17-4PH-100-1/2" DIA. Q124	17-4PH-100-1/2"
33	1	17-4PH-100-1/2" DIA. Q125	17-4PH-100-1/2"
34	1	17-4PH-100-1/2" DIA. Q126	17-4PH-100-1/2"
35	1	17-4PH-100-1/2" DIA. Q127	17-4PH-100-1/2"
36	1	17-4PH-100-1/2" DIA. Q128	17-4PH-100-1/2"
37	1	17-4PH-100-1/2" DIA. Q129	17-4PH-100-1/2"
38	1	17-4PH-100-1/2" DIA. Q130	17-4PH-100-1/2"
39	1	17-4PH-100-1/2" DIA. Q131	17-4PH-100-1/2"
40	1	17-4PH-100-1/2" DIA. Q132	17-4PH-100-1/2"
41	1	17-4PH-100-1/2" DIA. Q133	17-4PH-100-1/2"
42	1	17-4PH-100-1/2" DIA. Q134	17-4PH-100-1/2"
43	1	17-4PH-100-1/2" DIA. Q135	17-4PH-100-1/2"
44	1	17-4PH-100-1/2" DIA. Q136	17-4PH-100-1/2"
45	1	17-4PH-100-1/2" DIA. Q137	17-4PH-100-1/2"
46	1	17-4PH-100-1/2" DIA. Q138	17-4PH-100-1/2"
47	1	17-4PH-100-1/2" DIA. Q139	17-4PH-100-1/2"
48	1	17-4PH-100-1/2" DIA. Q140	17-4PH-100-1/2"
49	1	17-4PH-100-1/2" DIA. Q141	17-4PH-100-1/2"
50	1	17-4PH-100-1/2" DIA. Q142	17-4PH-100-1/2"
51	1	17-4PH-100-1/2" DIA. Q143	17-4PH-100-1/2"
52	1	17-4PH-100-1/2" DIA. Q144	17-4PH-100-1/2"
53	1	17-4PH-100-1/2" DIA. Q145	17-4PH-100-1/2"
54	1	17-4PH-100-1/2" DIA. Q146	17-4PH-100-1/2"
55	1	17-4PH-100-1/2" DIA. Q147	17-4PH-100-1/2"
56	1	17-4PH-100-1/2" DIA. Q148	17-4PH-100-1/2"
57	1	17-4PH-100-1/2" DIA. Q149	17-4PH-100-1/2"
58	1	17-4PH-100-1/2" DIA. Q150	17-4PH-100-1/2"
59	1	17-4PH-100-1/2" DIA. Q151	17-4PH-100-1/2"
60	1	17-4PH-100-1/2" DIA. Q152	17-4PH-100-1/2"
61	1	17-4PH-100-1/2" DIA. Q153	17-4PH-100-1/2"
62	1	17-4PH-100-1/2" DIA. Q154	17-4PH-100-1/2"
63	1	17-4PH-100-1/2" DIA. Q155	17-4PH-100-1/2"
64	1	17-4PH-100-1/2" DIA. Q156	17-4PH-100-1/2"
65	1	17-4PH-100-1/2" DIA. Q157	17-4PH-100-1/2"
66	1	17-4PH-100-1/2" DIA. Q158	17-4PH-100-1/2"
67	1	17-4PH-100-1/2" DIA. Q159	17-4PH-100-1/2"
68	1	17-4PH-100-1/2" DIA. Q160	17-4PH-100-1/2"
69	1	17-4PH-100-1/2" DIA. Q161	17-4PH-100-1/2"
70	1	17-4PH-100-1/2" DIA. Q162	17-4PH-100-1/2"
71	1	17-4PH-100-1/2" DIA. Q163	17-4PH-100-1/2"
72	1	17-4PH-100-1/2" DIA. Q164	17-4PH-100-1/2"
73	1	17-4PH-100-1/2" DIA. Q165	17-4PH-100-1/2"
74	1	17-4PH-100-1/2" DIA. Q166	17-4PH-100-1/2"
75	1	17-4PH-100-1/2" DIA. Q167	17-4PH-100-1/2"
76	1	17-4PH-100-1/2" DIA. Q168	17-4PH-100-1/2"
77	1	17-4PH-100-1/2" DIA. Q169	17-4PH-100-1/2"
78	1	17-4PH-100-1/2" DIA. Q170	17-4PH-100-1/2"
79	1	17-4PH-100-1/2" DIA. Q171	17-4PH-100-1/2"
80	1	17-4PH-100-1/2" DIA. Q172	17-4PH-100-1/2"
81	1	17-4PH-100-1/2" DIA. Q173	17-4PH-100-1/2"
82	1	17-4PH-100-1/2" DIA. Q174	17-4PH-100-1/2"
83	1	17-4PH-100-1/2" DIA. Q175	17-4PH-100-1/2"
84	1	17-4PH-100-1/2" DIA. Q176	17-4PH-100-1/2"
85	1	17-4PH-100-1/2" DIA. Q177	17-4PH-100-1/2"
86	1	17-4PH-100-1/2" DIA. Q178	17-4PH-100-1/2"
87	1	17-4PH-100-1/2" DIA. Q179	17-4PH-100-1/2"
88	1	17-4PH-100-1/2" DIA. Q180	17-4PH-100-1/2"
89	1	17-4PH-100-1/2" DIA. Q181	17-4PH-100-1/2"
90	1	17-4PH-100-1/2" DIA. Q182	17-4PH-100-1/2"
91	1	17-4PH-100-1/2" DIA. Q183	17-4PH-100-1/2"
92	1	17-4PH-100-1/2" DIA. Q184	17-4PH-100-1/2"
93	1	17-4PH-100-1/2" DIA. Q185	17-4PH-100-1/2"
94	1	17-4PH-100-1/2" DIA. Q186	17-4PH-100-1/2"
95	1	17-4PH-100-1/2" DIA. Q187	17-4PH-100-1/2"
96	1	17-4PH-100-1/2" DIA. Q188	17-4PH-100-1/2"
97	1	17-4PH-100-1/2" DIA. Q189	17-4PH-100-1/2"
98	1	17-4PH-100-1/2" DIA. Q190	17-4PH-100-1/2"
99	1	17-4PH-100-1/2" DIA. Q191	17-4PH-100-1/2"
100	1	17-4PH-100-1/2" DIA. Q192	17-4PH-100-1/2"

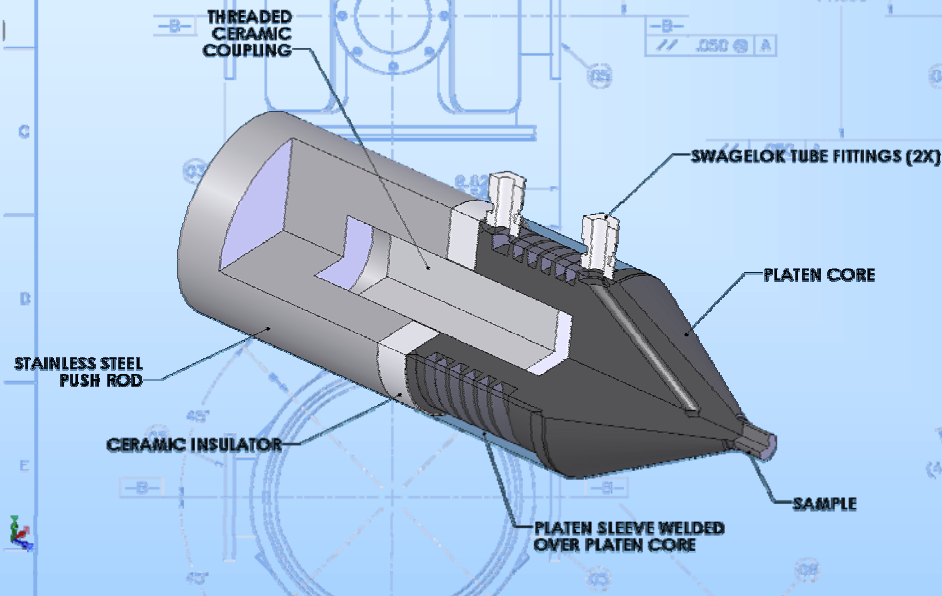
VACUUM CHAMBER
KCC3101A

Latest Cryogenic Loading Capability – Platen Design



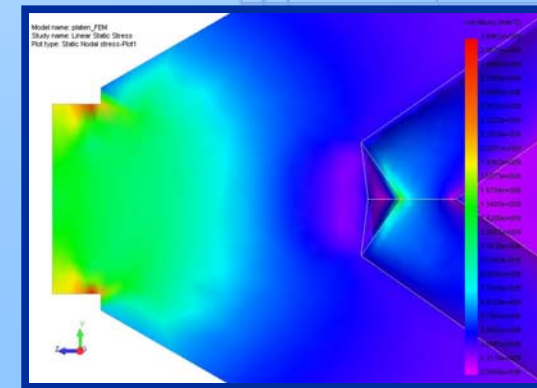
Cooling Features

- Three-piece welded design incorporates cooling channel into platen core to deliver LN2 closer to sample
- Internal cooling coils are incorporated to eliminate thermal contact resistance



FEA Design Validation

- Stress concentrations were analyzed around cooling passages to eliminate brittle fracture of platen core under load

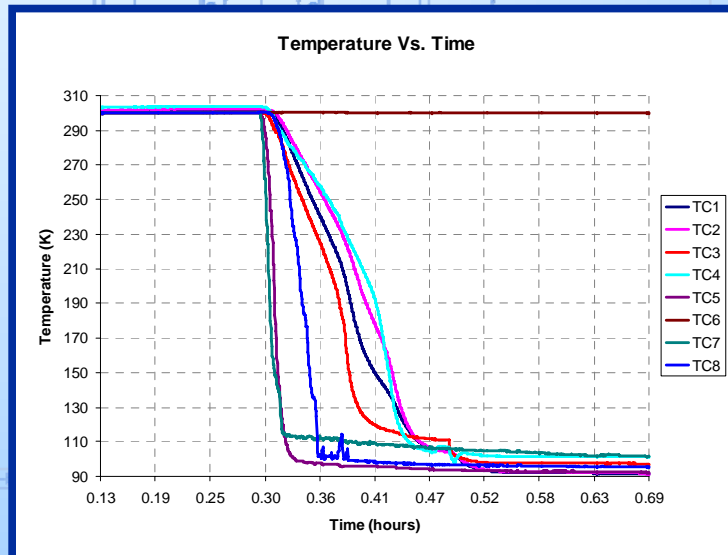


REV	DATE	DESCRIPTION	DESIGNED BY	CHECKED BY
01	08/01/01	INITIAL DESIGN	J. J. ...	J. J. ...
02	08/01/01	REVISED FOR MANUFACTURING	J. J. ...	J. J. ...
03	08/01/01	REVISED FOR MANUFACTURING	J. J. ...	J. J. ...
04	08/01/01	REVISED FOR MANUFACTURING	J. J. ...	J. J. ...

Model name: platen_FEM	Study name: Linear Static Stress	Plot type: Static Node stress-Plot
Model name: platen_FEM	Study name: Linear Static Stress	Plot type: Static Node stress-Plot
Model name: platen_FEM	Study name: Linear Static Stress	Plot type: Static Node stress-Plot
Model name: platen_FEM	Study name: Linear Static Stress	Plot type: Static Node stress-Plot
Model name: platen_FEM	Study name: Linear Static Stress	Plot type: Static Node stress-Plot

NOTES:
 1. ALL DIMENSIONS ARE IN INCHES UNLESS OTHERWISE SPECIFIED.
 2. DIMENSIONS AND TOLERANCES APPLY AFTER FINISH.
 3. MAINTAIN A 1/16" RADIUS ON ALL SURFACES.
 4. ENTIRE ASSEMBLY MUST BE LEAK TIGHT. MAXIMUM ALLOWABLE HELIUM LEAK RATE = 1.0×10^{-3} SIM-PL/SEC.

Latest Cryogenic Loading Capability - Performance



Cooling Curve for NiTiFe Sample

Problems w/ Latest System Design

- Large thermal offset in strain gage measurements
- Brittle ceramic couplings can fracture due to thermal contraction of mating components

LN2 Volumetric Flow Rate

- Reduced to an average of 16 L/hr

Steady State Temperature

- Reduced to 89 K

Required Cooling Time

- Reached steady state in 18 min



NOTES:
1. ALL DIMENSIONS ARE IN INCHES.
2. DIMENSIONS ARE TO BE APPLIED AFTER BEING AND INDENTED.
3. MAINTAIN A 0.001 INCH GAP ON ALL INTERNAL SURFACES.
4. ENTIRE ASSEMBLY MUST BE LEAK TIGHT. MAXIMUM ALLOWABLE LEAK RATE = 1.0 x 10⁻³ SIM-PL/SEC.

50	01	1000000	REVISIONS	REVISIONS
50	02	1000000	REVISIONS	REVISIONS
50	03	1000000	REVISIONS	REVISIONS
50	04	1000000	REVISIONS	REVISIONS
50	05	1000000	REVISIONS	REVISIONS
50	06	1000000	REVISIONS	REVISIONS
50	07	1000000	REVISIONS	REVISIONS
50	08	1000000	REVISIONS	REVISIONS
50	09	1000000	REVISIONS	REVISIONS
50	10	1000000	REVISIONS	REVISIONS
50	11	1000000	REVISIONS	REVISIONS
50	12	1000000	REVISIONS	REVISIONS
50	13	1000000	REVISIONS	REVISIONS
50	14	1000000	REVISIONS	REVISIONS
50	15	1000000	REVISIONS	REVISIONS
50	16	1000000	REVISIONS	REVISIONS
50	17	1000000	REVISIONS	REVISIONS
50	18	1000000	REVISIONS	REVISIONS
50	19	1000000	REVISIONS	REVISIONS
50	20	1000000	REVISIONS	REVISIONS
50	21	1000000	REVISIONS	REVISIONS
50	22	1000000	REVISIONS	REVISIONS
50	23	1000000	REVISIONS	REVISIONS
50	24	1000000	REVISIONS	REVISIONS
50	25	1000000	REVISIONS	REVISIONS
50	26	1000000	REVISIONS	REVISIONS
50	27	1000000	REVISIONS	REVISIONS
50	28	1000000	REVISIONS	REVISIONS
50	29	1000000	REVISIONS	REVISIONS
50	30	1000000	REVISIONS	REVISIONS
50	31	1000000	REVISIONS	REVISIONS
50	32	1000000	REVISIONS	REVISIONS
50	33	1000000	REVISIONS	REVISIONS
50	34	1000000	REVISIONS	REVISIONS
50	35	1000000	REVISIONS	REVISIONS
50	36	1000000	REVISIONS	REVISIONS
50	37	1000000	REVISIONS	REVISIONS
50	38	1000000	REVISIONS	REVISIONS
50	39	1000000	REVISIONS	REVISIONS
50	40	1000000	REVISIONS	REVISIONS
50	41	1000000	REVISIONS	REVISIONS
50	42	1000000	REVISIONS	REVISIONS
50	43	1000000	REVISIONS	REVISIONS
50	44	1000000	REVISIONS	REVISIONS
50	45	1000000	REVISIONS	REVISIONS
50	46	1000000	REVISIONS	REVISIONS
50	47	1000000	REVISIONS	REVISIONS
50	48	1000000	REVISIONS	REVISIONS
50	49	1000000	REVISIONS	REVISIONS
50	50	1000000	REVISIONS	REVISIONS

- ❖ **Cryogenic loading capability successfully implemented on SMARTS**
- ❖ **Three design iterations have been built and tested**
 - **Unloaded design for testing a variety of static specimens at low temperatures**
 - **Two load-frame designs have been implemented resulting in test temperatures as low as 89 K**
 - **These systems have provided useful results for materials scientists at UCF and LANL, and NASA engineers**
- ❖ **Cryogenic system improvements are planned**
 - **Implementation of automated LN2 flow control and a Dewar manifold**
 - **Utilization of a PID temperature controller and higher wattage cartridge heaters**
 - **Addition of a second strain gage channel and/or a ceramic legged extensometer**

❖ **Further cryogenic measurements are planned on shape memory alloys**

50	01	REVISIONS	REVISED DESIGN DRAWING
50	02	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	03	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	04	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	05	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	06	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	07	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	08	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	09	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	10	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	11	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	12	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	13	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	14	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	15	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	16	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	17	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	18	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	19	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	20	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	21	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	22	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	23	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	24	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	25	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	26	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	27	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	28	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	29	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	30	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	31	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	32	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	33	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	34	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	35	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	36	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	37	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	38	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	39	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	40	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	41	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	42	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	43	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	44	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	45	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	46	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	47	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	48	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	49	10/20/00-100-100-100-100	REVISED DESIGN DRAWING
50	50	10/20/00-100-100-100-100	REVISED DESIGN DRAWING

Acknowledgements



- NASA GRC (NAG3-2751)
- NSF Career Program (DMR-0239512)
- Los Alamos National Laboratory
- UCF – UF Space Research Initiative
- Z. Nagy (Sierra Lobo)
- W. Notardonato (NASA Kennedy Space Center)

NO.	QTY	DESCRIPTION	REFERENCE PART NUMBER
01	01	CHAMBER	CHAMBER
02	01	TOP COVER (FOR Q1)	TOP COVER (FOR Q1)
03	01	BOTTOM COVER (FOR Q1)	BOTTOM COVER (FOR Q1)
04	01	TOP COVER (FOR Q2)	TOP COVER (FOR Q2)
05	01	BOTTOM COVER (FOR Q2)	BOTTOM COVER (FOR Q2)
06	01	CHAMBER	CHAMBER
07	01	TOP COVER (FOR Q3)	TOP COVER (FOR Q3)
08	01	BOTTOM COVER (FOR Q3)	BOTTOM COVER (FOR Q3)
09	01	CHAMBER	CHAMBER
10	01	TOP COVER (FOR Q4)	TOP COVER (FOR Q4)
11	01	BOTTOM COVER (FOR Q4)	BOTTOM COVER (FOR Q4)

UNIVERSITY OF CENTRAL FLORIDA
MMA&E DEPARTMENT

REVISIONS		APPROVED BY: PROJECT MANAGER	
NO.	DESCRIPTION	DATE	INITIALS
01	ISSUE FOR FABRICATION	11/11/03	
02	ISSUE FOR ASSEMBLY	11/11/03	
03	ISSUE FOR TESTING	11/11/03	
04	ISSUE FOR DELIVERY	11/11/03	

MATERIALS		FINISHES	
NO.	DESCRIPTION	NO.	DESCRIPTION
01	304 STAINLESS STEEL	01	200 GRIT SANDBLAST
02	ALUMINUM	02	ANODIZED
03	COPPER	03	POLISHED
04	INCONEL	04	ANODIZED

DESIGNER		DATE	
NO.	DESCRIPTION	NO.	DESCRIPTION
01	ISSUE FOR FABRICATION	01	11/11/03
02	ISSUE FOR ASSEMBLY	02	11/11/03
03	ISSUE FOR TESTING	03	11/11/03
04	ISSUE FOR DELIVERY	04	11/11/03

NOTES:

1. ALL DIMENSIONS AND TOLERANCES ARE IN INCHES.
2. DIMENSIONS AND TOLERANCES APPLY AFTER WELDING AND ASSEMBLY.
3. MAINTAIN A 1/8" RADIUS OR BETTER FINISH ON ALL INTERNAL CHAMFERED SURFACES.
4. ENTIRE ASSEMBLY MUST BE LEAK TIGHT. MAXIMUM ALLOWABLE HELIUM LEAK RATE = 1.0×10^{-3} SIMPSON/SEER.

KCC3101A