UPGRADE ON CRYOGENIC LINES: AT REFRIGERATOR

D0 Engineering Note: 3823.115-EN-⁴³⁹~~000~~
September 26, 1995

Andrew Kuwazaki
RD/D0 Mechanical Group

Approved by:

A handwritten signature in black ink, appearing to read 'Andrew Kuwazaki', is written over a horizontal line.

SUMMARY

This is an upgrade to the thermal contraction analysis sound in D0 Engineering Note: 3823.115-EN-426. In this new design, a portion of the transfer lines are consolidated into one 6" vacuum jacket. Since all four transfer lines follow the same path and are of equal lengths, the stress analysis is performed on only one transfer line using the design system ALGOR®. The GHe Cooldown Supply line is analyzed for combined pressure, thermal movement, and dead weight and all the stresses were below the allowable stress limit of 25,050 psi.

RECOMMENDATIONS

The spider guides should be placed as closely as possible to the designated areas as seen in both the analysis and the drawing.

Thermal Contraction Analysis of Four Cryogenic Utility Lines for D0 Upgrade.

SUMMARY CHART

	<i>Maximum Hoop Stress (psi)</i>	<i>Maximum Longitudinal Stress (psi)</i>	<i>Maximum Principal Stress (psi)</i>	<i>Maximum Code Stress (psi)</i>	<i>Allowable Stress (psi)</i>	<i>Maximum X Displacement (inches)</i>	<i>Maximum Y Displacement (inches)</i>	<i>Maximum Z Displacement (inches)</i>
GHE Cooldown Supply	1631 (at START)	9516 (at point I)	9516 (at point I)	9709 (at point I)	25,050	0.439 (at point G)	0.408 (at point I)	0.217 (at point G)

* Information is only provided for the GHE cooldown supply, because the GHE cooldown return and the two LN2 lines have similar geometric shape and follow the same path.

SUBJECT

THERMAL CONTRACTION ANALYSIS
OF FOUR CRYOGENIC UTILITY LINES

NAME

ANDY KUWAZAKI

DATE

7/17/95

REVISION DATE

GHe COOLDOWN SUPPLY
(WITH SPIDER-TYPE GUIDE)

SECTION "A-A"

(NOT TO SCALE)

SUBJECT THERMAL CONTRACTION ANALYSIS
OF FOUR CRYOGENIC UTILITY LINES

NAME ANDY KUWAZAKI
DATE 7/17/95 REVISION DATE

(NOT TO SCALE)

GH_e COOLDOWN SUPPLY
(WITH SPIDER-TYPE GUIDE)

* NOT TRUE LENGTH.

*** System Deflections ***

Point Name	Displacements/inch			Rotations/degree		
	X	Y	Z	X	Y	Z
START	0.000	-0.000	0.000	0.000	-0.000	-0.000
A	0.023	-0.039	0.002	0.011	-0.031	-0.216
B	0.088	-0.077	0.003	-0.002	-0.062	-0.391
C	0.049	-0.163	0.018	-0.034	-0.074	-0.371
C1	-0.000	0.045	0.000	0.183	-0.074	0.088
D	0.017	0.093	-0.071	0.381	-0.074	0.031
D1	-0.000	0.000	-0.109	0.469	-0.091	-0.057
E	-0.017	-0.100	-0.151	0.399	-0.020	-0.151
F	-0.042	-0.071	-0.209	0.351	0.141	-0.150
F1	0.118	-0.000	-0.000	0.176	0.094	-0.050
F2	0.279	-0.000	0.000	0.001	0.204	0.105
G	0.439	-0.166	0.217	-0.175	-0.165	0.201
G1	0.000	-0.000	0.056	-0.110	-0.308	0.145
G2	-0.000	0.000	-0.059	0.081	0.091	0.105
H	0.012	-0.087	-0.156	0.290	-0.008	0.072
H1	0.000	-0.183	-0.000	0.138	0.006	-0.064
H2	-0.000	-0.280	0.000	0.047	0.021	0.251
I	-0.268	-0.408	0.093	-0.005	0.040	0.065
I	-0.268	-0.408	0.093	-0.005	0.040	0.065
I1	-0.111	-0.000	0.052	-0.202	0.017	-0.373
I2	0.011	-0.000	-0.005	0.119	-0.005	0.290
J	0.090	-0.122	-0.045	-0.014	-0.009	-0.005
J1	0.000	-0.042	-0.000	-0.106	-0.027	-0.229
K	-0.042	0.038	0.019	0.000	-0.044	0.016
L.Near	-0.031	0.077	0.017	0.008	-0.053	0.091
L.Far	-0.006	0.083	0.012	-0.003	-0.056	0.112
M.Near	0.001	0.079	0.010	-0.007	-0.054	0.110
M.Far	0.009	0.055	0.004	-0.019	-0.040	0.071
END	-0.000	0.000	0.000	-0.000	-0.000	0.000

CONCLUSION:

PIPE ROUTE WILL WORK ASSUMING
SPIDER-TYPE GUIDES ARE PLACED AS
CLOSELY AS POSSIBLE TO THE DESIGNATED
AREAS.

*** Forces and Moments acting on Restraints ***

Point Name	Forces/lb			Moments/inch-lb		
	X	Y	Z	X	Y	Z
START	2	-19	1	14	-14	-139
C1	-0	0	3	0	0	0
D1	-11	8	0	0	0	0
F1	0	-1	-9	0	0	0
F2	0	-5	13	0	0	0
G1	16	-5	0	0	0	0
G2	-9	1	0	0	0	0
H1	11	0	-16	0	0	0
H2	-21	0	15	0	0	0
I1	-0	-15	-0	0	0	0
I2	0	-11	0	0	0	0
J1	13	0	-7	0	0	0
END	-1	5	1	-20	-13	18

*** Forces and Moments in Element Coordinate System ***

Point Name	Forces/lb			Moments/inch-lb		
	X	Y	Z	X	Y	Z
START	19	-1	-2	14	139	-14
A	-18	1	2	-14	-115	-1
B	-17	1	2	-14	-92	-15
C	2	-17	1	-15	0	114
C1	13	1	-2	-0	-14	-62
C1	-13	-4	2	0	14	62
D	12	4	-2	-0	-40	-124
D1	4	-12	-2	-40	-20	18
D1	-4	3	-9	40	20	-18
E	4	-3	9	-40	97	56
F	2	4	9	-97	42	19
F1	9	1	-4	19	-110	-10
F1	-9	1	-5	-19	110	10
F2	9	2	5	19	142	-57
F2	-9	3	8	-19	-142	57
G	9	0	-8	19	-246	6
G1	8	3	9	-6	206	-61
G1	-8	2	7	6	-206	61
G2	8	0	-7	-6	-49	-27
G2	-8	-1	-2	6	49	27
H	8	3	2	-6	3	-81
H1	4	8	-2	3	-58	-152
H1	-4	9	-9	-3	58	152
H2	6	-9	9	3	206	109
H2	-6	-6	12	-3	-206	-109
I	8	6	-12	3	-272	-127
I	-13	-8	0	1	-3	-300
I1	13	11	-0	-1	-9	-188
I1	-13	4	-0	1	9	188
I2	13	-1	0	-1	2	-77
I2	-13	12	0	1	-2	77
J	13	-10	-0	-1	-4	235
J	-10	-6	-12	-4	213	-99
J1	9	6	12	4	86	-47
J1	-9	1	1	-4	-86	47
K	8	-1	-1	4	52	-13
L.Near	7	-1	-1	4	36	4
L.Far	-1	-6	1	11	3	4
M.Near	-1	-6	1	11	6	17
M.Far	-6	1	1	13	-4	41
END	-5	-1	1	13	-18	20

*** Forces and Moments in Global Coordinate System ***

Point Name	Forces/lb			Moments/inch-lb		
	X	Y	Z	X	Y	Z
START	-2	19	-1	-14	14	139
A	2	-18	1	-1	-14	-115
B	2	-17	1	-15	-14	-92
C	2	-17	1	-15	0	114
C1	2	-13	1	62	0	-14
C1	-2	13	-4	-62	-0	14
D	2	-12	4	124	0	-40
D1	2	-12	4	-18	-20	-40
D1	9	3	-4	18	20	40
E	-9	-3	4	-56	97	-40
F	-9	-2	4	-19	97	42
F1	-9	1	4	-19	-110	10
F1	9	1	5	19	110	-10
F2	-9	2	-5	-19	142	57
F2	9	3	-8	19	-142	-57
G	-9	0	8	-19	-246	-6
G1	-9	3	8	61	206	-6
G1	-7	2	-8	-61	-206	6
G2	7	0	8	27	-49	-6
G2	2	-1	-8	-27	49	6
H	-2	3	8	81	3	-6
H1	-2	4	8	-152	3	-58
H1	-9	-4	9	152	-3	58
H2	9	6	-9	109	3	206
H2	12	-6	-6	-109	-3	-206
I	-12	8	6	-127	3	-272
I1	-12	11	6	81	-9	169
I1	12	4	-5	-81	9	-169
I2	-12	-1	5	34	2	69
I2	12	12	-6	-34	-2	-69
J	-12	-10	6	-99	-4	-213
J1	-12	-9	6	47	-4	86
J1	-1	9	1	-47	4	-86
K	1	-8	-1	13	-4	52
L.Near	1	-7	-1	-4	-4	36
L.Far	1	-6	-1	-11	3	-4
M.Near	1	-6	-1	-11	6	-17
M.Far	1	-6	-1	-4	13	-41
END	1	-5	-1	20	13	-18

*** System Stresses (ANSI B31.3) ***

Point Name	In- Plane SIF	Out Plane SIF	Section Modulus	Stresses/psi		Principal	Code	Allow.
				Hoop	Longitu.			
START	1.00	1.00	0.03	1631	4634	4649	5040	62 25
A	1.00	1.00	0.03	1631	3923	3942	4316	62 25
B	1.00	1.00	0.03	1631	3266	3292	3683	62 25
C	1.00	1.00	0.03	1631	4092	4092	4288	62 25
C1	1.00	1.00	0.03	1631	2564	2564	3281	62 25
D	1.00	1.00	0.03	1631	4521	4521	5606	62 25
D1	1.00	1.00	0.03	1631	1452	2129	3655	62 25
E	1.00	1.00	0.03	1631	2669	3668	4737	62 25
F	1.00	1.00	0.03	1631	1990	3249	4350	62 25
F1	1.00	1.00	0.03	1631	3936	3969	4819	62 25
F2	1.00	1.00	0.03	1631	5159	5181	8105	62 25
G	1.00	1.00	0.03	1631	7902	7915	9661	62 25
G1	1.00	1.00	0.03	1631	6971	6972	8732	62 25
G2	1.00	1.00	0.03	1631	2314	2326	6644	62 25
H	1.00	1.00	0.03	1631	3017	3018	7210	62 25
H1	1.00	1.00	0.03	1631	5430	5431	5714	62 25
H2	1.00	1.00	0.03	1631	7512	7512	7744	62 25
I	1.00	1.00	0.03	1631	9516	9516	9709	62 25
I1	1.00	1.00	0.03	1631	6213	6213	6406	62 25
I2	1.00	1.00	0.03	1631	2958	2958	3152	62 25
J	1.00	1.00	0.03	1631	7603	7604	7797	62 25
J1	1.00	1.00	0.03	1631	3567	3569	3783	62 25
K	1.00	1.00	0.03	1631	2253	2258	3231	62 25
L.Near	1.00	1.00	0.03	1631	1734	1759	3459	62 25
L.Far	1.00	1.00	0.03	1631	774	1660	1650	62 25
M.Near	1.00	1.00	0.03	1631	1150	1679	1509	62 25
M.Far	1.00	1.00	0.03	1631	1817	1934	3326	62 25
END	1.00	1.00	0.03	1631	1395	1735	3764	62 25

PipePlus version 4.50
D-Zero Solenoid Upgrade
Load : Dead Weight + Pressure 1 + Thermal 1

Fermi Nat'l Accelerator Lab 07/18/95 13:59 Page R-06

File : GASHES2

*** System Maxima ***

Maximum X displacement = 0.439 inch at point G
Maximum Y displacement = -0.408 inch at point I
Maximum Z displacement = 0.217 inch at point G

Maximum X rotation = 0.469 degree at point D1
Maximum Y rotation = -0.308 degree at point G1
Maximum Z rotation = -0.391 degree at point B

Maximum X force = 12 lb at point I1
Maximum Y force = 19 lb at point START
Maximum Z force = 9 lb at point H1

Maximum X moment = -152 inch-lb at point H1
Maximum Y moment = -246 inch-lb at point G
Maximum Z moment = -272 inch-lb at point I

Maximum hoop stress = 1631 psi at point START
Maximum longitudinal stress = 9516 psi at point I
Maximum principal stress = 9516 psi at point I
Maximum code stress = 9709 psi at point I
Maximum stress ratio (code/allowable) = 0.16 at point I

File Name GASHE2
Project D-Zero Solenoid Upgrade
Department Research Division / D-Zero Mechanical
Contract Number
Description Revision of Cryogenic Utility Lines for
D0 Upgrade
Prepared by Andrew T. Kuwazaki
Checked by

ANSI code ANSI B31.3
Input unit English
Output unit English
Output columns 80
Base temperature 70
F factor 1.0
E factor 1.33

Number of dynamic modes.. 8
Cut-off frequency 33 Hz
Max no. of iterations ... 12
Convergence tolerance ... 3
Force tolerance 5 lb

Frm Point /To name	DX (feet)	DY (feet)	DZ (feet)	Radius (inch)	X (feet)	Y (feet)	Z (feet)
C This analysis is intended as a preliminary estimate of the defelctions and C stresses in the 0.5" GHe Supply pipe which is encased in a 6" vacuum C jacket. This analysis represents the behavior of the other 3 lines, the C GHe Return line and the two LN2 lines, all of which follow the same path C and have similar geometries. C The load combination: Dead Weight + Pressure + Thermal C All points followed by a number represent spider-type locations. C							
F START					0.000	0.000	0.000
T A		12"			0.000	1.000	0.000
T B		12"			0.000	2.000	0.000
T C	12"				1.000	2.000	0.000
T C1		-65"			1.000	-3.417	0.000
T D		-15"			1.000	-4.667	0.000
T D1			12"		1.000	-4.667	1.000
T E			13"		1.000	-4.667	2.083
T F		-9"			1.000	-5.417	2.083
T F1	-50"				-3.167	-5.417	2.083
T F2	-50"				-7.333	-5.417	2.083
T G	-50"				-11.500	-5.417	2.083
T G1			50"		-11.500	-5.417	6.250
T G2			36"		-11.500	-5.417	9.250
T H			30"		-11.500	-5.417	11.750
T H1		30"			-11.500	-2.917	11.750
T H2		30"			-11.500	-0.417	11.750
T I		40"			-11.500	2.917	11.750
F I	-11.500	2.917	11.750		-11.500	2.917	11.750
T I1	-45"		21.25"		-15.250	2.917	13.521
T I2	-38"		17.95"		-18.417	2.917	15.017
T J	-25"		11.8"		-20.500	2.917	16.000
T J1		-25"			-20.500	0.833	16.000
T K		-25"			-20.500	-1.250	16.000
T L		-1'5"		5"	-20.500	-2.667	16.000
T M	-12"			5"	-21.500	-2.667	16.000
T END		1'10"			-21.500	-0.833	16.000

Point	Data	Description
START	Pipe	Pipe data identifier = P1 Nominal Diameter = .5 Pipe Schedule = Actual Pipe O. D. = .840 inch Wall Thickness = .083 inch Corrosion Allowance = 0 inch Insulation Thickness = 0 inch Insulation Density = 0 lb/cu.ft Content S. G. = 0
	Material	Data Identifier = SS Austenitic stainless (301-309, 316, 321, 237) Density = 0.2899 lb/cu.inch Tempera. Modulus Expansion (deg.F) (psi) (inch/inch) -325. 30400000 -0.00321 -150. 29900000 -0.00189 -50. 29400000 -0.00103 70. 28300000 0.00000 200. 27700000 0.00122 300. 27100000 0.00218 400. 26600000 0.00317 500. 26100000 0.00417 600. 25400000 0.00520 700. 24800000 0.00625 800. 24100000 0.00733 900. 23400000 0.00843 1000. 22700000 0.00957 1100. 22000000 0.01070 1200. 21300000 0.01183 1300. 20700000 0.01297 1400. 19300000 0.01410 Temperature Allowable stresses (deg.F) (psi) -425 25050
	Load	Load data identifier = GHE Case Temperature Pressure Expansion No. (deg.F) (psig) (inch/inch) 1 -450 350 -0.003210
	Anchor	Rigid in all directions
A		
B		
C		
C1	Guide	
D		
D1	Guide	
E		
F		
F1	Guide	
F2	Guide	
G		
G1	Guide	
G2	Guide	

Point	Data	Description
H		
H1	Guide	
H2	Guide	
I		
I		
I1	Guide	
I2	Guide	
J		
J1	Guide	
K		
L		
M		
END	Anchor	Rigid in all directions

Case number	Combination
-----	-----
1	D.W. + Pres1 + Ther1

6" VJ Transfer Line

Section "A-A"