DØ Cryo-Corner Piping Flexibility Analysis

Douglas Clark
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REV. 3-7-96 R.RUCINSKI

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$$\delta = R\theta$$

Where,

-R is the distance from the vertical section to the bayonet.

- θ is the angle of rotation of the vertical section.

The angle of rotation of the vertical section is given by the torsion formula:

$$\theta = \frac{TL}{GJ_{eff}}$$

Where,

-T is the applied torque in inch pounds, equal to the product of the applied load and the distance from the vertical section to the bayonet.

-L is the length, in inches, of the vertical section which undergoes the rotation.

-G is the shear modulus in pounds per square inch.

- J_{eff} is the effective polar area moment of inertia:

$$J_{eff} = J_1 + J_2$$

The added movement can similarly be reduced to a proportional relationship between the applied load and the corresponding deflection.

The proportionality constant κ_2 (pounds/inch) is thus given by:

$$\kappa_2 = \frac{GJ}{LR^2}$$

The total horizontal movement for the cryogenic transfer lines is then the sum of the two deflections. In a similar manner the "spring constants" may be combined to give a more complete estimate of the horizontal flexibility. The combined proportionality constant is equal to the inverse of the sum of the inverses of the two individual constants.

RESULTS

Tables 1 and 2 summarize the available horizontal flexibility for each of the six lines in both the assembly hall and the collision hall. The last column provides the amount of force required to deflect each line 1/2 inch in the horizontal plane. This figure is an extension of the spring constant analogy and provides a quick comparison of the relative stiffnesses of each line.

DISCUSSION

The analysis makes many assumptions which are not completely valid. For example, the inner line is much more flexible than the table indicates. Thus the analysis should not be taken as an absolute measure of the amount of force necessary to deflect the lines. The analysis does provide a means of comparison between individual lines and between the assembly hall and collision hall.

The last column in tables 1 and 2 indicate which lines are the stiffest comparatively. In addition, by comparing the stiffness of each line in the collision hall with the corresponding line in the assembly hall, a qualitative assesment can be made as to whether the lines in the collision hall are flexible enough.

CONCLUSION

Table 1 indicates that the stiffest line is the cryogenic vent line while the most flexible line is the 6 inch insulating vacuum line. The table also shows that the four remaining lines are roughly of the same stiffness. This follows closely with the experience of installing the U-tubes in the assembly hall. The vent line was by far the stiffest, while the other lines are comparitively more flexible. However, the value for the LAr line is misleading. It is as flexible as the other 1 1/2 x 3 lines. Using this as a basis, the collision hall connections should be slightly more stiff, but not appreciably. The vent line represents the only anticipated "difficulty". Provided that the building piping is constructed to reasonable tolerances, there should be no need to modify the existing U-tubes for use in the Collision hall.

REFERENCES

1. Roarke, R. J., Formulas for Stress and Strain, fifth edition, McGraw Hill Book Co. New York: 1975.
2. DØ DWG. ME-222906 sht. 1-4.
3. DØ cryo log book

TABLE 1: ASSEMBLY HALL CRYO-CORNER

Transfer Line	IPS(s)	I in ⁴	L in	E psi	κ lbs/in	J in ⁴	G psi	R in	D in	κ lbs/in	K lbs/in	P * lbs
LAR	1 1/2 x 3	2.07	107	2.76E+07	279.28	4.13	1.06E+07	44	32	718.21	201.09	100.54
GAR	1 1/2 x 3	2.07	131	2.76E+07	153.94	4.13	1.06E+07	98	32	142.52	74.00	37.00
LN2	1 1/2 x 3	2.07	136	2.76E+07	136.01	4.13	1.06E+07	86	32	188.00	78.92	39.46
Vent	6 x 8	49.8	167	2.76E+07	1770.33	99.6	1.06E+07	143	30	1720.62	872.56	436.28
Util Vac	4	3.96	200	2.76E+07	81.97	7.92	1.06E+07	NA	NA	NA	81.97	40.99
Insul Vac	6	14.4	558	2.76E+07	13.72	28.8	1.06E+07	NA	NA	NA	13.72	6.86
* This is the force required to deflect the pipe 1/2 inch												

TABLE 2: COLLISION HALL CRYO-CORNER

Transfer Line	IPS(s)	I in ⁴	L in	E psi	κ lbs/in	J in ⁴	G psi	R in	D in	κ lbs/in	K lbs/in	P * lbs
LAR	1 1/2 x 3	2.07	74	2.76E+07	844.30	4.13	1.06E+07	44	32	718.21	388.08	194.04
GAR	1 1/2 x 3	2.07	98	2.76E+07	363.51	4.13	1.06E+07	98	32	142.52	102.38	51.19
LN2	1 1/2 x 3	2.07	104	2.76E+07	304.15	4.13	1.06E+07	86	32	188.00	116.18	58.09
Vent	6 x 8	49.8	177	2.76E+07	1499.58	99.6	1.06E+07	143	30	1720.62	801.26	400.63
Util Vac	4	3.96	167	2.76E+07	140.80	7.92	1.06E+07	NA	NA	NA	140.80	70.40
Insul Vac	6	14.4	420	2.76E+07	32.16	28.8	1.06E+07	NA	NA	NA	32.16	16.08
* This is the force required to deflect the pipe 1/2 inch												

N/A - not applicable

FERMILAB
ENGINEERING NOTE

SECTION
RD / CRYO

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SERIAL-CATEGORY

PAGE

SUBJECT

CRYO CORNER U-TUBE FIT-UP

NAME

R. RUCINSKI

DATE

1-29-92

REVISION DATE

	A	B	C	D	E	F	G	H	J	K	L
ASSY HALL	21 $\frac{1}{4}$	21 $\frac{1}{2}$	6 $\frac{1}{16}$	14 $\frac{3}{4}$	8 $\frac{1}{4}$	12 $\frac{5}{16}$	16 $\frac{1}{4}$	13 $\frac{1}{2}$	18 $\frac{9}{16}$	22 $\frac{3}{4}$	8 $\frac{1}{4}$
COLLISION HALL	21 $\frac{1}{2}$	21 $\frac{1}{2}$	5 $\frac{5}{8}$	15 $\frac{5}{16}$	8 $\frac{7}{8}$	13 $\frac{13}{16}$	15 $\frac{1}{4}$	11	18 $\frac{1}{2}$	20 $\frac{7}{8}$	8

	M	N	O	P	Q	R	S	T	U	V	W
ASSY	22 $\frac{7}{8}$	15 $\frac{1}{2}$	3 $\frac{15}{16}$	3 $\frac{1}{16}$	48 $\frac{1}{2}$	50 $\frac{7}{8}$	50 $\frac{5}{8}$	38	21 $\frac{3}{4}$	44 $\frac{3}{4}$	49 $\frac{1}{2}$
COLL.	23	15 $\frac{3}{4}$	5 $\frac{7}{8}$	3 $\frac{1}{8}$	50 $\frac{3}{8}$	49 $\frac{13}{16}$	49 $\frac{3}{16}$	38 $\frac{3}{4}$	23	44 $\frac{7}{16}$	49 $\frac{3}{8}$

COLLISION HALL
PATTERN

DRAWN AS ASSY HALL
COLLISION HALL MIRROR IMAGE!

ELEVATIONS

LN₂ (FLOOR TO TOP OF CLAMP) = Q
GAR (" ") = R
LAR (" ") = S
IV (FLOOR TO TOP OF FLANGE) = T
UV (FLG. TOP TO VENT FLG. TOP) = U
VENT (" " TOP OF FLG) = V

66 $\frac{1}{2}$ " ASSY HALL UV TO FLOOR
67 $\frac{11}{16}$ " COLL HALL " " "

FLEXIBILITY OF COLLISION HALL PIPES

A, B, $-\frac{1}{4}"$, $+3"$

C N/A

D $\pm 3\frac{1}{4}"$

E, F N/A

G $\pm 1\frac{1}{4}"$

H, J N/A

K $-\frac{1}{4}"$, $+3"$

L, M. N/A

N, $\pm \frac{1}{4}"$ ALONG WITH U, MUST MOVE AT 45°
TO HORIZONTAL

O, P, N/A

Q $-3"$ R $+2$, $-0"$ S $+1\frac{1}{2}"$, $-1"$ T $\pm 1"$

U SEE ABOVE

V $+1\frac{1}{2}"$, $-0"$

SUBJECT

CRYO CORNER U-TUBE FIT-UP

NAME

R. RUCINSKI

DATE

1-29-92

REVISION DATE

3-7-96 RAR

ASS'Y HALL

COLLISION HALL

A	B	C	D	E	F	G	H	J	K	L
21 ¹ / ₄	21 ¹ / ₂	6 ¹ / ₁₆	14 ³ / ₄	8 ¹ / ₄	12 ⁵ / ₁₆	16 ¹ / ₄	13 ¹ / ₂	18 ⁹ / ₁₆	22 ³ / ₄	8 ¹ / ₄
21 ¹ / ₂	21 ¹ / ₂	5 ⁵ / ₈	15 ⁵ / ₁₆	8 ⁷ / ₈	13 ¹³ / ₁₆	15 ¹ / ₄	11	18 ¹ / ₂	20 ⁷ / ₈	8

ASS'Y (HOOKED UP)

COLL. (FREE)

COLL. (HOOKED UP)

ASS'Y (FREE)

M	N	O	P	Q	R	S	T	U	V	W	U+V
22 ⁷ / ₈	15 ¹ / ₂	3 ¹⁵ / ₁₆	3 ¹ / ₁₆	48 ¹ / ₂	50 ³ / ₈	50 ⁵ / ₈	38	21 ³ / ₄	44 ³ / ₄	49 ¹ / ₂	66 ¹ / ₂
23	15 ³ / ₄	5 ⁷ / ₈	3 ¹ / ₈	50 ³ / ₈	49 ³ / ₁₆	49 ³ / ₁₆	38 ³ / ₄	23	44 ⁷ / ₁₆	49 ³ / ₈	67 ⁷ / ₁₆
				49 ¹ / ₄	50 ¹⁵ / ₁₆	50 ¹ / ₄	38 ¹¹ / ₁₆	22 ¹ / ₄	45 ⁷ / ₁₆		67 ¹¹ / ₁₆
				48 ⁵ / ₈	49 ⁵ / ₈	50 ³ / ₈	38 ⁵ / ₁₆	21 ¹ / ₂	44 ³ / ₄		66 ¹ / ₄

COLL. HALL RANGE
FROM PG. 2 & FREE MEAS.

MIN
MAX

COLLISION HALL

PATTERN

DOWN
UP

LN₂ GAR LAR IV UV VENT

* RECOMMEND
DISCONNECTING.

ELEVATIONS

LN₂ (FLOOR TO TOP OF CLAMP) = Q
GAR (" ") = R
LAR (" ") = S
IV (FLOOR TO TOP OF FLANGE) = T
UV (FLOOR TO VENT FLG. TOP) = U
VENT (FLOOR TO TOP OF FLG. LOWER) = V

66¹/₂" ASS'Y WALL UV TO FLOOR
67¹¹/₁₆" COLL. HALL " " "

DRAWN AS ASS'Y HALL

COLLISION HALL MIRROR IMAGE!

NOTE?
ALL FLANGE MEAS. TO TOP OF LOWER FLANGE

UV Ø = 4.5" Ø
LAR, GAR, LN₂ = 3.5" Ø
IV & VENT = 6⁵/₈" Ø

FLEXIBILITY OF COLLISION HALL PIPES

A, B, $-1/4"$, $+3"$

C N/A

D $\pm 3/4"$

E, F N/A

G $\pm 1/4"$

H, J N/A

K $-1/4"$, $+3"$

L, M. N/A

N, $\pm 1/4"$ ALONG WITH U, MUST MOVE AT 45° TO HORIZONTAL

O, P, N/A

Q $-3"$

R $+2$, $-0"$

S $+1 1/2"$, $-1"$

T $\pm 1"$

U SEE ABOVE

V $+1 1/2"$, $-0"$

WALL

○ = COLLISION HALL FREE

○ = COLLISION HALL HOOKED UP

STEEL
TRACK

ITEM NO. PART NO.

UNLESS OTHERWISE SPECII

.XX .XXX ANG
± ± ±

1. BREAK ALL SHARP EDG
.015 MAX.
2. DO NOT SCALE DRWG.
3. DIMENSIONING IN ACC
WITH ANSI Y14.5M-19
STD'S.
4. ALL DIMENSIONS ARE
INCHES.

✓ MAX. ALL MACHII
SURFACES

NO DIMS. TO LOCATE "UV"
ASS'Y. HALL FREE

UV

LA_r FILL

VENT

IV

GA_r

LN₂ SUPPLY

WALL

() = ASSEMBLE HALL FREE

- ASSEMBLE HALL HOOKED UP

NOT ENOUGH INFO
TO DEVELOP ASS'Y HALL
COMPARISONS.

ITEM NO. PART NO.

UNLESS OTHERWISE SPECII

.XX	.XXX	ANG
±	±	±

1. BREAK ALL SHARP EDG
.015 MAX.
2. DO NOT SCALE DRWG.
3. DIMENSIONING IN ACC
WITH ANSI Y14.5M-19
STD'S.
4. ALL DIMENSIONS ARE
INCHES.

MAX. ALL MACH'G
SURFACES

STEEL
TRACK

REVISION DATE 3-7-96 RAR

LN₂ GAr LAr IV UV VENT

UV $\phi = 4.5'' \phi$
 LAR, GAR, LN₂ = $3.5'' \phi$
 IV & VENT = $6^{3/8}'' \phi$

CRYO CORNER U-TUBES - HOOKED UP

A $21\frac{3}{4}$	B $21\frac{11}{16}$	C $5\frac{5}{16}$	D $14\frac{3}{8}$	E $9\frac{5}{8}$	F $14\frac{1}{4}$	G $16\frac{3}{8}$	H $11\frac{1}{4}\frac{1}{8}$	I —	J $18\frac{11}{16}$
K $22\frac{15}{16}$	L $8\frac{5}{8}$	M $23\frac{1}{2}$	N $15\frac{5}{8}$	O $5\frac{11}{16}$	P ≈ 4	Q $49\frac{3}{16}$	R $51\frac{2}{8}$	S $49\frac{11}{16}$	
T $38\frac{13}{16}$	U $22\frac{1}{4}$	V $45\frac{3}{8}$	W $49\frac{1}{2}$			UV TO FLOOR $67\frac{5}{8}$			

LOOK @ TOP OF DETECTOR FOR CLEARANCE
EF

CRYO CORNER U-TUBES COLLISION HALL
- HOOKED UP

A $21\frac{3}{4}$	B $21\frac{11}{16}$	C $5\frac{5}{16}$	D $14\frac{3}{8}$	E $9\frac{5}{8}$	F $14\frac{1}{4}$	G $16\frac{3}{8}$	H $11\frac{1}{4} \pm \frac{1}{8}$	I —	J $18\frac{11}{16}$
K $22\frac{15}{16}$	L $8\frac{5}{8}$	M $23\frac{1}{2}$	N $15\frac{5}{8}$	O $5\frac{11}{16} \approx 4$	P 4	Q $49\frac{3}{16}$	R $51\frac{2}{8}$	S $49\frac{11}{16}$	
T $38\frac{13}{16}$	U $22\frac{1}{4}$	V $45\frac{3}{8}$	W $49\frac{1}{2}$			UV TO FLOOR $67\frac{5}{8}$			

LOOK @ TOP OF DETECTOR FOR CLEARANCE
EF