DØ ENGINEERING NOTE 3740.215-EN-131

CC-EC
TRANSPORTER
ANALYSIS

DECEMBER 7, 1987

H.J. STREDDE

The following calculations were used to develop a structure required to transport completed calorimeters (CC-EC) from the assembly area to a staging point for installation onto center beam.

The transporter (see Figure 1, page 2) is equipped with four (4) 200 ton hydraulic cylinders and four (4) 200 ton capacity Hillman Rollers. The components are used for the lifting and moving of calorimeters.

R. Wands is doing the Ansys analysis based on 2 conditions:

- a) Statically loaded on the transporter support corner.
- b) Loaded on 3 Hilman's with 1 Hilman removed.

See EN-134 for this finite element analysis.

SUBJECT

DΦ CALORIMETER (S) TRANSPORTER

NAME

H. STREDDE

DATE

11-5-87

REVISION DATE

12-1-87

MAT'L: A-36 STEEL

(SEE pg 3 for B/m)

ALL FILLET WELDS

1/2" $\sqrt{60^\circ}$ 3/4"

BEVEL WELDS 3/4"

(4" PL TO 3" BEAM TOP PL)

SUBJECT

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11/17/87

REVISION DATE

11-20-87

BILL OF MATERIAL:

L	W	THK	No. Pcs		VOL (IN ³)
104" x	15"	x 1"	2	(RAILS)	3120
72" x	16	x 1 1/2"	4	(^A BEAM T+B)	6912
88" x	16	x 1 1/2"	2	(^B BEAM T)	4224
128" x	16	x 1 1/2"	2	(^B BEAM B)	6144
128" x	13	x 3/4	2	(^B BEAM OUTSIDE RIB)	2496
36" x	13	x 3/4	4	(^B BEAM INSIDE RIB)	1326
31" x	13	x 3/4	2	(^B BEAM INSIDE RIB)	604.5
12" x	13	x 3/4	4	(CORNER RIB)	468
16" x	13	x 1	4	(PULL RING STIFFENERS)	832
98" x	13	x 3/4	4	(^A BEAM RIB)	3822
14" x	8	x 3/4	8	(CYL SUPP.)	672
13 1/2" x	8	x 3/4	4	(CYL SUPP.)	324
11 1/2" x	13 1/2"	x 3/4	4	(CYL SUPP.)	465.75
20" x	16"	x 4	4	(CYL PADS)	5120

36530.25

EST WGT (.283²/IN³) ≈ 10,338 LBS

+ WELDS.

+ 32 LBS (PULL RING DISC)

10,370 LBS

+ WELDS.

COST ESTIMATE: 11-20-87 [BEFORE MINOR MAT'L CHGS.]
(N.J. LESNIEWSKI)3900⁰⁰ MAT'L7800⁰⁰ FAB⇒ 11,700⁰⁰ TOTAL

SUBJECT

CC LOADING

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H. STREDDE

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'B' - BEAM

MAT'L A-36 STEEL, $S_y = 36 \text{ ksi}$ ALLOWABLE STRESSES: $S_B = .6 \times 36 = 21.6 \text{ ksi}$; $S_s = .4 \times 36 = 14.4 \text{ ksi}$

$$Z = \frac{M}{S_B} = \frac{Pa}{S_B} = \frac{100 \times 2 \times 34}{21.6 \text{ ksi}} = 315 \text{ in}^3$$

TRY 2" FLANGE PLATES

	A	y	Ay	I_{xx}	Ay'^2
①	32	15	480	10.67	1568
②	18	8	144	216	0
③	32	1	32	10.67	1568
	82		656		
				$I_T = 3373 \text{ in}^4$	

$$\bar{y} = \frac{Ay}{A} = \frac{656}{82} = 8" \quad Z = \frac{3373}{8} = 422 \text{ in}^3 > 315 \quad \text{OK}$$

TRY $1\frac{1}{2}$ PLATES IN PLACE OF 2", LEAVE OVERALL

	A	y	Ay	I_{xx}	Ay'^2
①	24	$15\frac{1}{4}$	366	4.5	1261
②	$19\frac{1}{2}$	8	156	275	0
③	24	$3\frac{1}{4}$	18	4.5	1261
	$67\frac{1}{2}$		540		
				$I_T = 2806 \text{ in}^4$	

$$y' = \frac{540}{67\frac{1}{2}} = 8" \quad Z = \frac{2806}{8} = 351 \text{ in}^3 > 315 \quad \text{OK}$$

STRESS
SHEAR, THEN SECTION

$$\tau = \frac{200000 \text{ LBS.}}{67.5 \text{ in}^2} = 2963 \text{ psi}$$

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LOADING 'A' BEAM (CC)

$$Z = \frac{M}{S_B} = \frac{Pl}{4S_B} = \frac{100 \times 2 \times 88}{4 \times 21.6} = 203 \text{ IN.}^3$$

< 315 For 'B' BEAMS
'B' BEAMS SAFE FOR
ENTIRE STRUCTURE.

DEFLECTION AT CTR: $\Delta = \frac{Wa}{24EI} (3l^2 - 4a^2) = 0.059" \uparrow$

DEFLECTION AT SUPPORTS: $\Delta = \frac{Wa}{6EI} (3l - 4a) = 0.002" \uparrow$
RELATIVE TO ENDS

HILMAN ROLLER POSITION WHEN RELOCATING 'CC'.
FOR FIXTURE CHANGE OVER 'F' TO 'C'.

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HORIZONTAL SHEAR STRESS:

$$P = 200 \text{ kips} = V$$

$$a = 1\frac{1}{2} \times 16 = 24 \text{ in}^2$$

$$y = 8 - .75 = 7.25 \text{ in}$$

$$t = 2 \times .75 = 1.5 \text{ in}$$

$$I = 2806 \text{ in}^4$$

$$n = 2 \text{ welds}$$

$$\tau = \frac{V a y}{I n}$$

$$\tau = \frac{200,000 \text{ lbs} \times 24 \text{ in}^2 \times 7.25 \text{ in}}{2806 \text{ in}^4 \times 2} = 6200 \text{ lbs/in.}$$

$$\text{AVAILABLE FORCE / WELD SIZE (E60 mat'l)} = .3 \times 60 \times .707 = 12.7 \text{ kips/in}$$

$$\text{REQ'D LEG SIZE} = \frac{6.2}{12.7} = 0.487 \text{ SAY } \frac{1}{2} \text{ FILLET}$$

HORIZONTAL
MAX. SHEAR STRESS IN BOX BEAM:

$$\tau = \frac{V Q}{I t}$$

$$= \frac{200,000 \times 6.1 \times 33.75}{2806 \times 1.5}$$

$$= 9782 \text{ psi} < 14,400 \text{ ALLOWABLE}$$

	A	y	Ay	I _{x-x}	Ay ²
①	24	7 1/4	174	4.5	31.74
②	9.75	3 1/4	31.7	34.3	79.2
	33.75	205.7		I _y =	
				y' =	
				33.75	6.1

WELD SIZE FOR TRACK PLATE

$$\tau = \frac{200,000 \times 15 \times 3/4 \times 8.375}{2806 \times 2}$$

$$= 3358 \text{ lbs/in.}$$

$$\text{REQ'D} = \frac{3.358}{12.7} = 0.264, \text{ SAY } \frac{3}{8} \text{ FILLET!}$$

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TORSIONAL MOMENT $I_p = I_{x-x} + I_{y-y}$

$$I_{x-x} = 2806 \text{ in}^4$$

	A	X	AX	I_{yy}	AX^2
①	48	8	384.0	1024.0	0
②	$9\frac{3}{4}$	$15\frac{1}{8}$	15.8	0.5	396.2
③	$9\frac{3}{4}$	$14\frac{3}{8}$	140.2	0.5	396.2
	67.5	540		$I_{T-y} = 1817.4 \text{ in}^4$	

$$X' = \frac{540}{67.5} = 8 \text{ in} \quad I_p = 2806 + 1817 = 4623 \text{ in}^4$$

	A	Y	A_y	I_{x-x}	$A_y'^2$
①	24	22.5	540.0	6.75	755.3
②	19.5	15.25	297.4	274.625	52.4
③	7.5	8.0	60.0	1.4	592.7
④	10.875	3.625	39.4	47.6	1913.6
⑤	30.0	20.5	615.0	15.625	391.0

$$91\frac{7}{8} \quad 1551.8 \quad I_T = 4051 \text{ in}^4$$

$$\bar{Y} = \frac{1551.8}{91.875} = 16.89 \text{ in}$$

$$Z_{TOP} = \frac{4051}{23.25 - 16.89} = 636.9 \text{ in}^3 \quad Z_{BOT} = \frac{4051}{16.89} = 239.8 \text{ in}^3$$

SUBJECT

NAME H. STREDDO

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ENERGAC CYL @ 200 TON Cap.
9 1/2" ϕ BODY.

REF: ROARK + YOUNG^{5TH}
TABLE 26
CASE 2a Pg 389
3 EDGES Simply Supp.
1 EDGE FREE
UNIFORMLY LOADED

ASSUME PLATE uniformly loaded with cyl. Force, $\frac{200 \text{ KIP}}{(9.5)(.785)} = 2823 \text{ LBS/IN}^2$
VERY CONSERVATIVE.

THEN, $A = 1$; $B = .67$; $\alpha = .0140$

$q = 2823 \text{ LBS/IN}^2$; $\sigma = 21 \text{ KSI}$

$$t = \left[\frac{B q b^2}{\sigma} \right]^{1/2} = 3.6 \text{ THICK, USE } 4"$$

$$\Delta_{\max} = \frac{-\alpha q b^4}{E t^3} = 4.27 \times 10^{-3} \downarrow$$

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Weld size:

$$\text{Allowable Load/in} = (.3 \times .707 \times 60 \text{ ksi}) = 12.7 \text{ kips/in. (1" fillet)}$$

$$V = 200 \text{ kips.}$$

$$I = 4051 \text{ in}^4$$

$$t = 1.5 \text{ in.}$$

$$\tau = \frac{VQ}{IT}$$

	A	y	Ay	I _{x-x}	Ay ²
①	24	5.61	134.6	6.75	44.26
②	30	3.61	108.3	15.625	12.36
③	7.29	2.43	17.71	14.35	24.20

$$61.29 \quad 260.61 \quad I_T = 117.545 \text{ in}^4$$

$$\bar{y} = \frac{260.61}{61.29} = 4.252$$

SHEAR STRESS THRU CG OF ENTIRE SECTION.

$$\tau = \frac{200000 \times 61.29 \times 4.252}{4051 \times 1.5} = 8577 \text{ psi} < 14,400 \text{ psi ALLOWABLE OK}$$

Weld Size:

$$\delta_1 = \frac{200000 \times 54 \times 4.49}{4051 \times 2} = 5985 \text{ lbs/in.}$$

$$\delta_2 = \frac{200000 \times 24 \times 5.61}{4051 \times 2} = 3324 \text{ lbs/in.}$$

A	y	Ay
24	5.61	134.6
30	3.61	108.3
54		242.9

$$\text{use } \delta_1 = 6000 \text{ lbs/in.}$$

$$\bar{y} = \frac{242.9}{54} = 4.49 \text{ in.}$$

$$\text{FILLET} = \frac{6000}{12.7} = 0.472 \text{ say } \frac{1}{2} \text{ FILLET.}$$

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How do we move TRANSPORTER?

A - max LOAD ≈ 350 TONS

B - will use 4 HILMAN rollers @ 200 TON EACH.

C - rolling friction $\approx 5\%$ (3 PT LOADING?)
(CATALOG VALUE).

REQ'D FORCE $\approx .05 \times 350 = 17.5$ TONS.

$$I_{y-y} = 1817 \text{ in}^4$$

$$Z = \frac{I}{S} = \frac{1817}{8} = 227 \text{ in}^3$$

$$S = \frac{M}{Z} = \frac{PL}{4Z} = \frac{40000 \times 88}{4 \times 227} = 3877 \text{ PSI}$$

DEFLECTION:

$$\Delta = \frac{PL^3}{48EI} = \frac{200 \times 2000 \times 88^3}{48 \times 30 \times 10^6 \times 1817} = 0.104 \text{ in}$$

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PLATE THICKNESS FOR Pull RING:
(JERGEN'S P/N 23435) $\approx$ LOAD RATING 30 KIPS
THD SIZE 2-4 1/2 x 2.96 LG.

LET ALLOWABLE BENDING STRESS = 20000 PSI
REF: ROARK & YOUNG 5TH ED. TABLE 26, CASE 8b, PG. 393.

ALL EDGES FIXED, CONCENTRIC LOAD ON SMALL r_0 @ CTR.

$$\sigma_{CTR} = \frac{3W}{2\pi t^2} \left[(1+\nu) \ln \frac{2b}{r_0'} + \beta_1 \right] ; \Delta_{MAX} = \frac{\alpha W b^2}{E t^3}$$

$$\sigma_{CTR \text{ OF EDGE}} = \frac{-\beta_2 W}{t^2}$$

$$a=b=13; \beta_1 = -0.238; \beta_2 = 0.7542; \alpha = 0.0611$$

$$r_0' = r_0 \text{ when } r_0 > 0.5t$$

$$r_0 = 1 \quad 1.38 \leftarrow \text{USE THIS, WHEN } \Delta = .0026$$

$$= 2 \quad 1.22$$

$$= 2\frac{1}{2} \quad 1.16$$

$$= 3 \quad 1.11$$

$$\text{AND } \sigma_{CTR \text{ OF EDGE}} = 7920 \text{ psi}$$

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