**End Cap Calorimeter
Inner Hadronic Module Installation**

by

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3740.225-EN-264

FERMILAB

ENGINEERING NOTE

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SUBJECT

I. H. INSTALLATION BEAM TRIPOD

NAME

H. J. STREDDE

DATE

8/2/90

REVISION DATE

SUBJECT

I. H. INSTALLATION BEAM-TRIPOD

NAME

H. J. STREDDE

DATE

8-2-90

REVISION DATE

SUBJECT

I. H. Tripod Support - LEG FORCES

NAME H. J. STREDDE

DATE 8/28/90

REVISION DATE 9-13-90

Assume Force on Tripod is
50,500, EQUALLY DISTRIBUTED
ON EACH LEG.

Then $F_y = 16833 \text{ LBS}$

$$F_x = \frac{41.282}{208} \times 16833 = 3340 \text{ LBS.}$$

$$F_c = \frac{212.057}{208} \times 16833 = 17,161 \text{ LBS.}$$

$$\begin{aligned} \sum M_A &= 16833 \times 41.282 - 3340 \times 208 \\ &= 18012 \text{ LBS} \end{aligned}$$

Assume: Top $\rightarrow$ FIXED
Bottom $\rightarrow$ TRANSLATION FREE
ROTATION FIXED } $K = 1.2$
 $F_y = 36 \text{ KSI}$

$$\text{THEFORE } KL = \frac{1.2 \times 212}{12} = 21.2 \Rightarrow \text{ALLOWABLE LOAD ON } 6" \text{ SCH. 40} = 62 \text{ KIPS}$$

From TABLE C-36, Pg 3-16 9TH EDITION AISC:

$$\frac{KL}{r} = \frac{1.2 \times 212}{2.25} = 113.07 ; F_a = 11,120 \text{ psi ALLOWABLE STRESS}$$

$$F_a = \frac{P}{A} + \frac{M_e}{I}$$

$$\begin{aligned} C &= 3.312" \\ I &= 28.1 \text{ in}^4 \\ A &= 5.58 \text{ in}^2 \end{aligned}$$

ECCENTRICITY OF
RADIUS OF PIPE

$$\begin{aligned} M &= P_e \\ &= 17161 \times \frac{6.625}{2} \end{aligned}$$

$$11,120 \geq \frac{17161}{5.58} + \frac{17161 \times 3.312 \times 3.312}{28.1}$$

$11,120 \text{ psi} > 9,774 \text{ psi} \rightarrow 6" \text{ SCH 40 pipe is SAFE!}$

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SUBJECT

I. H. INSTALLATION BEAM-TRIPOD

NAME

H. J. STREDDER

DATE

8-7-90

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SUBJECT

I.H. INSTALLATION BEAM SUPPORT
TRIPOD TO BEAM CONNECTION

NAME

H. J. STREDDE

DATE

8/7/90

REVISION DATE

1" FERRY-CAP
WASHER +
NUT
TYP 6 PLCS $\frac{1}{2}$ " GUSSET
TYP 4 PLCSW18x119
(2 pcs)

SUBJECT

NAME

DATE

7-31-90

REVISION DATE

8-29-90

SET Δ at 0.2"

$$\Delta_E = \frac{Pa_1}{48EI} (3L^2 - 4a_1^2) + \frac{Pa_2}{48EI} (3L^2 - 4a_2^2)$$

$$= \frac{P}{48EI} [a_1 (3L^2 - 4a_1^2) + a_2 (3L^2 - 4a_2^2)]$$

$$I = \frac{20 \times 2000}{48 \times 29 \times 10^6 \times 0.2} [65(3 \times 278^2 - 4 \times 65^2) + 136(3 \times 278^2 - 4 \times 136^2)]$$

$$= 5,092 \text{ in.}^4$$

NOT AVAILABLE / central steel or ANYWHERE ELSE

use 2, W18 x 143 SEAM WELDED; $I = 5500 \text{ in.}^4$
 $S = 564 \text{ in.}^3$

use 2, W18 x 119 w/ 1/2 cap PLATES; $I = 6280 \text{ in.}^4$, $S = 628 \text{ in.}^3$

$$R_2 = \frac{65 \times 40000 + 136 \times 40000}{278} = 29,352 \text{ LBS}$$

$$R_1 = 80000 - 29,352 = 50,647 \text{ LBS}$$

$$M_{\max} = 4.17 \times 10^6 \text{ LB-INS.}$$

$$S = \frac{4.17 \times 10^6}{628} = 6,637 \text{ psi}$$

$$\text{WEB STRESS} = \frac{40000}{2(19 \times 0.55)} = 1608 \text{ psi}$$

ENGINEERING NOTE

7/16

SUBJECT

I. H. HANGER BLOCK & LINKS
SIDE VIEW

NAME

H. J. STREDDÉ

DATE

9/10/90

REVISION DATE

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SUBJECT

I. H. HADGER LINKS

NAME

H. J. STREDDER

DATE

9-10-90

REVISION DATE

SUBJECT

I.H. LINK STRESSES

NAME

H. J. STREDDE

DATE

9-11-90

REVISION DATE

10-19-90

1 1/2" ϕ P.I.D
TEAR-OUT:

$$S_s = \frac{20000}{2 \times 1 1/8 \times 1 1/2} = 5,926 \text{ psi} < \frac{.4 \times 36,000}{14,400}$$

BEG-PIN ON LINK:

$$S_B = \frac{20000}{1 1/2 \times 1 1/2} = 8,888 \text{ psi} < \frac{.95 \times 36,000}{34,200}$$

SHEAR ON P.I.D

$$\tau = \frac{20000}{2 \times (1.5)^2 \times .785} = 5,662 \text{ psi} < \frac{.4 \times 100,000}{40,000}$$

3" ϕ P.I.D

TEAR WT

$$S_s = \frac{20000}{2 \times 2 1/2 \times 1 1/2} = 2,666 \text{ psi} < \frac{.4 \times 36,000}{14,400}$$

BEG - P.I.D ON LINK

$$S_B = \frac{20000}{3 \times 1 1/2} = 4,444 \text{ psi} < \frac{.95 \times 36,000}{34,200}$$

BENDING STRESS ON 1 1/2" ϕ P.I.D (STRESS PROOF)

$$S_B = \frac{20000 \times .875 \times 4}{\pi \times .75^3} = 52,816 \text{ psi} < \frac{.6 \times 100,000}{60,000}$$

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SUBJECT

I. H. HANGER BLOCK & LINKS
FRONT VIEW

NAME

H. J. STREDDE

DATE

9-10-90

REVISION DATE

$1" \varnothing$
BOLT
4 PLCSC.R. 1010-1020
STL BAR $\frac{1}{2} \varnothing$
STRESS PROOF
PIN.

10"

PIN RETAINER

SUBJECT

I. H. HANGER BLOCK
BOTTOM VIEW

NAME

H. J. STREDDE

DATE _____

9-11-90

REVISION DATE

SUBJECT

NAME

H. J. STREDDE

DATE

9-10-90

REVISION DATE

$$\text{LET } \Delta = .015$$

$$\Delta = \frac{PL^3}{48EI}$$

$$\text{THEN } I = \frac{PL^3}{48E\Delta}$$

$$P = 20 \times 2000 \text{ LBS}$$

$$L = 16 \text{ in}$$

$$E = 29 \times 10^6 \text{ psi}$$

$$\Delta = 0.015 \text{ in}$$

$$I = \frac{20 \times 2000 \times 16^3}{48 \times 29 \times 10^6 \times 0.015} = 78.467 \text{ in}^4$$

$$\text{Actual } I \text{ is } 74.5 \text{ in}^4$$

$$\Delta = \frac{20 \times 2000 \times 16^3}{48 \times 29 \times 10^6 \times 74.5} = 0.016 \text{ in} \downarrow$$

ASSUME $1\frac{1}{2} \times 16$ PLATE REACTS TO LOAD

$$\text{THEN } I = \frac{1}{12} (1\frac{1}{2})^3 (16) = 4.5 \text{ in}^4$$

$$\Delta = \frac{20 \times 2000 \times 6^3}{48 \times 29 \times 10^6 \times 4.5} = 0.0014 \text{ in} \downarrow$$

SUBJECT

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H. J. STREDDE

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9/10/90

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$$\bar{Y} = \frac{\sum A y}{\sum A} = \frac{(1.5 \times 8 \times .75) + (4.5 \times 3.625 \times 3.75) - (1.50 \times 3.625 \times 4.25)}{(1.5 \times 8) + (4.5 \times 3.625) - (1.50 \times 3.625)}$$

$$= 2.057"$$

$$I = I_0 + Ad^2$$

$$= \left[\frac{1}{12} (1.5^3 \times 8) + (1.5 \times 8 \times 1.307)^2 \right] + \left[\frac{1}{12} (4.5^3 \times 3.625) + (4.5 \times 3.625 \times 1.693)^2 \right]$$

$$- \left[\frac{(1.5)^3 (3.625)}{12} + (1.50 \times 3.625 \times 2.193)^2 \right]$$

$$= 20.780 + 74.283 - 27.170$$

$$I = 67.893 \text{ in}^4$$

$$Z_T = \frac{67.893}{2.057} = 33.005 \text{ in}^3$$

$$Z_B = \frac{67.893}{6 - 2.057} = 17.219 \text{ in}^3$$

$$S = \frac{M_c}{Z} = \frac{PL}{4Z} = \frac{40000 \times 16}{4 \times 17.219} = 9,292 \text{ psi}$$

SUBJECT

NAME

H. J. STREDDE

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9/13/90

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W 18 x 119

$V = 52000 \text{ LBS}$

$I = 2 \times 2190 = 4380 \text{ in}^4$

$a = .5 \times 20 = 10 \text{ in}^2$

$y = \frac{19}{2} + \frac{1}{4} = 9.75 \text{ in.}$

$$f_h = \frac{Vay}{I_n} = \frac{52000 \times 10 \times 9.75}{4380 \times 2} = 579 \text{ LBS/in.}$$

$$w = \frac{\text{actual}}{\text{allowable}} = \frac{579}{14850} = .039$$

use $\frac{1}{4}$ weld, then $\frac{.039}{.250} = 15\%$

USE $\frac{1}{4} \text{ } \swarrow \searrow \text{ } 2-8 \text{ } \leftarrow \text{E 7018}$

space weld

$$f_h = \frac{52000 \times 22.5 \times 1.062 \times 8.969}{4380} = 2544 \text{ LBS/in.}$$

$$w = \frac{2544}{14850} = 0.171$$

SUBJECT

I.H. LINK BLOCK - WELD &
FASTENER SIZE

NAME

H. J. STREDDE

DATE

9-14-90

REVISION DATE

WELD SIZE BLOCK A to B:

ALLOWABLE LENGTH OF WELD

$$L_w = 2 \times 16$$

$$= 32"$$

$$\text{FORCE \#/IN} = \frac{20 \times 2000}{32} = 1250 \#/\text{IN.}$$

$$w = \frac{1250}{14850} = .084"$$

MIN. WELD SIZE SHOULD BE $\sim 1/2$

$$\frac{.084}{.500} = 17\% \text{ use } 1/2$$

FASTENER - LINK BLOCK TO BEAM

$$P = 40000 \text{ LBS}$$

$$N = 4, \text{ NUMBER OF BOLTS}$$

$$\text{LOAD PER BOLT} = \frac{40000}{4} = 10000 \text{ LBS} = 10 \text{ KIPS}$$

$$\text{ASSUME } 1" \phi \text{ BOLTS, PROOF STRENGTH} = 78 \text{ Kpsi} \left(\begin{array}{l} \text{REF: MECH. ENGR} \\ \text{DES. BY SHIGLEY} \\ \text{3RD EDITION} \end{array} \right)$$

$$\text{TENSILE STRESS AREA} = 0.606 \text{ IN}^2$$

$$\text{PROOF LOAD} = 78 \times 0.606 = 47.3 \text{ KIPS}$$

SUBJECT

I.H. INSTALLATION BEAM
CLEARANCE TO COOLING LOOPS

NAME

H. STREDDE

DATE

9-11-90

REVISION DATE

$$A = \left[(10)^2 + (75 \frac{1}{4})^2 \right]^{1/2} = 75.912 < 90.062 - 2.188 = 87.874"$$

~12" CLEARANCE

$$B = \left[(11 \frac{1}{4})^2 + (75 \frac{1}{4})^2 \right]^{1/2} = 76.086 < 90.062 - 2.188 = 87.874$$

~11 7/8" CLEARANCE.

SUBJECT

FASTER SIZE: BEAM TO TRIPOD

NAME

H. STREDDER

DATE

9-90

REVISION DATE

$$F = \text{WGT OF I.H.} = 64000 \text{ LBS.}$$

F IS SHEAR FORCE OF BOLTS FASTENING BEAM TO TRIPOD 2 BOLTS AT EACH CORNER, TAKE FORCE

$$\phi \text{ of Fastener} = \left[\frac{64000 \times 4}{2 \cdot \pi \cdot 48000} \right]^{1/2} = 0.92", \text{ SAY } 1" \phi$$

$\frac{4 \times 120000}{1449 \text{ BOLTS}}$ $\nearrow$

SUBJECT

EAST-WEST TIPPING OF TRIPOD ASSEM.

NAME

H. STREDDE

DATE

9/90

REVISION DATE

$$W = \text{WGT OF I. H.} = 32 \text{ TONS}$$

$$\left[207^2 + 39\frac{1}{2}^2 \right]^{\frac{1}{2}} = 210.7"$$

$$\sum M_A = 207 \times F - W \times 39\frac{1}{2}$$

$$F = \frac{32^T \times 39\frac{1}{2}}{207} = 6.1 \text{ TONS}$$

LBL OVERTURNING CRITERIA, RAISE C.G. 3" IS MET
WITH LINK AB (TRUE LENGTH) 3" > THAN VERTICAL
DIMENSION.

SUBJECT

NAME

DATE

REVISION DATE

F CAN BE ≈ 16 TONS
HYD. CYL. FORCE PUSHING EC SUB-ASSEMBLY.
W = 32 TONS, WGT OF IHL

$$\Sigma M_A = (116 \frac{1}{2} \times 32) - 151 \times F$$

$$F = \frac{(116 \frac{1}{2})(32)}{151} = 24.6 \text{ T}$$

$$\Sigma M_B = (84.5 \times 32) - (15 \times 16) + (32 \times R)$$

$$R = \frac{(151 \times 16) - (84.5 \times 32)}{32} = -9 \text{ T}$$

REACTION AT A due W = 19000 LBS

$$\text{plus } F = \frac{19000}{37000 \text{ LBS}}$$

$$\frac{P}{A} = \frac{37000}{5.58} = 6631 \text{ psi}$$

$$\frac{P_{ec}}{I} = \frac{37000 \times 3.312 \times 3.312}{28.1} = 14,443 \text{ psi}$$

21,074 psi

IH Installation Fixture

The fixture used to hold the IH module while the EC Calorimeter is pulled over it consists of two tripod frames with a double wide flange between them. The two tripods have legs made of 6" Schedule 40 pipe, these legs are tied together with 2" Schedule 40 pipe. One of the legs sits on and is attached to a box made of 3/4" plates.

The fixture was analyzed using ANSYS. The element used was a 3-D beam (STIF4). Equivalent properties were figured for the double wide flange. The legs of the tripods were constrained in the Y direction (vertical). The box at the bottom of the tripod leg was not used in this analysis, the leg was constrained at the point of attachment to the box. The cross beam was loaded at two points representing the IH load.

The reaction force at the point where the tripod leg attaches to the box was then used in an analysis of the box itself. The box was modeled using plate elements (STIF63). The bottom of the box was constrained in the Y (vertical) direction. The top of the box was loaded in roughly a circular area to represent the pipe attachment area. The reaction force from the previous analysis was divided among these nodes.

The results from both analyses are tabulated below.

BEAM ANALYSIS

STRESS

702 psi axial
-3342 psi axial
287 psi bending (szz)
-136 psi bending (szz)
7451 psi bending (syy)
-519 psi bending (syy)

LOCATION

2" pipe - tie piece
Tripod leg over box
Tripod leg below tie
Tripod leg
Cross beam
2" pipe - tie piece

DEFLECTION

-.2157

LOCATION

Top beam @ 168"

PLATE ANALYSIS

STRESS INTENSITY

12253 psi (bottom)

12253 psi (middle)

12493 psi (top)

LOCATION

Bottom of vertical plate (under load)

Bottom of vertical plate (under load)

Top of vertical plate (under load)

DEFLECTION

.0078"

LOCATION

Center of top plate

ANSYS 4.4
SEP 18 1996
14:27:46
POST1 DISPL
STEP=1
ITER=1
DMX =0.0078

DSCA=151.16
ZU =1
DIST=11.825
XF =6.25
YF =10.75

TITLE

ANSYS 4.4
SEP 18 1990
13:38:58
POST1 STRES
STEP=1
ITER=1
SI (AVG)
TOP
DMX =0.0078
SMN =18.2
SMX =12493

XU =1
YU =1
ZU =1
DIST=14.258
XF =6.25
YF =10.75
A =711.22
B =2097
C =3483
D =4869
E =6255
F =7641

H =10414
I =11800

TITLE

TITLE

ANSYS 4.4
SEP 18 1990
12:42:47
POST1 STRES
STEP=1
ITER=1
SI (AVG)
TOP
DMX =0.0078
SMN =18.2
SMX =12493

ZU =1
DIST=11.825
XF =6.25
YF =10.75
A =711.22
B =2097
C =3483
D =4869
E =6255
F =7641

H =10414
I =11800

ANSYS 4.4
SEP 18 1990
13:45:35
POST1 STRESS
STEP=1
ITER=1
SI (AUG)
BOTTOM
DMX =0.0078
SMN =18.217
SMX =12253

XU =1
YU =1
ZU =1
DIST=14.258
XF =6.25
YF =10.75
A =697.96
B =2057
C =3417
D =4776
E =6135
F =7495

H =10214
I =11573

TITLE

ANSYS 4.
SEP 18 199
12:27:43
POST1 STRE
STEP=1
ITER=1
SI (AVG)
MIDDLE
DMX =0.007
SMN =18.20
SMX =12253

XU =1
YU =1
ZU =1
DIST=14.25
XF =6.25
YF =10.75
A =697.8
B =2057
C =3417
D =4776
E =6135
F =7495

H =10214
I =11573

TITLE

ANSYS 4.4
 OCT 2 1990
 08:21:46
 PREP7 ELEMEN
 ELEM NUM

XU =1
 YU =1
 ZU =1
 DIST=193.77
 XF =170
 YF =108.75

ANSYS 4.4
OCT 2 1990
08:24:13
PREP7 ELEMEN
ELEM NUM

ZU =1
DIST=187
XF =170
YF =108.75

TITLE