D0 ENGINEERING NOTE

3823.132-EN-502

SAMUS TOROID INSTALLATION FIXTURE

H. Stredde

June 27, 1990
revised July 15, 1998

Approved:

A handwritten signature in black ink, appearing to read "Rudy Thompson", is written over a horizontal line. The signature is fluid and cursive, with a long horizontal stroke extending to the right.

The SAMUS (Small Angle Muon System) toroids have been designed and fabricated in the USSR and delivered to D0 ready for installation into the D0 detector. These toroids will be installed into the aperture of the EF's (End Toroids).

The aperture in the EF's is 72" vertically and 66" horizontally. The Samus toroid is 70" vertically by 64" horizontally by 66" long and weighs approximately 38 tons. The Samus toroid has a 20" by 20" aperture in the center and it is through this aperture that the lift fixture must fit. The toroid must be "threaded" through the EF aperture. Further, the Samus toroid coils are wound about the vertical portion of the aperture and thus limit the area where a lift fixture can make contact and not damage the coils. The fixture is designed to lift along a surface adjacent to the coils, but with clearance to the coil and with contact to the upper steel block of the toroid. The lift and installation will be done with the 50 ton crane at D0.

The fixture was tested by lifting the Samus Toroid 2" off the floor and holding the weight for 10 minutes. Deflection was as predicted by the design calculations.

Enclosed are sketches of the fixture and its relation to both Toroids (Samus and EF), along with hand calculations and a Finite Element Analysis. The FEA work was done by Kay Weber of the Accelerator Engineering Department.

FIXTURE MODIFICATION- Removal of SAMUS Toroids

The Samus toroids are to be removed from the EF toroids for run II. These toroids were installed before the B & C-layer PDT's were installed on top of the EF's. The original installation fixture was built to clear the top surface of the EF and therefore has to be modified in length in order to clear the top layer PDT's. This results in a change in length of 64". The fixture will be cut in the center and an appropriate section of material added by welding to provide the needed length.

The fixture will be tested by using a hydraulic cylinder and two columns to fill the gap of the fixture "C" frame. Pressure will be applied to the cylinder to provide a force of 48 tons on the fixture. (38 x 1.25).

Sketches of the modified fixture and test apparatus are included, along with the appropriate calculations that are indicated by * in the revised copy.

SECTION A-A

TEST LOAD 96000 LBS.

DEFLECTION ≈ .438"

2-23-99

H. STREDDE

SUBJECT

SAMUS INSTALLATION FIXTURE
(NO PROPORTIONAL DRIFT TUBES INSTALLED)

NAME

H. STREDDO

DATE

11-6-89

REVISION DATE

7.15.98*

SCALE: $3\frac{1}{8}" = 1'-0"$

40 TONS

53 $\frac{3}{8}"$

SECT. 1

SEE DWG:

3740.000-MG-294021

15" = PDT'S

3" = CL. PDT to EF

45 $\frac{1}{2}"$ = TRUSS

63.5

5" ~ 68"

* FIXTURE MODIFIED FOR
REMOVAL OF TOROIDS
W/ B & C LAYER (ROOF)
PDT'S IN PLACE

EST. FIXTURE WT:

$$\text{SECT 1} = \frac{170}{12} \times 2617 \text{ lb} = 3800$$

$$\text{SECT 2} = \frac{224}{12} \times 165 \text{ lb} = 3080$$

$$\text{HOOK P.T.} \approx 550$$

$$\approx 7500 \text{ LB}$$

SUBJECT

NAME

H. J. STREDOE

DATE

5/10/90

REVISION DATE

SECTION
PROPERTIES

$$I = 3942 \text{ in}^4$$

$$S = 456 \text{ in}^3$$

$$A = 76.7 \text{ in}^2$$

SECTION 1

SECTION
PROPERTIES

$$I = 7470 \text{ in}^4$$

$$S = 520 \text{ in}^3$$

$$A = 48.8 \text{ in}^2$$

SECTION 2

SUBJECT

NAME

H. J. STREDDE

DATE

5/10/90

REVISION DATE

5/17/90

DESIGN TO DEFLECTION ORIENTED -

$$M_{max} = (40000 \times 108.75) = 4.27 \times 10^6 \text{ IN-LB.}$$

$$F_a = 10,000 \text{ psi}$$

$$S = \frac{4.27 \times 10^6}{10000} = 427 \text{ IN}^3 > 232 \text{ IN}^3 \rightarrow \text{ADD TOP \& BOTTOM PLATES}$$

AVAILABLE MATERIAL

W14 x 145

$$I = 1710 \text{ IN}^4$$

$$S = 232 \text{ IN}^3$$

TO PROVIDE NEEDED STRENGTH AT LOAD CONTACT POINTS
USE 1" THK X 18" WIDE (MIN) PLATE, GUSSETED AT LOAD PTS.

TABLE A 2-236
AISC - 80.9

$$\text{NEW } I \rightarrow I = 1710 + (1 \times 18 \times 124) = 3942 \text{ IN}^4; C = \frac{14.75 + 2}{2} = 8.375$$

$$S = \frac{3942}{8.375} = 471 \text{ IN}^3$$

LOOKING AT DEFLECTION AT FREE END

$$\begin{aligned} \Delta_{\text{TOTAL}} &= \frac{P_1 b_1^2}{6EI} (3l - b_1) + \frac{P_2 b_2^2}{6EI} (3l - b_2) \\ &= \frac{40000}{6 \times 29 \times 10^6 \times 3942} \left[(10^2)(3 \times 73 - 10) + (58^2)(3 \times 73 - 58) \right] \\ &= .033 \downarrow \text{ OK.} \end{aligned}$$

$b_1 = 10"$
 $b_2 = 58"$
 $l = 73"$

CHECK STRESS:

$$F_b = \frac{4.27 \times 10^6}{471} = 9,065 \text{ psi OK!} < 21.6 \text{ ksi } (.6 \times F_y)$$

SHEAR IN WEB:

$$\frac{80000 \text{ LBS}}{14.75 \times .688} = 7,883 \text{ psi} < 14,400 \text{ ALLOWABLE } (.4 F_y)$$

SUBJECT

NAME

H. J. STREDDER

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Top BEAM:

SAME SECTION AS BOTTOM, WITH REINFORCEMENT
AT LIFTING EYE.

W14x145

W/1" PLATES TOP + BOTTOM

 $I = 3942 \text{ in}^4$ $S = 471 \text{ in}^3$

* Two PICK PTS
1 - LOADED
2 - Empty

DEFLECTED AT LOAD: $\Delta = \frac{PL^3}{3EI} = \frac{80000 \times 39^3}{3 \times 29 \times 10^6 \times 3942} = 0.014" \uparrow$

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VERTICAL BEAM:

EQUIVALENT LOAD;

$$M = \frac{PL}{8} \quad \therefore \quad P = \frac{8M}{L} = \frac{(8)(4.27 \times 10^6)}{160 \times 224}$$

$$* \quad \Delta = \frac{PL^3}{192EI} = \frac{2.135 \times 10^5 \text{ LBS}}{152500} = 0.040" \quad 0.041"$$

SHEAR THRU WEB:

$$\text{WEB AREA} = 26.75 \times .438 = 11.68 \text{ in}^2$$

$$V = \frac{P}{2} = \frac{152500}{2} = 76,250$$

$$\tau = \frac{76250}{11.68 \text{ in}^2} = \sim 6500 \text{ psi}$$

SUBJECT

DEFLECTION OF LOADED FIXTURE)
(DEBUCKETING WGT OF FIXTURE)

NAME

N. J. STREDDE

DATE

11-7-89

* REVISION DATE

7-15-98

DEFLECTION: (REF. DESIGN OF WELDMENTS, BUDGET)
Pg 2.11/6

DEFLECTION DUE TO AXIAL ELONGATION:

$$\Delta_a = \frac{PL_2}{A_2 E} = \frac{40 \times 2000 \times 176.75}{48.8 \times 29 \times 10^6} = 0.010 \text{ } 0.014"$$

$$P = 40 \text{ TONS}$$

$$L_1 = 53.375"$$

$$L_2 = 176.75"$$

$$A_1 = 78.7 \text{ in}^2$$

$$I_1 = 394.2 \text{ in}^4$$

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

$$E_3 = 12 \times 10^6 \text{ psi}$$

$$A_2 = 48.8 \text{ in}^2$$

$$I_2 = 7470 \text{ in}^4$$

DEFLECTION DUE TO BENDING:

ROTATION OF VERT. MEMBER,

$$\Delta_B = \frac{PL_1^2 L_2}{2EI_2} = \frac{40 \times 2000 \times (53.375)^2 \times 176.75}{2 \times 29 \times 10^6 \times 7470} = 0.092" \cdot 125"$$

ROTATION ACTING AS CANTILEVER,

$$\Delta_C = \frac{PL_1^3}{3EI_1} = \frac{40 \times 2000 \times (53.375)^3}{3 \times 29 \times 10^6 \times 3942} = 0.035"$$

DEFLECTION DUE SHEAR:

$$\Delta_{d_{top}} = \frac{PL_1 \alpha_2}{A_2 E_s} = \frac{40 \times 2000 \times 8 \frac{3}{8} \times 7.234}{48.2 \times 12 \times 10^6} = 0.082$$

TOTAL DEFLECTION:

$$\Delta_T = \Delta_a + 2(\Delta_B + \Delta_C + \Delta_d) = 0.010 + 2(0.092 + 0.035 + 0.082) = 0.428" \cdot 0.014 + 2(0.125 + 0.035 + 0.082) = 0.498"$$

a = area of SHADED SECTION

A = TOTAL SECTION AREA

Y = CENTROID OF SHADED SECTION

I = MOMENT OF TOTAL SECTION

T = WEB THICKNESS

$$\alpha = \frac{a \cdot Y \cdot A}{I_T} = 7.234$$

SUBJECT

NAME

H. J. STREDDE

DATE

5/10/90

REVISION DATE

WELD SIZE, PLATE TO I-BEAM FLANGE (SECT. 1)

$$f = \frac{V A_y}{I_x} = \frac{40 \times 2000 \times \overset{\text{PLATE}}{(18 \times 1)} \times \overset{\text{CENTROID}}{(7\frac{3}{8} + \frac{1}{2})}}{3942 \times 2} = 1438 \text{ LBS/IN.}$$

$$\text{FILLET SIZE} = \frac{1438}{\frac{14850}{3 \times 70711 \times 70000}} = 0.0968$$

MIN. SIZE DUE TO MATERIAL THICKNESS $\approx 1/4$ USING 3/8 weld; $\frac{0.097}{0.375} = 26\%$ OF CONTINUOUS WELD

SAY 4" WELD ON 8" CTR.

 $\frac{3}{8} \sqrt{4-8} \leftarrow 7018$ PLATE TO I-BEAM (SECT. 2)

$$f = \frac{40 \times 2000 \times \overset{\text{PLATE}}{(12 \times 1)} \times \overset{\text{CENTROID}}{(13\frac{3}{8} + \frac{1}{2})}}{7470 \times 2} = 892 \text{ LBS/IN.}$$

$$\text{FILLET SIZE} = \frac{892}{14850} = 0.060"$$

USING 3/8 FILLET, $\frac{0.060}{0.375} = 16\%$

SAY 3" WELD ON 12" CTRS

 $\frac{3}{8} \sqrt{4-12} \leftarrow 7018$

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ENGINEERING NOTE

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SERIAL-CATEGORY

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SUBJECT

SAMS TOROID LIFT FIXTURE

NAME

H. J. STREDDÉ

DATE

3/21/90

REVISION DATE

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SUBJECT

Hook Link - DETAIL

NAME

H. J. STREDDE

DATE

5/14/90

REVISION DATE

7-9-90

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ENGINEERING NOTE

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SUBJECT

Hook Link - Cross Section

NAME

H. J. STREDE

DATE

7/9/90

REVISION DATE

SUBJECT

HOOK LINK ANALYSIS

NAME

H. J. STREDDE

DATE

7-9-90

REVISION DATE

LINK: MAT'L 3" THICK
H.R.S.

STRESSES:

TEAR OUT THRU TOP

$$S = \frac{40 \times 2000}{6 \times 3} = 4,444 \text{ psi}$$

THRU SIDE, $S = \frac{40 \times 2000}{4 \times 3} = 6,667 \text{ psi}$

WELD SIZE:

LENGTH OF IS EQUAL TO PERIMETER OF W14x145
THAT DISTANCE IS ABOUT 85"

$$f = \frac{40 \times 2000}{85} = 941 \text{ LBS/IN.}$$

$$\text{LEG SIZE} = \frac{941}{14850 (\text{ALLOW/1" FILLET})} = 0.11"$$

MIN REQ'D BASED ON PLATE THICKNESS $\approx 5/16$

USE 3/8.

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ENGINEERING NOTE

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SERIAL-CATEGORY

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SUBJECT

'C' FRAME - CORNER CONNECTION (TYP)

NAME

H. J. STREDDE

DATE

5-14-90

REVISION DATE

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ENGINEERING NOTE

SECTION

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SERIAL-CATEGORY

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SUBJECT

SAMUS INSTALLATION FIXTURE
BOTTOM BEAM

NAME

H. J. STREDOE

DATE

4/26/90

REVISION DATE

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ENGINEERING NOTE

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SUBJECT

CROSS-SECTION → SAMUS
INSTALLATION BEAM

NAME

H. J. STRODDE

DATE

4/26/90

REVISION DATE

SECTION A-A

TYP

SUBJECT

CORNER ANALYSIS

NAME

H. J. STREDDE

DATE

5/15/90

REVISION DATE

Web THICKNESS:

$$t_w = \frac{2.63 M}{F_y A}$$

$$F_y = 36 \text{ KSI}$$

$$M = 4.27 \times 10^6 \text{ IN-LBS} = 4.27 \times 10^3 \text{ IN-KIP}$$

$$\text{THEO } t_w = \frac{2.63 \times 4.27 \times 10^3}{36 \times 14 \frac{7}{8} \times 26 \frac{3}{4}} = .784" > \begin{matrix} 7/16 & \text{W27} \times 84 \\ 11/16 & \text{W14} \times 145 \end{matrix}$$

To increase web use diagonal Stiffeners:

$$\text{REQ. STIFFENER AREA} = \frac{1}{\cos \phi} \left[\frac{1.76 M}{d_b F_y} - 0.67 t_w d_c \right]$$

$$\phi = 29.07^\circ$$

$$\cos \phi = 0.87396$$

$$= \frac{1}{0.87396} \left[\frac{(1.76 \times 4.27 \times 10^3)}{(14.875 \times 36)} - (0.67 \times .438 \times 26.75) \right]$$

$$= 7.075 \text{ IN}^2$$

$$\text{use } 3/4 \text{ plate, THEO, } \frac{7.075}{.75 \times 2} \approx 5" \text{ plate width}$$

STIFFENER IS $3/4 \times 5 \times (28.5 \text{ REF}) \text{ LG.}$

$$\text{Flange Force} = F_y A_f = (36 \times 9.960 \times .640) = 229 \text{ KIP}$$

$$\text{WELD CAPACITY} = (a) \times (.707 \times 21 \times 2) = 29.7 a$$

$$\text{LENGTH AVAILABLE} = 14.875 - 2 = 12.875$$

$$\text{REQ'D } a = \frac{229}{(29.7 \times 12.875)} = 0.599" \text{ SAY } 5/8 \text{ FILLER ALONG AB}$$

SUBJECT

NAME

H. J. STREDE

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Weld Size $\rightarrow$ BC :

40 TON LOAD ; $F_w = .6 \times 36 = 21.6 \text{ ksi}$

TENSILE LOAD: 40 TONS = 80 KIPS.

SHEAR LOAD: $MN = .15 \times 40 \text{ TONS} = 6 \text{ TONS} = 12 \text{ KIPS.}$

TREATING weld as a LINE (REF: BUDGETT 6.3-3)

$$S = \frac{M}{S_w} ; S_w = 2bd + \frac{d^2}{3}$$

$$= (2)(10)(26\frac{3}{4}) + \frac{(26\frac{3}{4})^2}{3}$$

$$= 773.5 \text{ in}^2$$

$$f_b = \frac{4.08 \times 10^6}{773.5} = 5275 \text{ LBS/in.}$$

$$f_r = \frac{40 \times 2000}{(2)(10 + 10 + 25.5 + 25.5 + 9 + 9)} = 899 \text{ LBS/in.}$$

$$f_v = \frac{12000}{(2)(25.5)} = 235 \text{ LBS/in}$$

$$f_{\text{weld}} = \left[(899 + 235)^2 + (5275)^2 \right]^{1/2} = 5396 \text{ LBS/in.}$$

allowable force on Weld (1" fillet) = $(.3)(.707 \text{ in})(70) = 14850 \text{ LBS}$

weld size = $\frac{5396}{14850} = 0.363"$ SAY $\frac{3}{8}$ FILLET

BELOW-THE-HOOK LIFTING DEVICE Engineering Note Cover Page

Lifting Device Numbers:

FNAL Site No.: _____ Div. Specific No.: _____ Asset No. _____
if applicable if applicable if applicable

ASME B30.20 Group: ☒ Group I Structural and Mechanical Lifting Devices
(check one) ☐ Group II Vacuum Lifting Devices
☐ Group III Magnets, Close Proximity Operated
☐ Group IV Magnets, Remote Operated

Device Name or Description: SAMUS MAGNET(S) LIFTING DEVICE ('C' FRAME)

Device was: Purchased from a Commercial Lifting Device Manufacturer
mfg. name: _____

(check all applicable) ☒ Designed and Built at Fermilab
☐ Designed by Fermilab and Built by a Vendor
Assy drawing number: _____
☐ Provided by a User or Other Laboratory
Other. Describe: _____

Engineering Note Prepared by: H. STEDDE Date: 6.27.90Engineering Note Reviewed by: [Signature] Date: REV. 7.15.98

Lifting Device Data:

Capacity: 33 TONSFixture Weight: 3.5 TONS

Service: normal heavy severe (refer to B30.20 for definitions)

Duty Cycle: _____ 8, 16 or 24 hour rating (applicable to groups III, and IV)

Inspections Frequency: _____

Rated Load Test by FNAL (if applicable): Date: 2.23.99 Load: 48 TONS

Check if Load Test was by Vendor and attach the certificate.

Satisfactory Load Test Witnessed by: Donald A. GoloskieSignature (of Load Test Witness): Donald A. Goloskie

Notes or Special Information: