Fermilab

Particle Physics Division

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Mechanical Department Engineering Note

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Title: D0 TEST CRYOSTAT REMOVAL FROM NWA

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Key Words: NWA, D0 Test Cryostat, Cryostat Lifting Fixture, D0 Test Cryostat Lifting Fixture

Abstract/Summary:

The D0 Test Cryostat is to be removed from its current position in NWA and positioned on a flat bed trailer for transport to a site neat the D0 Laboratory. The existing Turntable is to be used as a lifting fixture to accomplish this task.

The existing Hilman roller support plates of the Turntable were originally designed to transmit the load of the Cryostat to the frame below through compression. Another set of Hilman rollers were bolted directly under the rocking support Hilman rollers which means these support plates are taking the vertical load of the Turntable and horizontal load due to rotating the Cryostat, not the vertical load of the cryostat itself. The first

calculation shows that these plates would be overstressed if the Turntable were used to lift the Cryostat and its contents.

The remaining portion of this engineering note is a design to reinforce the turntable so it will be able to lift the Cryostat and its contents. A W12 steel beam is welded to the top of the Turntable on each side of the cryostat. The load of the Cryostat is transmitted to the top of these beams through reinforced steel plates, which are welded to the existing roller support beams of the Cryostat. Lifting lugs are welded to the top of the W12

The design analysis was performed according to both AISC, "Allowable Stress Design "Code and ANSI B30_20," Below the Hook Lifting Devices". The results show that all members will safely support the Turntable and Cryostat assembly within the allowable stress and deflection limits.

Applicable Codes:

- ***AISC Manual of Steel Construction, Allowable Stress Design, Ninth Edition***
- ***ANSI/ASME B30.20-1993, Below the Hook Lifting Devices***
- ***ANSI/AWS D1.1-98, Structural Welding Code - Steel***

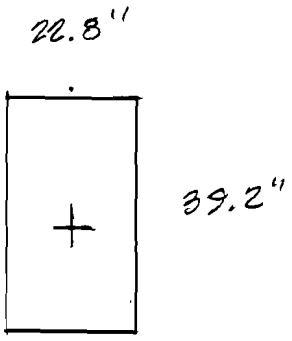
CHECK EXISTING TURNTABLE FOR LIFTING LOADS:

CHECK 1" HILMAN ROLLER SUPPORT PLATE:

SIZE = 22.8125 x 39.1875

P_{MAX} = 56,000# (FROM DØ DRWG. 399342)

USE CASE #4 FROM ROARK & YOUNG.



$a/b = 39.2/22.8 = 1.58$

a/b	1.5	2.0
β	0.66	0.73

$\beta = 0.66$

$q = 56000/39.2(22.8)$

$= 62.7\#/IN^2$

$f_b = 0.66(62.7)(22.8)^2/(1.0)^2$

$= 21,512$ PSI

$F_b = 36,000/3 = 12,000$ PSI $< 21,512$ N.G.

ESTIMATED WEIGHT OF VESSEL & CONTENTS:

CRYOSTAT	30,000#
MODULES	116,990#
SUPPORT GRID	6,000#
	152,990#
TURNTABLE	9000
	161,990# ESTIMATED

ACTUAL:

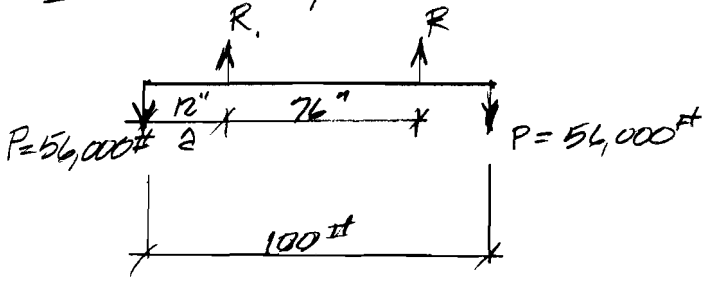
	42,000#
	43,000#
	45,000#
	56,000#
	186,000# ← USE

SUPPORT BEAM DESIGN:

FOR DESIGN, USE 56,000# LOADS

SPAN = 100"

CASE #1 - LIFTING LUGS BETWEEN CRYOSTAT SUPPORTS



$$M = Pa = 56{,}000(12) = 672{,}000\ \#\text{-IN}$$

$$S_{x\ REQ'D} = 672{,}000/12{,}000 = 56\ IN^3$$

$$\text{MAX. } \Delta = L/180 = 100/180 = 0.56"$$

TRY W12 x 120

$S_x = 163\ IN^3 > 56\ IN^3$ ok $\quad I_x = 1070\ IN^4$

$$\Delta_{END} = \frac{Pa^2}{3EI}\left(a + \frac{3}{2}L\right)$$

$$= \frac{56{,}000(12)^2}{3(29{,}000{,}000)(1070)}\left(12 + \frac{3}{2}(76)\right)$$

$$= 0.01" < 0.56 \text{ ok}$$

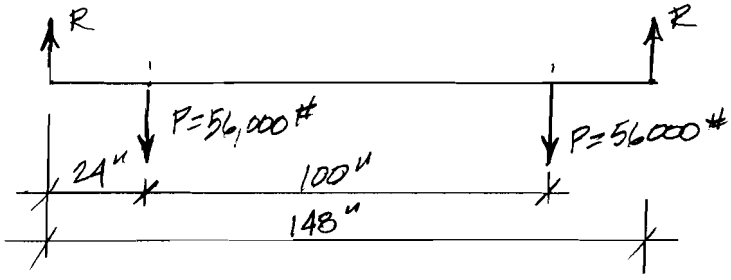
$$\Delta_{CENTER} = \frac{PL^2a}{8EI}$$

$$= \frac{56000(76)^2(12)}{8(29000000)(1070)}$$

$$= 0.015" < 0.5L" \text{ ok}$$

USE W 12 x 120

CASE #2 LIFTING LUGS OUTSIDE OF CRYOSTAT SUPPORTS



$M = P\ell = 56{,}000(24)$

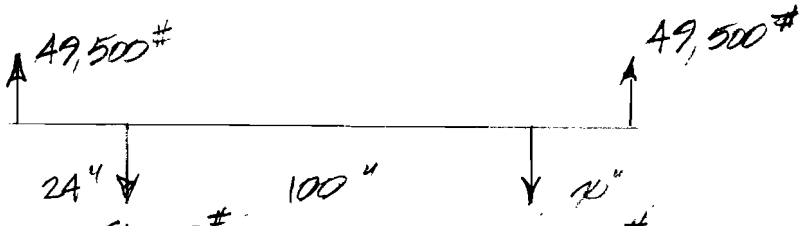
$= 1{,}344{,}000\ \#\text{-IN}$

$S_{x\ REQ'D} = 1344000/12000$

$= 112\ IN^3 < 163\ IN^3$ OK

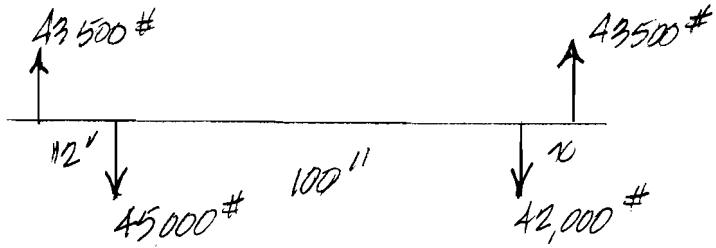
USE W12 × 120

LOCATE LIFTING LUGS TO BALANCE LOAD:



$(24(56{,}000) + 124(43{,}000))/49500 = 134.87$

$x = 134.87 - 124 = 10.86$ SAY 11"



$(12(45000) + 112(42{,}000))/43{,}500 = 120.55$

$x = 120.55 - 112 = 8.55$ SAY 8½"

NEW SUPPORT PLATE DESIGN:

DISTANCE FROM NEW BEAM TO ROCKING ROLLER SUPPORT PLATE = 17"

$$M = 17(56{,}000) = 952{,}000\ \#\text{-IN}$$

TRY 1" PLATE: PLATE MATERIAL $F_y = 33^{KSI}$

HEIGHT OF SECTION @ MAX. MOMENT = 15.625"

$$A = (1)(15.625) = 15.625$$

$$I = \frac{1(15.625)^3}{12} = 317.9\ IN^4$$

$$r = \sqrt{\frac{317.9}{15.625}} = 4.5$$

$$KL/r = 2.0(17)/4.5 = 7.6 < 200 \quad \underline{OK}$$

$t = 1"$

$b = 15.625"$

$$b/t = 15.625/1 = 15.625$$

LIMITING WIDTH-THICKNESS RATIO $= 95/\sqrt{F_y/k_c}$

$$k_c = \frac{4.05}{(h/t)^{0.46}} = \frac{4.05}{\left(\frac{15.625}{1}\right)^{0.46}} = 1.14$$

$$95/\sqrt{33/1.14} = 17.7 > 15.625 \quad OK$$

∴ REDUCTION FACTOR NOT REQ'D. (APPENDIX B P. 5-98)

ADD TOP AND BOTTOM FLANGE PLATES

TRY 1" × 7" PLATES

$$76b_f/\sqrt{F_y} = 76(7)/\sqrt{33} = 92.6"$$

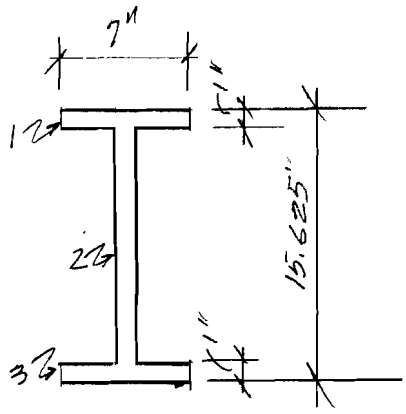
WHICH IS GREATER THAN THE LENGTH OF THE BEAM

∴ $F_b = 0.60\,F_y$ FOR AISC REQUIREMENTS

BUT SINCE THIS IS A LIFTING FIXTURE

$$F_b = 1/3(33) = 11.0\ KSI$$

$$S_x\ REQ'D = 952{,}000/11{,}000 = 86.6\ IN^2$$



	A	y	Ay	Ay^2	I_o	Ay^2+I_o
1	7.0	15.125	105.875	1601.359	0.583	1601.942
2	13.625	7.813	106.452	831.709	210.78	1042.489
3	7.0	0.5	3.5	1.75	0.583	2.333
	27.625		215.827			2646.764
						−1686.312

$\bar{y} = 215.827/27.625 = 7.813$

$A\bar{y}^2 = 27.625(7.813)^2 = 1686.312$

$I_{xx} = 960.452 \text{ IN}^4$

$S_x = 960.452/7.813 = 122.9 \text{ IN}^3 > 79.31 \text{ IN}^3$ ok

LIFTING LUG:

HEAVIEST LOAD = 56,000 + 9000/3 (1/3 TURNTABLE WT.) + (120)(10') = 1200# (BEAMS)

= 60,200#

USE $2\frac{3}{8}$" ϕ HOLE FOR $2\frac{1}{4}$" ϕ SHACKLE

ALLOW. TENSILE STRESS = 11,000 PSI

$A_{REQ'D} = 60,200/11,000 = 5.5 \text{ IN}^2$

MIN. WIDTH OF 1" PLATE:

2.375 + 5.5 = 7.875" SAY 8"

MIN. WIDTH OF 2" PLATE:

5.5/2 + 2.375 = 5.125", USE 2" EA. SIDE OF HOLE

TENSION = 2(2)(2)(12) = 96^K > 60.2^K ok

SHEAR = 2(2)(2)(12 = 96^K > 60.2^K ok

WELD: MIN. SIZE = 5/16" TAB. J2.4 p 5-67

f_v = 5/16(12)(.707) = 2.65 K/IN

60.2/2.65 = 22" WELD REQ'D

BASE OF LUG MUST BE 12" LONG
WELD EA. SIDE = 24" WELD OK