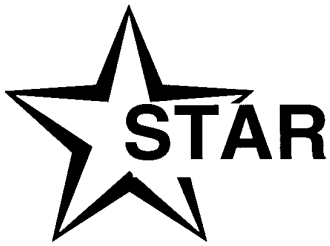


Controlled STAR Note # 0308

Ernest Orlando Lawrence Berkeley National Laboratory - University of California

Controlled STAR Note # 0308	Engineering Note # M7649	WBS # 4.2.10	Page Count 11
Author Russell Wells		Date 10/10/97	

PROGRAM-PROJECT-JOB

STAR Project

TITLE

Shipping Support Extension and Spacer

REV. A
REV. B

Jay Marx, Project Director

10/23/97

Bill Edwards, Project Manager

Lawrence Berkeley Laboratory – University of California	Code	Serial	STAR doc #	Page
Engineering Note	SR0210	M 7649	CSN0308	1 of 10
Author	Department	Date	STAR WBS#	
Russell Wells	Mechanical Engineering	10/10/97	4.2.10	

Program

Solenoidal Tracker at RHIC (STAR)

Subprogram

Time Projection Chamber - Assembly and Test

Title

Shipping Support Extension and Spacer

Responsible Designer : Russell Wells Date 10/22/97

Russell Wells

Reviewed by : Robert C. Shilling Date 10/22/97

ROBERT C. SHILLING

Introduction

The TPC Lifting Fixture, LBL Engineering Note M7548, is designed to work in conjunction with the TPC Test Stand Support. To use the TPC Lifting Fixture with the Shipping Support Frame an extension is needed. The following note covers the design and testing of the Shipping Support Extension, 21F0424A and Lifting Fixture Spacer, 21F0404A.

The TPC weighs 12,200 lb., the shipping support 7,900 lb. and the four extensions and spacers are roughly 400 lb. for a total of 20,500 lb. The fixture distributes the load evenly between the four lifting points producing a load on each individual spacer and extension of 5,125 lb.

Description

The shipping extension is fabricated from 8 x 4 x 0.5 inch carbon steel rectangular tube and a top plate of 1.25 inch thick A-36 steel. Through holes on the side of the tube accomodate four 3/4 inch bolts while four 3/4 - 10 threaded holes in the top plate are used to bolt the lifting fixture to the extension. As its name implies, the spacer bolts between the extension and the shipping frame. The spacer is a 10 inch long section of 8 x 6 x 0.5 inch carbon steel rectangular tube. Four through holes on each 8 x 10 inch face of the tube accomodate 3/4 inch bolts. Refer to the attached LBL drawings 21F0404A and 21F0424A.

Calculations

Tensile stress, Extension, rectangular tube.

Due to the 10 degree cut through the tube for bolt access, assume that only half of the cross section carries the load,

Cross sectional area of 8 x 4 x 0.5 rectangular tube, from ref. 1:

$$A_{8x4} := 10.1 \cdot in^2$$

For design purposes use a load of 6000 lb. $F := 6000 \cdot lbf$

$$A_t := \frac{A_{8x4}}{2} \qquad \sigma_t := \frac{F}{A_t} \qquad \sigma_t = 1.188 \cdot 10^3 \cdot \frac{lbf}{in^2}$$

Bending Stress at edge of clamped section:

The rectangular tube is cut away to a thickness of 3.48 inches to allow for bolting. This leaves a deep channel section. Using ME-10 to graphically determine the area modulus, Ich, at the cut section gives:

$$I_{ch} := 7.34 \cdot in^4 \qquad c := 2.45 \cdot in$$

$$M := 2\ in \cdot F$$

$$\sigma_b := \frac{M \cdot c}{I_{ch}} \qquad \sigma_b = 4.005 \cdot 10^3 \cdot \frac{lbf}{in^2}$$

Combined stress at the edge of the clamped section:

$$\sigma_c := \sigma_t + \sigma_b$$

$$\sigma_c = 5.194 \cdot 10^3 \cdot \frac{lbf}{in^2}$$

Safety Factor , based on ultimate strength of carbon steel structural shapes.

$$\sigma_{ult} := 58000 \cdot \frac{lbf}{in^2} \qquad SF := \frac{\sigma_{ult}}{\sigma_c} \qquad SF = 11.168 \qquad \textbf{OK, SF> 5}$$

Stress in fillet weld.

Effective throat width of 0.5 inch fillet weld.

$$t_w := 0.5 \cdot .707 \cdot in$$

Effective stress area

$$A_w := 2 \cdot (4 \cdot in + 8 \cdot in) \cdot t_w$$

Stress in weld

$$\sigma_w := \frac{F}{A_w} \qquad \sigma_w = 707.214 \cdot \frac{lbf}{in^2}$$

Stress on 3/4 - 10 fastener.

Assuming the load is shared equally between bolts:

$$F_b := \frac{F}{4}$$

Stress area: $A_b := 0.334 \cdot in^2$

Shear $\tau_b := \frac{F_b}{A_b} \qquad \tau_b = 4.491 \cdot 10^3 \cdot \frac{lbf}{in^2}$

Minimum tensile strength grade 2 fastener , ref. 2: $\sigma_{ult} := 64000 \cdot \frac{lbf}{in^2}$

Minimum shear strength is approximately 1/2 of tensile strength

Safety Factor:

$$SF := \frac{\frac{\sigma_{ult}}{2}}{\tau_b} \qquad SF = 7.125 \qquad OK$$

Axial stress on 3/4 - 10 bolts due to prying.

Under worst case conditions in the bolts joining the spacer to the support frame column are not tightened sufficiently. In this case the moment generated by the offset between the line of action of the lifting fixture and the side of the support frame column is resisted by the lower pair of bolts attaching the spacer to the column. This moment generates a prying action on these bolts with the fulcrum at the top edge of the spacer.

Applied moment

Distance from line of action of lifting fixture to side of support column is 10 inches.

$d := 10 \cdot in$

$M := F \cdot d$

The distance from the top edge of the spacer to the center of the lower bolt holes is 8 inches.

$h := 8 \cdot in$

Axial force on the lower two bolts

$$F_{ba} := \left(\frac{1}{2}\right) \cdot \frac{M}{h} \qquad F_{ba} = 3.75 \cdot 10^3 \cdot lbf$$

Axial stress

$$\sigma_{ba} := \frac{F_{ba}}{A_b}$$

$$\sigma_{ba} = 1.123 \cdot 10^4 \cdot \frac{lbf}{in^2}$$

Safety Factor:

$$SF := \frac{\sigma_{ult}}{\sigma_{ba}} \qquad SF = 5.7 \qquad \text{OK}$$

Shear tear out of spacer at bolt hole.

Given a is the distance from edge of hole to edge of plate, dH is the hole diameter, b is the wall thickness and the distance from hole center to edge is 2.0 inches.

$$b := .5 \cdot in \qquad d_H := .813 \qquad a := 2.0 \cdot in - \frac{d_H}{2} \cdot in$$

The load is shared between four bolts.

$$\tau_{to} := \frac{\frac{F}{4}}{2 \cdot a \cdot b} \qquad \tau_{to} = 941.324 \cdot \frac{lbf}{in^2}$$

Safety Factor

For carbon steel structural shapes.

$$\sigma_{ult} := 58000 \cdot \frac{lbf}{in^2}$$

Minimum shear strength is approximately 1/2 of tensile strength

$$SF := \frac{\frac{\sigma_{ult}}{2}}{\tau_{to}} \qquad SF = 30.808 \qquad OK$$

Bearing failure, where D is the diameter of the bolt.

$$D := .75 \cdot in$$

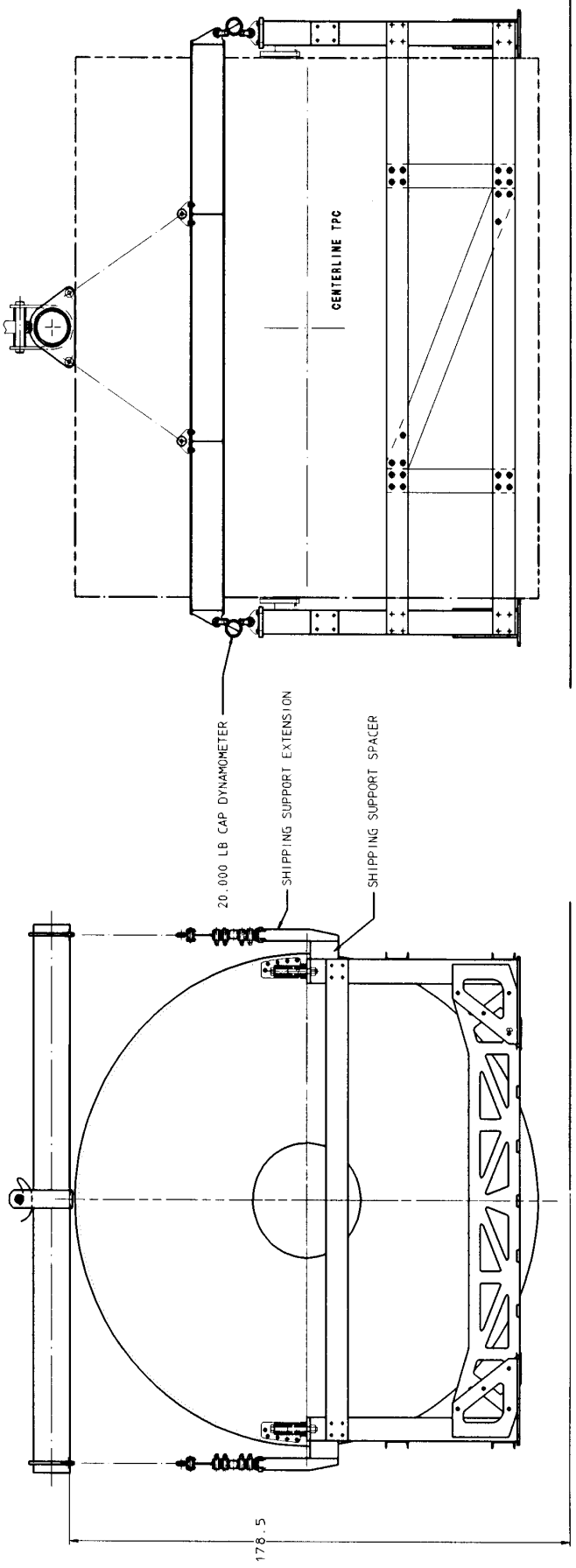
$$\sigma_b := \frac{\frac{F}{4}}{D \cdot b} \qquad \sigma_b = 4 \cdot 10^3 \cdot \frac{lbf}{in^2}$$

Safety Factor

$$SF := \frac{\sigma_{ult}}{\sigma_b} \qquad SF = 14.5 \qquad OK$$

Conclusion .

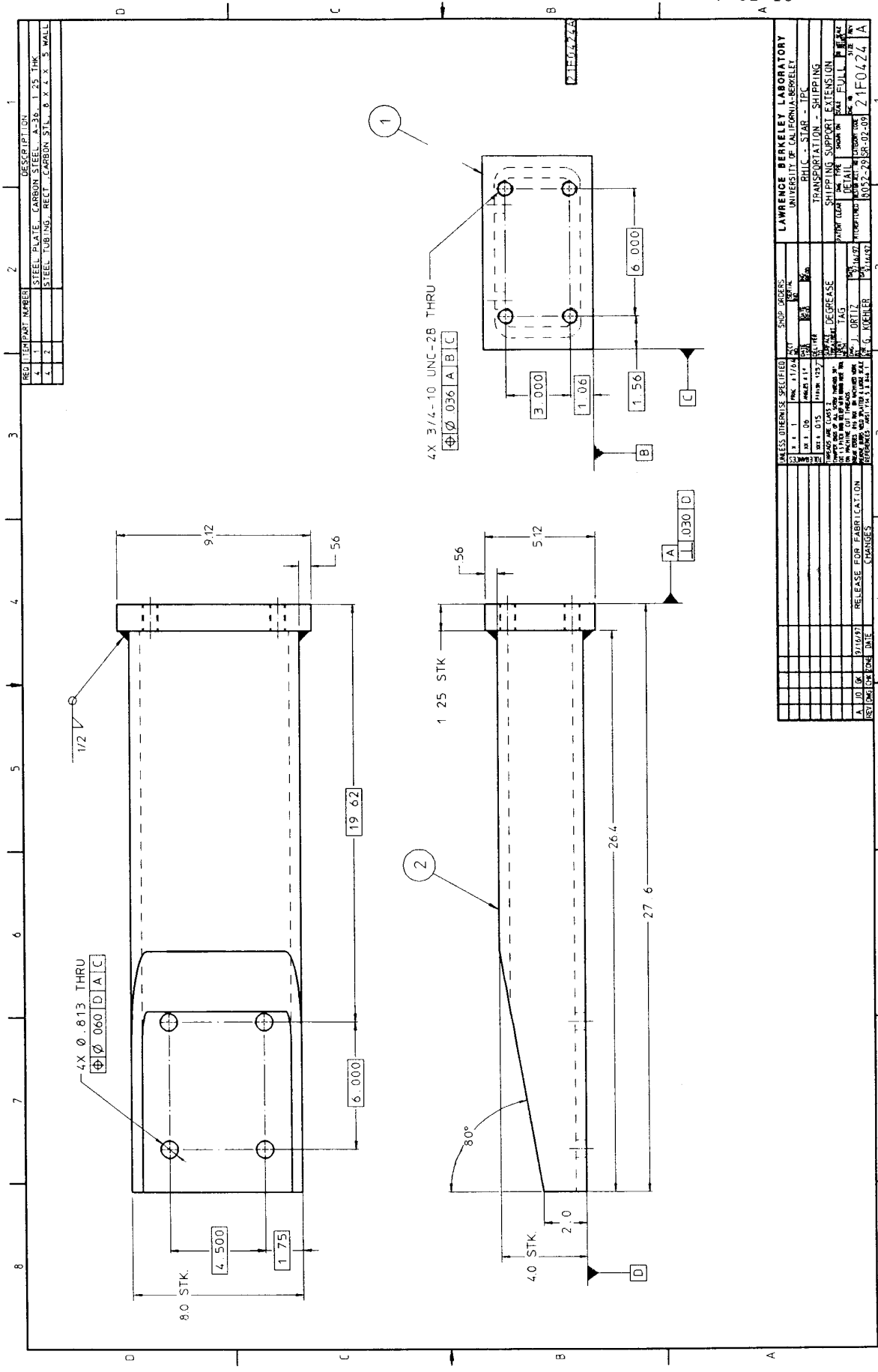
The design of the TPC Shipping Support Spacer and Extension are consistent with good practices and the Laboratories Safety Manual PUB 3000 for lifting fixtures. The maximum stresses do not exceed 1/5 th of the ultimate strength of the material.

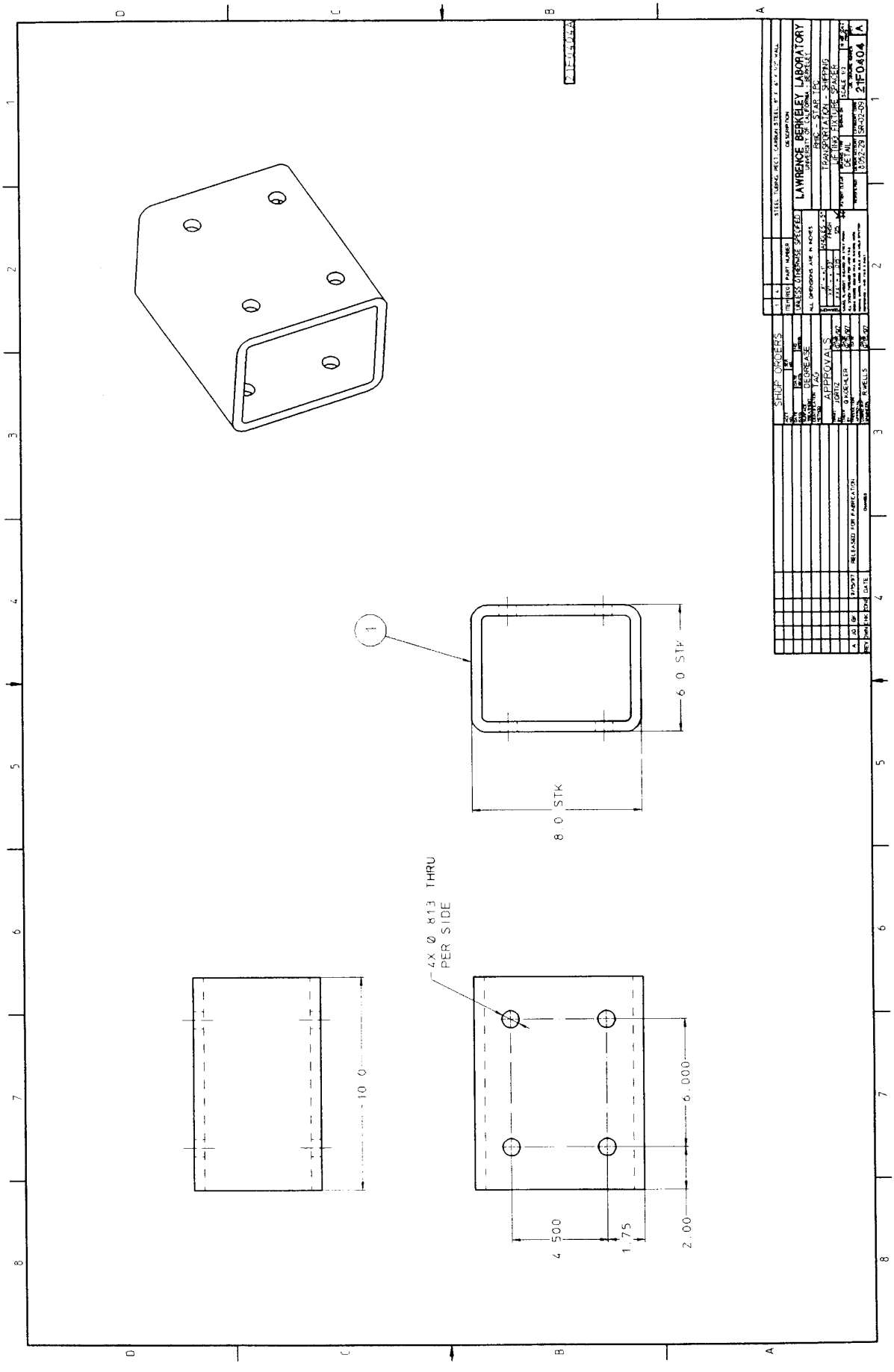


ELEVATION VIEW

END VIEW

TPC LIFTING FIXTURE ON SHIPPING SUPPORT


LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY
RHIC - STAR - TPC
TRANSPORTATION - SHIPPING
SHIPPING SUPPORT EXTENSION
21F0424
A
DESCRIPTION
STEEL PLATE, CARBON STEEL, A-36, 1.25 THK
STEEL TUBING, RECT, CARBON STL, 8 X 4 X .5 WALL
RELEASE FOR FABRICATION
CHANGES
4X 3/4-10 UNC-2B THRU
Ø .036 A B C
4X Ø .813 THRU
Ø .060 D A C
1 25 STK
8.0 STK.
4.0 STK
80°
3.000
1.06
1.56
6.000
9.12
5.12
.56
19.62
26.4
27.6
2.0
4.500
1.75
.030 D



/jortiz/STAR/TRANS_SHIP/LIFTINGFIXTURE SPACER.DET....15-Sep-97

Oakland * Santa Clara * Sacramento

Testing Engineers, Incorporated

NDT DEPARTMENT

2811 Adeline Street * Oakland, CA 94623 * 510-835-3142

LABORATORY NO. Y1015 DATE 10/15/97
CLIENT U. C . Lawrence Berkeley Lab.
ADDRESS No. 1 Cyclotron Road
Berkeley, CA 94720
JOB LOCATION NDT LAB - OAKLAND
CLIENT P.O. NO. 6465960
JOB NO.
ITEM DESCRIPTION LIFTING FIXTURE
PLAN OR DRAWING NO. SEE BELOW
EXAMINATION: PARTIAL SEE BELOW 100%

MAGNETIC PARTICLE INSPECTION REPORT

NDE Standard ASTM E709

Acceptance Standard NO CRACKS

Procedure No. SPP-MT-213 (Rev. 1)

Stage of Fab.: In Process ☐ Final ☒

Type of Work: New ☒ Repair ☐

Heat Treatment: Before Inspection ☒ After Inspection ☐

Surface Condition: AS ROLLED/PAINTED

Material: Type STEEL Temp. AMBIENT

Equipment Manufacturer:
MAGNAFLUX CORP.

Model No. ARO-966
S/N 52337

AC ☐ DC ☒ Wet ☒ Dry ☐
Fluorescent ☒ Visible ☐

Particle Type Magnaflux Corp. 14A
Head Amperage 2,500
Central Conductor Amperage N/A
Coil Amperage 1,500 (5 turn coil)
Prod Amperage N/A
Spacing N/A
AC Yoke DC Yoke
Demagnetized: YES ☒ NO ☐
Other NDT Required: YES ☐ NO ☒
Type:

PC # or SN #	ACC	REJ	REMARKS
LIFTING FIXTURE Dwg No. 21F0404, Rev. A (4 Total)	4	0	Performed magnetic particle inspection over the 2" diameter area centered on the 0.813" diameter holes and at each of the eight corners over the full radius and extending 2" from the machined edge. No rejectable indications were detected.

TEST WITNESSED BY:

Technician Timothy J. Parker Level: II
Asst. Tech. Level:
Certification Expiration Date: 5/00
Report Reviewed by:
Peter K. Palko, NDT Supervisor

WP/NDT/MAGNETIC/Y1015.1

Oakland * Santa Clara * Sacramento

Testing Engineers, Incorporated

NDT DEPARTMENT

2811 Adeline Street * Oakland, CA 94623 * 510-835-3142

LABORATORY NO. Y1015 DATE 10/15/97
CLIENT U. C . Lawrence Berkeley Lab.
ADDRESS No. 1 Cyclotron Road
Berkeley, CA 94720
JOB LOCATION NDT LAB - OAKLAND
CLIENT P.O. NO. 6465960
JOB NO.
ITEM DESCRIPTION LIFTING FIXTURE
PLAN OR DRAWING NO. SEE BELOW
EXAMINATION: PARTIAL SEE BELOW 100%

MAGNETIC PARTICLE INSPECTION REPORT

NDE Standard ASTM E709

Acceptance Standard NO CRACKS

Procedure No. SPP-MT-213 (Rev. 1)

Stage of Fab.: In Process ☐ Final ☒

Type of Work: New ☒ Repair ☐

Heat Treatment: Before Inspection ☒ After Inspection ☐

Surface Condition: AS WELDED/AS ROLLED/MACHINED

Material: Type STEEL Temp. AMBIENT

Equipment Manufacturer:
MAGNAFLUX CORP.

Model No. ARO-966
S/N 52337

AC ☐ DC ☒ Wet ☒ Dry ☐
Fluorescent ☒ Visible ☐

Particle Type Magnaflux Corp. 14A
Head Amperage 2,500
Central Conductor Amperage N/A
Coil Amperage 1,500 (5 turn coil)
Prod Amperage N/A
Spacing N/A
AC Yoke ___ DC Yoke
Demagnetized: YES ☒ NO ☐
Other NDT Required: YES ☐ NO ☒
Type:

PC # or SN #	ACC	REJ	REMARKS
LIFTING FIXTURE Dwg No. 21F0424, Rev. A (4 Total)	4	0	Performed magnetic particle inspection over the 2" diameter area centered on the 0.813" diameter holes and on 100% of the welds. No rejectable indications were detected.

TEST WITNESSED BY:

Technician Timothy J. Parker Level: II
Asst. Tech. Level:
Certification Expiration Date: 5/00
Report Reviewed by:
Peter K. Palko, NDT Supervisor

WP/NDT/MAGNETIC/Y1015.2

Oakland * Santa Clara * Sacramento

Testing Engineers, Incorporated

NDT DEPARTMENT

2811 Adeline Street * Oakland, CA 94623 * 510-835-3142

LABORATORY NO. Y1015 DATE 10/15/97
CLIENT U. C . Lawrence Berkeley Lab.
ADDRESS No. 1 Cyclotron Road
Berkeley, CA 94720
JOB LOCATION NDT LAB - OAKLAND
CLIENT P.O. NO. 6465960
JOB NO.
ITEM DESCRIPTION HEX HEAD BOLTS
PLAN OR DRAWING NO.
EXAMINATION: PARTIAL SEE BELOW 100%

MAGNETIC PARTICLE INSPECTION REPORT

NDE Standard ASTM E709

Acceptance Standard NO CRACKS

Procedure No. SPP-MT-213 (Rev. 1)

Stage of Fab.: In Process ☐ Final ☒

Type of Work: New ☒ Repair ☐

Heat Treatment: Before Inspection ☒ After Inspection ☐

Surface Condition: ZINC PLATED

Material: Type STEEL Temp. AMBIENT

Equipment Manufacturer:
MAGNAFLUX CORP.

Model No. ARO-966
S/N 52337

AC ☐ DC ☒ Wet ☒ Dry ☐
Fluorescent ☒ Visible ☐

Particle Type Magnaflux Corp. 14A
Head Amperage 1,000
Central Conductor Amperage N/A
Coil Amperage 2,000 (5 turn coil)
Prod Amperage N/A
Spacing N/A
AC Yoke DC Yoke
Demagnetized: YES ☒ NO ☐
Other NDT Required: YES ☐ NO ☒
Type:

PC # or SN #	ACC	REJ	REMARKS
HEX HEAD BOLTS 3/4" X 2" NC 10P (32 Total)	32	0	No rejectable indications detected.
NUTS For Above Bolts (32 Total)	32	0	No rejectable indications detected.

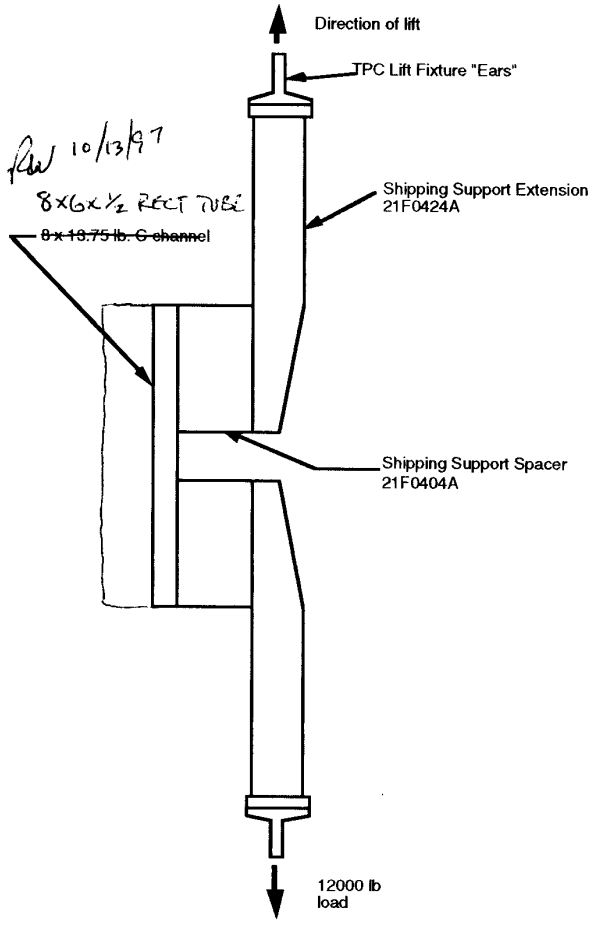
TEST WITNESSED BY:

Technician Timothy J. Parker Level: II
Asst. Tech. Level:
Certification Expiration Date: 5/00
Report Reviewed by:
Peter K. Pálko, NDT Supervisor

WP/NDT/MAGNETIC/Y1015

Proof Load Test

Pairs of Shipping Support Spacers and Extensions are to be bolted to a C channel and subjected to a proof load of 12,000 lb. in tension. Attachment to this assembly will be made via the "lifting ears" portion of the TPC Lifting Fixture. A static load will be applied by either lifting a 12,000 lb. weight or applying a 12,250 lb. tensile load as measured by a dynamometer between the crane and test piece. The load shall be applied for a minimum of 10 minutes.



Remarks:

Test Performed by: Dwright Crane Pro Svcs Date 10/13/97

Test Witnessed by: Russell Wells Date 10/13/97
Russell Wells