CRITICAL LIFT EVALUATION FORM

PERSON REQUESTING THE LIFT
Print Name K. Brown **Dept/Div.** Physics/STAR **Date** 1/6/04

PERSON IN CHARGE (PIC) Personnel Qualified in:
Print Name USE OF 1006 CRANE & PMT/MAPMT LIFTING Procedure
PIC must be present during the entire CRITICAL LIFT and be QUALIFIED to resolve any question or problems that might arise during the lifting operation.

DETERMINING FACTOR FOR CRITICAL LIFT

____ Load is greater than 85% of rated mobile crane capacity, or greater than 95% of rated fixed crane capacity, or greater than 50 tons.
____ Two or more cranes/booms are required or special hoisting/rigging equipment will be used.
____ Potential for release of radioactive/hazardous due to collision, or upset of load.
X Damage that would result in more than 3 weeks or 30% delay to schedule, or monetary value damages of $250,000 or greater.

OPERATING EQUIPMENT (mobile crane)

Type of Crane NA Manufacturer _____
Model No. _____ Serial No. _____
Manufacturer Restriction for WIND SPEED _____ (no lifts at wind speeds of 25 mph or greater)
Crane Equipped with Anemometer _____ (if not, Use BNL Weather Station)
Copies of Latest Annual Inspection _____ Latest Calibration Date of Instruments _____
Operator Licensed for Equipment _____ Expiration Date _____

OPERATING EQUIPMENT (overhead cranes)

Type of Crane Overhead Manufacturer ACE
Capacity 20 TON Latest Calibration Date of Instruments _____
Date of Latest Annual Inspection 8/1/03 Operator's SAC Expiration Date_____

DESCRIPTION OF ITEMS TO BE LIFTED

MAPMT / PMT Boxes For EEMC detector

HOW WEIGHT OF OBJECT OBTAINED

A. Certified Weight Scale MAPMT = 88.55# Ticket # Indiana State Certified Scale
PMT = 97.05#

B. Calculated Independently by More then One Source

1. Source _____ Weight _____
2. Source _____ Weight _____

C. If lift is an existing item (being removed or demolished), the weight must be recalculated, taking into account all modifications, including internal, as well as an Allowance for Scale, Sediment, Sludge, and Insulation. Calculation Work Sheets SHALL be included in the LIFT PLAN and have a PE stamp or be signed off by a QUALIFIED PERSON. **(When weights are calculated, a 10% tolerance margin shall be added. This value may be increased at the discretion of the Lifting Safety Committee).**

D. Shipping Manifests Weight _____ Manufacturer Data Weight _____

CENTER OF GRAVITY (CG)

CG will be marked onto load, and a drawing included showing how it was determined. see Lifting Procedure

DESCRIPTION & WEIGHT OF ALL RIGGING EQUIPMENT & CRANE ATTACHMENTS

Type of slings	Nylon Brilla	Rated Capacity 6200# @ 30°	Weight 20#
Shackles			
Lifting Rings/ Eyebolts	Jengans	2500 #	20 #
Riggings Hooks			
Load Block/Jib			
Spreader Bars/Below the Hook Lifting Devices **(must comply with ASME B30.20 Standard for Design, Testing, and Appropriate Markings)**		Rated Capacity	Weight

WEIGHT OF OBJECT, RIGGING EQUIOPMENT, & CRANE ATTACHMENTS

Source Solid Modeling Total Weight 1300# - Fixture & Box

EQUIPMENT AND LIFT RELATIONSHIP

A. Maximum Operating Radius: —

B. Planned Operating Radius: —

C. Allowable load at maximum lift radius anticipated (from Load Chart): —

D. Ratio of Lift to Allowable Load: .03

E. Clearance between Boom & Lift: —

F. Clearance to Surrounding Facilities/Utilities: —

G. Clear Path for Load Movement: 2"

STABILITY OF GROUND AREA

A. Soil Bearing Capacity: Na Source:

B. Mats Required: Size & Number:

C. Underground Utilities Location:

D. Ratio of Soil Bearing Capacity to Actual:

LIFTING OPERATION

A detailed drawing, to scale, MUST be included showing the Set-up Area, Lifting Area, Load Placement Area, and Sling Attachment Points w/sling angle reduction factor.

INSPECTION OF CONTRACTORS EQUIPMENT

All contractors' Lifting and Rigging Equipment must be inspected before being brought onto the BNL Site by BNL Hoisting & Rigging Inspector: Contact: John Hynan: (631) 344-5456

LIFT APPROVAL SIGNATURES

Professional Engineer/ Qualified Person:

Person in Charge (PIC): Tony Kuyper

Operator of Equipment: Qualified Personnel

Responsible Manger or Designee:

Lifting Safety Committee Recommendation: Approve: Disapprove:

LSC Committee Chair: 2/13/04

FINAL APPROVAL SIGNATURE:

Deputy Director for Operations M. Kerney for M.B. 2/17/04

PRE-LIFT MEETING

Date: Time: Location:

LIST OF ALL ATTACHMENTS

STAR Documented Work Procedure

Brookhaven National Laboratory
RHIC Project
STAR Collaboration
Documented Work Procedure No. : SOP-I&T-GEN-05-A
Rev. No.: A
Issue Date: December 16, 2003
Title: Documented Work Procedure for the Design and Required use procedures of the PMT/MAPMT Box Lifting Fixture for the EEMC (CSN 0448).

Approved by:

Author	Safety Coordinator
STAR Chief Eng./QA	C-A ES&H
Other:	Other:

Revision Record

Rev. No.	Date	Page	Subject	ECN

Controlled STAR Note 0448

Design and Required Use Procedures of the PMT/MAPMT Box Lifting Fixture for the EEMC

Prepared by: _____ *W.J. Leonhardt*

Approved by: _____ *R.L. Brown*

REVISION RECORD

Rev. No.	Date	Page	Subject	ECN
0	**3/21/03**	**All**	**DRAFT Release**	**N/A**
A	**7/17/03**	**All**	**INITIAL Release**	**N/A**

Design and Required Use Procedures of the PMT/MAPMT Box Lifting Fixture for the EEMC

Abstract

This note describes the design of the lifting fixture used to install and remove the PMT and MAPMT instrumentation boxes of the STAR Endcap Electromagnetic Calorimeter and sets out the required procedures for its use.

Required Approval

No person shall use this lifting fixture without training in its use and approval by the STAR Technical Support Group Leader.

General

The Endcap Electro Magnetic Calorimeter (EEMC) installed in the STAR detector is mounted on the inside surface of the detector's west poletip. The EEMC is connected to 108 instrumentation boxes, mounted on the poletip's outer surface, by optical fibers that pass around the outer edges of the poletip.

There are two types of instrumentation boxes, PMTs and MAPMTs. The sixty PMT boxes weigh approximately 105 lbs. each and are described in STAR drawing EEMC-400-D-1. The forty-eight MAPMT boxes weigh approximately 85 lbs. each and are described in STAR drawing EEMC418-D-1. Figure 1 shows a drawing of how the boxes are arrayed on the poletip and Figure 2 has two photographs showing several PMT boxes mounted on the poletip.

Since the boxes are relatively heavy and installed quite close together, it is impractical to install and remove them by hand and thus a dedicated lifting fixture is used. This note describes the design and use of this fixture.

Normal Operation

The PMT and MAPMT boxes are installed on the poletip very close to one another making it difficult to grab and hold on to them during installation and removal. To address this, special plates have been designed to attach onto the box face that is most readily accessible and then the lifting fixture is attached to these plates. This results in lifting the boxes with an overhanging load. To compensate for this, the lifting fixture has a large counterweight and a translating carriage that is adjusted in use to keep the fixture hanging plum.

Figure 3 shows a drawing of a computer model of the lifting fixture attached to a PMT box and figure 5 shows the assembly drawing of the fixture. In operation, an adapter plate is attached to a box and then the lifting fixture is attached to the adapter plate. Guide plates aid in this attaching process. The flange on the lifting fixture that attaches to the adapter plate can rotate to accommodate the various installation attitudes the boxes have on the poletip.

Once a box is mounted on the lifting fixture, the center of gravity (CG) changes and the upper carriage is translated to insure that the fixture/box combination hangs plum. Approximately 1000 lbs. of counterweight is used to keep the necessary translating distance to a minimum. Because of this large counter weight, the entire lifting fixture weighs approximately 1200 lbs.

The installation of a box requires that the lifting fixture bring a box to its location on the poletip hanging plumb. Alignment pins protrude from the box mounting locations to aid in installation and the boxes are guided onto these pins by a horizontal traverse using a combination of the building crane motion and pushing by the installation personnel. Long tools are then used to bolt the box into place. Once the box is fixed to the poletip, the potential exists for the crane to be lowered and all the weight of the lifting fixture transferred to the box mounting bolts. This would result in over-stressing the mounting bolts. To prevent this, the lifting fixture incorporates a sliding yoke. During operations, a box is affixed, through the mounting flange and shaft, to the yoke, which hangs on the counterweight assembly. The yoke normally hangs at its lowest position, relative to the counterweight when the box weight is supported by the counterweight. If the situation is reversed and the box is supporting the counterweight, the yoke slides up relative to the counterweight. Installation personnel are trained to halt operations if the yoke begins to move and take immediate action to relieve the box of any added load.

Specific box installation procedures are found in Appendix I and removal procedures in Appendix II.

Piggyback Operations

Periodically, components inside of PMT and MAPMT boxes require servicing or replacement. To accomplish this, the side panels of the boxes have to be removed. When the boxes are installed on the poletip there is neither sufficient room to remove these side panels nor room to access the insides of the boxes, therefore the boxes must be removed for servicing. When the boxes are initially installed, many optical fibers from the EEMC are connected to each box. This is a very labor-intensive process and the need to disconnect these fibers is to be avoided.

Piggyback operations have evolved so that boxes can be serviced without optical fiber disconnections. When a box needs servicing, an adapter plate is attached to that box's immediate neighbor. The box to be serviced is then removed in the normal fashion and attached to its neighbor in a "piggyback" fashion. Naturally, the initial installation of the optical fibers on the boxes is done in a way that provides enough slack for this operation. In the case of MAPMT boxes, the water lines have this slack as well.

Figure 4 shows a drawing of a computer model of the lifting fixture attached to a PMT box and piggybacked to another box. Figure 6 shows the assembly drawing of the piggyback operation. Figure 7 is a photograph showing the optical fibers attached to a PMT box. The pencil in the photo is pointing to the mounting holes for the adapter plate. To attach the plate, the wire connectors by the mounting holes are removed. Procedures for the piggyback operation are found in Appendix III.

Stress Analysis

The lifting fixture has undergone a stress analysis using hand calculations and engineering judgment. The results show that the minimum factor of safety during static operation is greater than 8 based on the material yield strength.

Relevant Drawings

The following is a list of the engineering drawings that describe the boxes, the lifting fixture and the box installation:

PMT Box Assembly	EEMC400-D-1
MAPMT Box Assembly	EEMC418-D-1
Box Lifting Fixture Assembly	EEMC460-E-1
Box Piggyback Installation	EEMC477-E-1
Box Mounting Locations	EEMC730-E-1&2

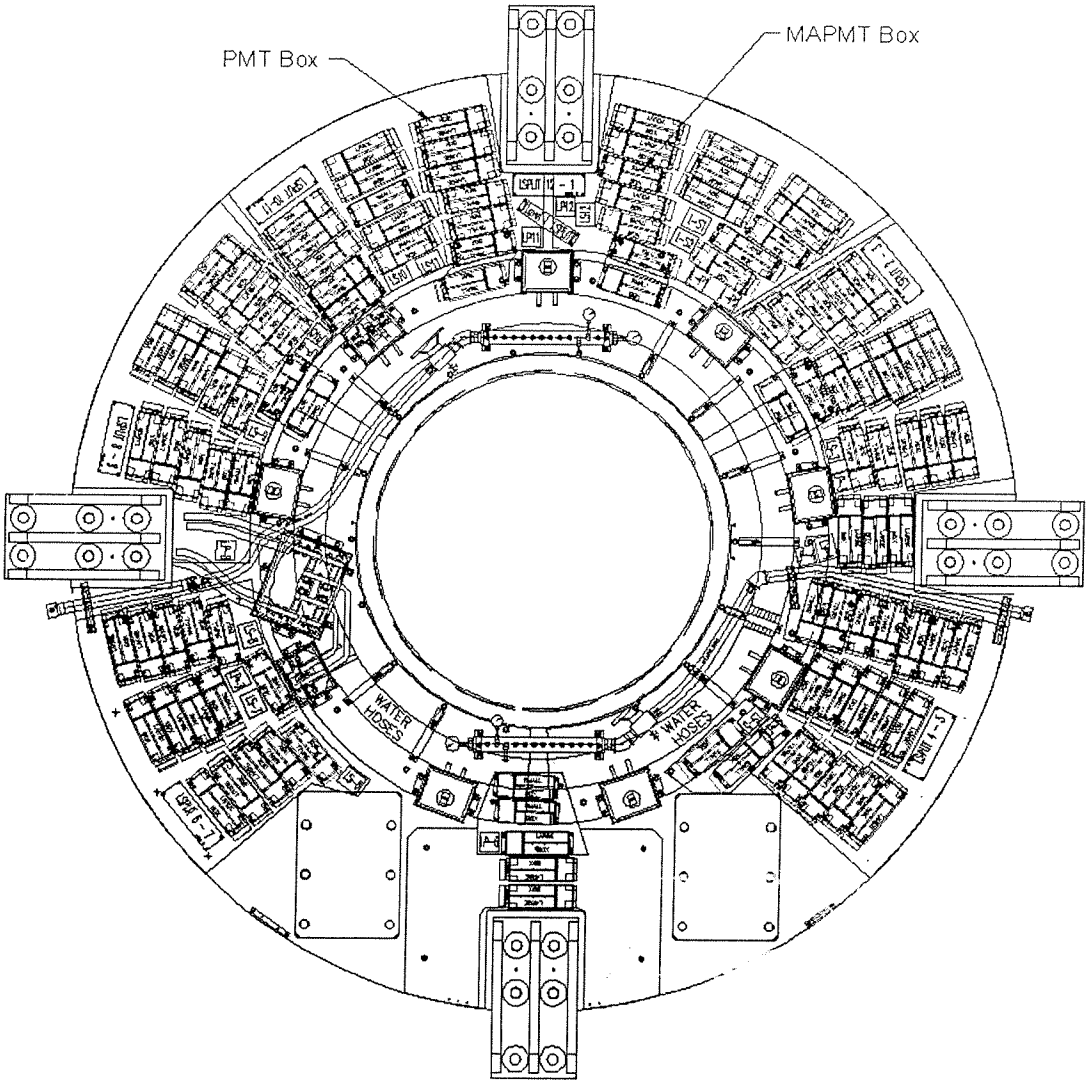


Figure 1 Array of PMT and MAPMT Boxes on STAR West Poletip

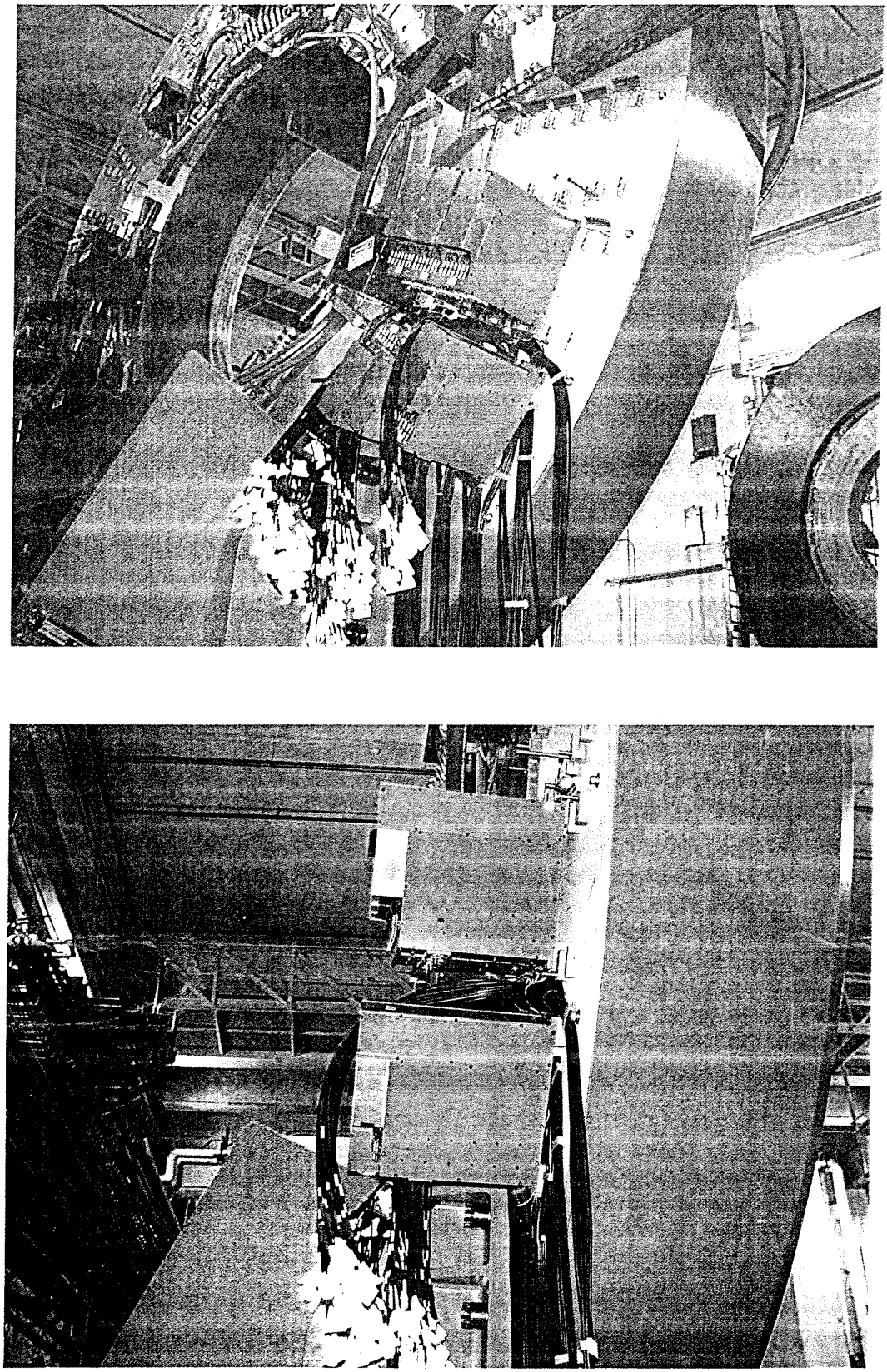


Figure 2 PMT Boxes Mounted on the Poletip

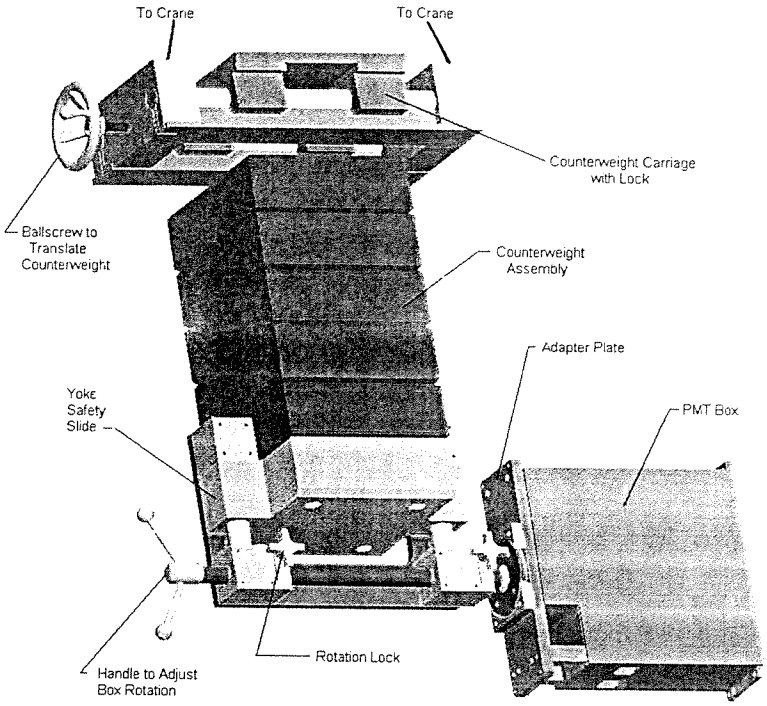


Figure 3 Computer Model of Lifting Fixture with PMT box Attached

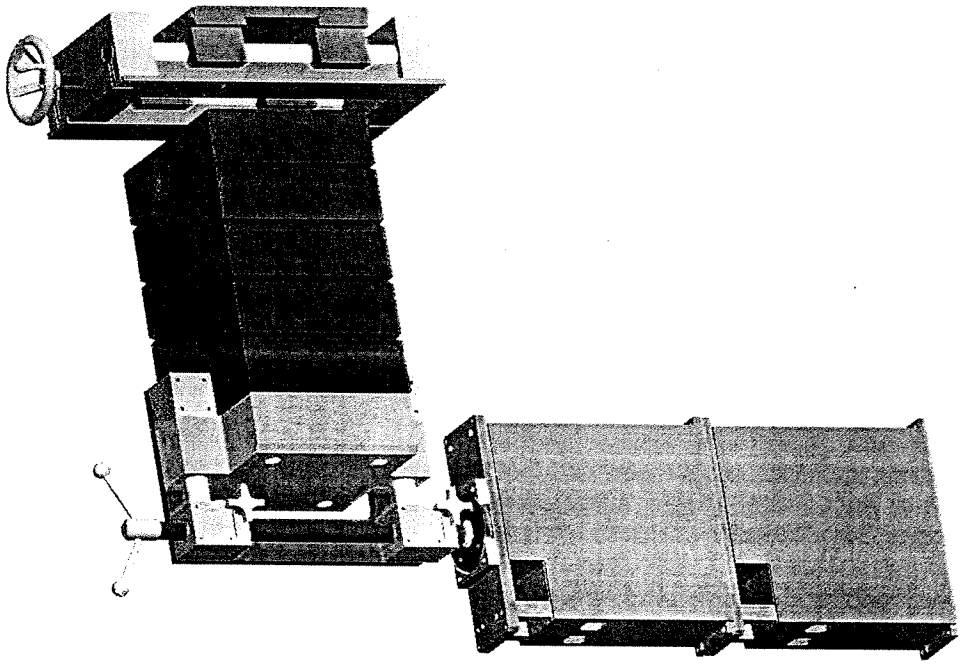


Figure 4 Computer Model of Lifting Fixture with PMT box Piggybacked to Neighbor

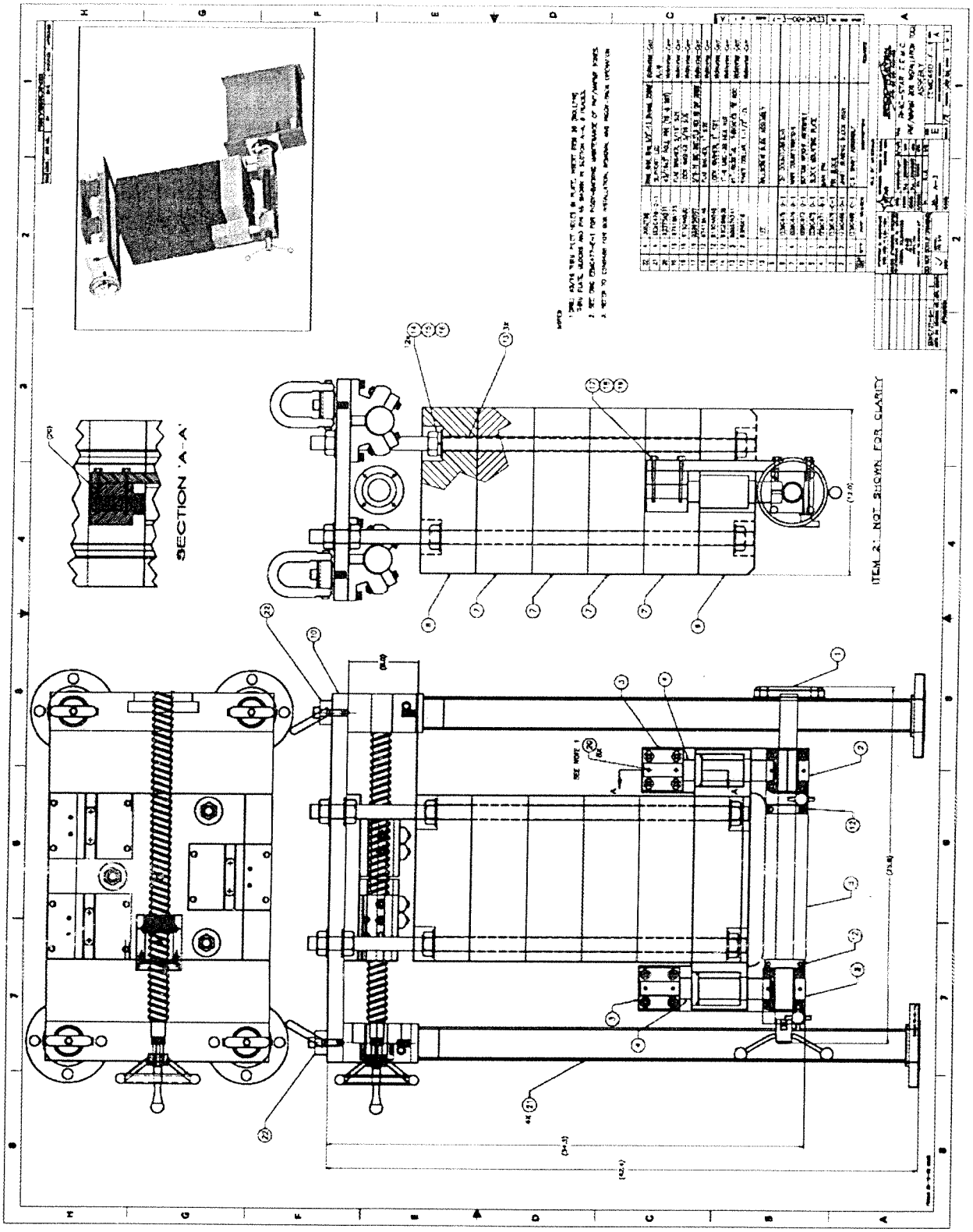


Figure 5 Lifting Fixture Assembly Drawing

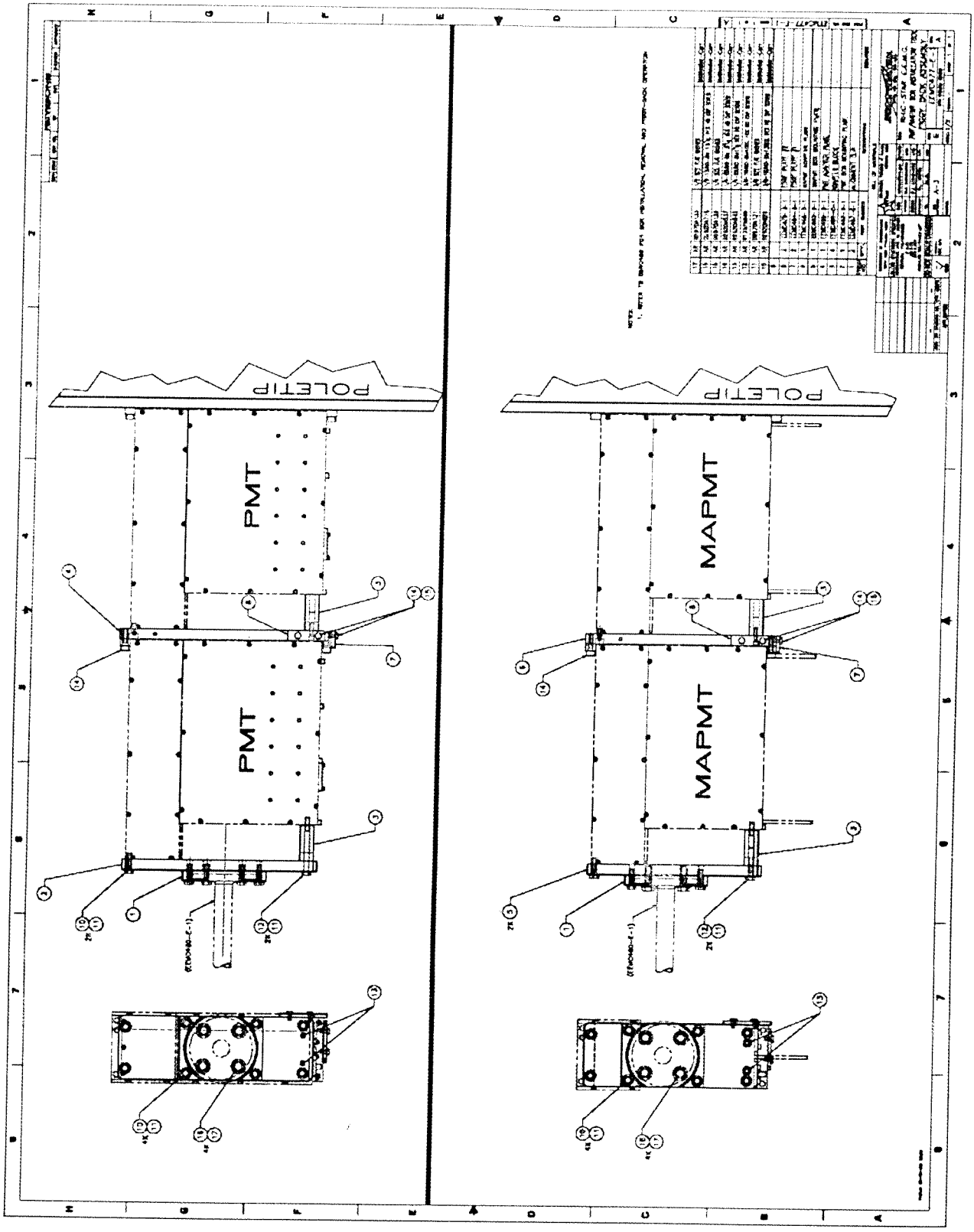


Figure 6 Assembly Drawing of Piggyback Operation

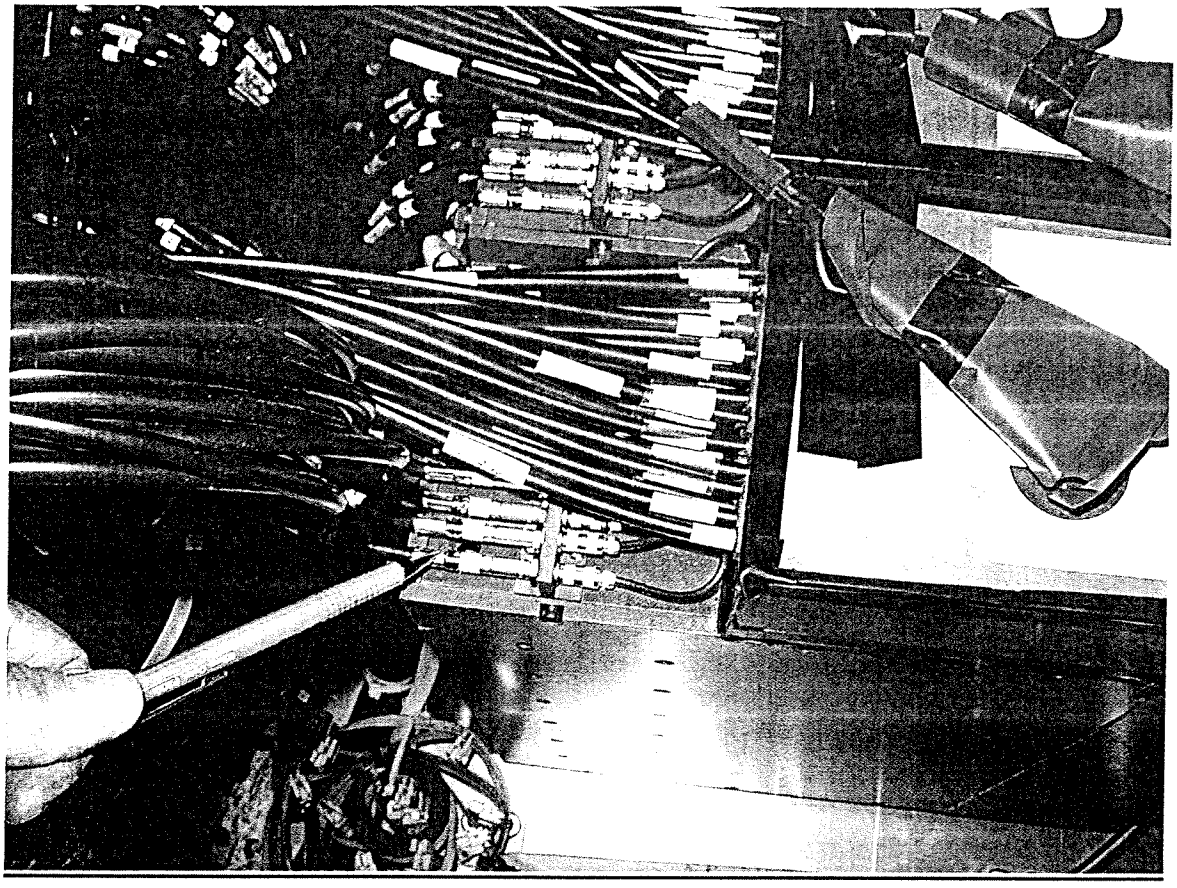


Figure 7 Electric and Fiber Connections on a PMT Box

BROOKHAVEN
NATIONAL LABORATORY

Building 902A
P.O. Box 5000
Upton, NY 11973-5000
Phone 631 344-8236
Fax 631 344-2190
gaffney@bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

date: *April 21, 2003* *SE85SR03*

to: *W. Leonhardt*

from: *Michael Gaffney*

subject: ***Safety Analysis for the STAR EEMC PMT Installation Device***

reference: *(a)* *Department of Energy Hoisting and Rigging Handbook, DOE-HDBK-1090-98.*

(b) *Brookhaven National Laboratory Drawing EEMC460-E-1, "RHIC-STAR E.E.M.C PMT/MPMT Box Installation Tool Assembly".*

The purpose of this memo is to document the safety analysis in respect to reference (a) for the RHIC-STAR Endcap Electromagnetic Calorimeter (EEMC) Photo Multiplier Tube (PMT/MAPMT) Box Installation Tool Assembly, reference (b).

Description:

The STAR EEMC PMT/MAPMT assemblies weigh about 100-lbs. and are mounted on the STAR Endcap. They are installed with very little clearance between assemblies. Due to impact if these assemblies were damage, these lifts were classified as critical. To install and maintain these assemblies, a lifting fixture, reference (b) was designed. Using the overhead crane in building 1006, the plan is to attach the device to the PMT/MAPMT assembly's exposed back cover and support the assembly level while it is unbolted from the Endcap.

The fixture is mounted to a PMT/MAPMT assembly using a specifically designed mounting plate. For alignment and positioning, the mounting plate is attached to a rotatable 1¼" diameter shaft using a 3/8-inch hex bolt. The fixture uses counterweights (approximately 1000-lbs) to maintain the PMT/MAPMT assembly aligned during installation/removal. The counterweight is required because the PMT/MAPMT assembly has to hang with its center of gravity approximately 10-inches from the mounting plate.

The counterweighted assembly is attached to the 1-inch thick plate (16-inches wide, 12-inches long) of the Ballscrew Glide Assembly using three (3) 1-inch diameter threaded rods (32" long). The plate is attached to two (2) 2-inch diameter shafts using three (3) slide bearings. These shafts are retained in blocks at each end. A 16-inch ballscrew positions the counterweight. Four (4) hoist rings (½-inch, rated 2,500-lbs./each) are threaded in the corner of the blocks to rig the device using the overhead crane.

Conclusion:

All stresses were found to be less than 5000-psi, therefore the EEMC PMT/MPMT Box Installation Tool Assembly, reference (b), has acceptable design safety.

As required by reference (a), the following items need to be performed:

- The unit inspected
- A 125% rated load test performed
- Rated load, device weight and part number permanently affixed.

It is recommended that the load test be performed to two parts. First, test the counterweighted portion (ballscrew glide assembly, mounting blocks, hoist rings). Then testing the lower portion (not effected by the counterweight) at 125-lbs.

If you have any questions, I may be reached at extension 8236.

cc:

T. Monahan
R. Brown
J. Hynan
Y. Makdisi
S. Kane

BROOKHAVEN
NATIONAL LABORATORY

Building 902A
P.O. Box 5000
Upton, NY 11973-5000
Phone 631 344-8236
Fax 631 344-2190
gaffney@bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

SE85SR03

date: *July 14, 2003*

to: *W. Leonhardt*

from: *Michael Gaffney*

subject: ***Load Test for the STAR EEMC PMT Installation Device***

reference: *(a)* *DOE HDBK-1095-95, "U.S. Department of Energy Hoisting and Rigging Handbook,"*

(b) *Brookhaven National Laboratory Memorandum from M. Gaffney to W. Leonhardt, "**Safety Analysis for the STAR EEMC PMT Installation Device,**" dated April 21, 2003*

enclosure: (1) *Load Test Report*

The purpose of this memo is to document the load test, as required by reference (a), of the RHIC-STAR Endcap Electromagnetic Calorimeter (EEMC) Photo Multiplier Tube/Multi-Anode Photo Multiplier Tube (PMT/MAPMT) Box Installation Device.

The device is design to align and install the PMT/MAPMT assembly onto the STAR Endcap. The PMT assembly weight is 107-lbs and the MAPMT assembly weight is 87-lbs. The assemblies are bolted to the end of a movable shaft. Counterweights are required to keep the assembly level by balance the center of gravity,. The unit weighs 1,200-lbs (with counterweights). Using slings and four (4) swivels, the device is rigged using a crane. On June 16, 2003, a load test was performed on the assembly. The device was secured to a known lifting point in the STAR experimental hall using a sling. A load cell was attached and the device was raised so an additional 600-lbs. of force was applied to the lifting points of the device for ten (10) minutes. On July 14, 2003, a PMT box was installed on the shaft (as used in the installation). This section of the device is below the counterweights and not loaded under the original test. A 25-lbs load was then added on top of the PMT.

Conclusion:

The load test for the STAR EEMC PMT Installation Device was satisfactory completed. The unit needs to be marked with its weight, what it was designed for and maximum load (107-lbs). If you have any questions, I may be reached at extension 8236.

cc:

T. Monahan
A. Farland
J. Hynan
R. Brown
S. Kane
Y. Makdisi

LOAD TEST REPORT

BROOKHAVEN NATIONAL LABORATORY

PLANT ENGINEERING
CRANES / HOISTS, RINGING EQUIPMENT
AND BELOW THE HOOK LIFTING DEVICES

DATE	June 16, 2003
BUILDING NO.	Building 1006
EQUIPMENT MANUFACTURER	Brookhaven National Laboratory
EQUIPMENT LOCATION	Building 1006
EQUIPMENT MODEL & SERIAL NO.	EEMC460-E-1

ITEMS

1. LOAD TEST INSPECTION REPORT CRANE, HOIST, & RIGGING EQUIPMENT INSPECTION PRIOR TO TEST	Satisfactory
2. RATED CAPACITY	1,400-lbs (under hook)
3. TEST WEIGHT ITEMS TO BE TESTED AS PER DOE HOISTING AND RIGGING MANUAL	600-lbs (measured via load cell)
4. EQUIPMENT OPERATOR	Ralph Brown
5. TEST CONDUCTED BY	William Leonhardt
6. TEST WITNESSED BY	Michael Gaffney
7. GROUP / DIVISION SAFETY REP	Michael Gaffney
8. COMPLETION OF LOAD TEST CRANE, HOIST, & RIGGING EQUIPMENT INSPECTION UPON COMPLETION OF LOAD TEST	Satisfactory

REMARKS

On 7/14/2003, the lower portion of the device was loaded to 132-lbs with no problems noted.

APPENDIX I

PMT & MAPMT Box Installation Procedure

1) Purpose:

This procedure gives detailed step by step instruction for the installation of PMT and MAPMT boxes, using the Box Lifting Fixture Assembly (EEMC460-E-1), on the West Pole Tip of the STAR Detector.

2) Responsibilities:

Only personnel approved by the STAR Technical Support Group Leader or STAR Liaison Engineer are authorized to perform this procedure. They must have a valid SAC card with practical training on the BLDG. 1006 IR Overhead Bridge Crane.

3) Prerequisites:

The performance of this procedure requires two trained, responsible and authorized personnel. Additional personnel can be trained by on- the-job-training with responsible personnel. Responsible personnel must insure the following prior to procedure commencement:

- Completion of Overhead Crane Operator training with a valid SAC card and practical training on the BLDG. 1006 IR Overhead Bridge Crane.
- Must read and acknowledge this procedure.
- Must have experience in the hands-on operation of the Box Lifting Fixture Assembly.
- Check with the STAR Shift Leader or Facilities Manager that the STAR Magnet Power Supply is Locked-out and Tagged-out.
- Call MCR operations coordinator and ask to have the C-A Vacuum Group close the STAR IR beam line vacuum sector isolation valves.

Note:

The valve status can be verified on the C-A PET Page in the STAR Control Room by going to RHIC/Vacuum/SectorValves/Sectors_5+6. This brings up the SectorValves/Sector_5+6 window where you can observe the status of valves g5-svx and g6-svx as either opened or closed.

Precautions:

Responsible personnel should inform the STAR Shift Leader or Facilities Manager of there intention to begin this procedure. Because of the critical nature of rigging loads with the overhead crane near large stray magnetic fields and around the RHIC vacuum beam pipe, the following precautions must be adhered to:

Caution:

The overhead bridge crane must not be operated in the IR when the STAR Magnet is energized due to large stray

magnetic fields. Insure that the magnet has been appropriately locked-out and tagged prior to energizing the crane.

Caution:

Accidental rupture of the STAR vacuum beam pipe would cause a shock wave to propagate along the pipe with the possibility of serious equipment damage. Insure that the C-A vacuum group has closed the STAR IR vacuum isolation valves.

Caution:

The rigging of loads over the top of or near the vacuum beam pipe is considered a critical lift and extreme caution must be used to insure the pipe is not damaged. Operating the overhead crane in this condition requires two responsible personnel; one as the crane operator and the second as a spotter.

Procedure:

In1. Confirm with the STAR Facility Manager that the STAR Magnet has been locked-out and that the vacuum IR sector isolation valves are closed.

In2. Install vacuum beam pipe protective covers, when working over or near pipe.

In3. Place PMT or MAPMT box on its side on a table with the surface opposite the base plate protruding beyond the edge of the table.

In4. Assemble the appropriate box mounting plate (EEMC462 for a PMT box and EEMC463 for a MAPMT box) and box mounting adapter block (EEMC461) to box using 3/8-16 hex head cap screws and washers. Assemble the two alignment cups (EEMC467) to the appropriate mounting plate using 3/8-16 hex head cap screws and washers. Use drawing EEMC477 for reference.

In5. Install the 4-legged nylon bridle (Liftex: MC-QOS-EE291x3 ft.) onto the four hoist rings on the installation tool (EEMC460) and attach to overhead crane hook.

In6. Confirm that translating carriage on installation tool is locked in the **no-load** position.

In7. Attach a tag line and lift installation tool with the crane approximately one foot off the floor and remove support legs.

In8. With the crane translate, raise or lower the installation tool so that the flange on the end of the installation tool shaft aligns with the holes on the box mounting plate. Rotate the shaft as required to aid in this alignment. Note, guides are provided on the mounting plate to engage the shaft flange. Again, use drawing EEMC477 for reference.

In9. Bolt the shaft flange to the box mounting plate using ½-13 hex head cap screws and washers.

In10. Lock the shaft from rotating using the shaft locking knobs (item 4 on drawing EEMC469).

In11. With the crane raise the box clear of the table. Unlock the carriage and turn the upper handle to translate the carriage to the positions for **PMT** or **MAPMT**

(depending on box being installed) until the installation tool and box assembly hangs plumb within one degree. Relock the carriage.

In12. Loosen the shaft locking knobs enough to rotate the box to the approximate attitude it will have when installed on the pole tip. Relock the shaft knobs.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

In13. With a crane operator and spotter translate and raise the box and installation tool assembly to position the box at its desired mounting location.

In14. Translate box horizontally using the crane and/or by pushing the box to engage it onto the mounting pins located on the butch or extension plate. Fine-tune the box rotation as required.

Caution:

Do not allow the weight of the installation tool to hang on the bolts holding the box to the butch or extension plate. The installation tool can slide along two vertical shafts to indicate when its weight is being transferred to a butch or extension plate.

In15. Bolt the box to the butch or extension plate using 3/8-16 high strength 12-point flange head screws. To seat the box flange properly against the butch or extension plate, it may be necessary to jog the box/mounting tool assembly slightly up and down.

In16. Remove the ½-13 hex head cap screws and washers from the shaft flange to the box mounting plate.

In17. With the crane translate the installation tool a short distance away from the box, and then translate the carriage on installation tool to the **no-load** position, and lock the carriage.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

In18. With the crane return installation tool to storage location. Install storage legs and lower to floor. Return crane to stored position and lock-out the power.

In19. Remove box mounting plate and adapter block installed in step3.

In20. Remove vacuum pipe protective covers when work over or near the vacuum beam pipe is completed.

In21. Inform STAR Shift Leader or Facilities Manager work is complete, crane is locked-out, and contact MCR to have C-A Vacuum Group open the STAR IR beam line vacuum sector isolation valves.

References:

The following is a list of the engineering drawings that describe the boxes, the lifting fixture and the box installation:

PMT Box Assembly	EEMC400-D-1
MAPMT Box Assembly	EEMC418-D-1
Box Lifting Fixture Assembly	EEMC460-E-1
Box Piggyback Installation	EEMC477-E-1
Box Mounting Locations	EEMC730-E-1&2

Read and Acknowledge:

Authorized personnel performing this procedure must read and acknowledge with there signature and date prior to start that they understand the requirements of this procedure and the means to avoid unnecessary risk to equipment and personnel. The completed procedure should be returned to the STAR Facilities Manager for archiving.

	Print Name	**Signature**	**Date**
1)			
2)			

APPENDIX II

PMT & MAPMT Box Removal Procedure

1) Purpose:

This procedure gives detailed step by step instruction for the removal of PMT and MAPMT boxes, using the Box Lifting Fixture Assembly (EEMC460-E-1), on the West Pole Tip of the STAR Detector.

2) Responsibilities:

Only personnel approved by the STAR Technical Support Group Leader or STAR Liaison Engineer are authorized to perform this procedure. They must have a valid SAC card with practical training on the BLDG. 1006 IR Overhead Bridge Crane.

3) Prerequisites:

The performance of this procedure requires two trained, responsible and authorized personnel. Additional personnel can be trained by on- the-job-training with responsible personnel. Responsible personnel must insure the following prior to procedure commencement:

- Completion of Overhead Crane Operator training with a valid SAC card and practical training on the BLDG. 1006 IR Overhead Bridge Crane.
- Must read and acknowledge this procedure.
- Must have experience in the hands-on operation of the Box Lifting Fixture Assembly.
- Check with the STAR Shift Leader or Facilities Manager that the STAR Magnet Power Supply is Locked-out and Tagged-out.
- Call MCR operations coordinator and ask to have the C-A Vacuum Group close the STAR IR beam line vacuum sector isolation valves.

Note:

The valve status can be verified on the C-A PET Page in the STAR Control Room by going to RHIC/Vacuum/SectorValves/Sectors_5+6. This brings up the SectorValves/Sector_5+6 window where you can observe the status of valves g5-svx and g6-svx as either opened or closed.

Precautions:

Responsible personnel should inform the STAR Shift Leader or Facilities Manager of there intention to begin this procedure. Because of the critical nature of rigging loads with the overhead crane near large stray magnetic fields and around the RHIC vacuum beam pipe, the following precautions must be adhered to:

Caution:

The overhead bridge crane must not be operated in the IR when the STAR Magnet is energized due to large stray magnetic fields. Insure that the magnet has been appropriately locked-out and tagged prior to energizing the crane.

Caution:

Accidental rupture of the STAR vacuum beam pipe would cause a shock wave to propagate along the pipe with the possibility of serious equipment damage. Insure that the C-A vacuum group has closed the STAR IR vacuum isolation valves.

Caution:

The rigging of loads over the top of or near the vacuum beam pipe is considered a critical lift and extreme caution must be used to insure the pipe is not damaged. Operating the overhead crane in this condition requires two responsible personnel; one as the crane operator and the second as a spotter.

Procedure:

Rm1. Confirm with the STAR Facility Manager that the STAR Magnet has been locked-out and that the vacuum IR sector isolation valves are closed.

Rm2. Install vacuum beam pipe protective covers, when working over or near pipe.

Rm3. Assemble the appropriate box mounting plate (EEMC462 for a PMT box and EEMC463 for a MAPMT box) and box mounting adapter block (EEMC461) to box being removed using 3/8-16 hex head cap screws and washers. Assemble the two alignment cups (EEMC467) to the appropriate mounting plate using 3/8-16 hex head cap screws and washers. Use drawing EEMC477 for reference.

Rm4. Install the 4-legged nylon bridle (Liftex: MC-QOS-EE291x3 ft.) onto the four hoist rings on the installation tool (EEMC460) and attach to overhead crane hook.

Rm5. Confirm that translating carriage on installation tool is locked in the **no-load** position.

Rm6. Attach a tag line and lift installation tool with the crane approximately one foot off the floor and remove support legs.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

Rm7. With a crane operator and spotter translate and raise or lower the installation tool so that the flange on the end of the installation tool shaft aligns with the holes on the box mounting plate. Rotate the shaft as required to aid in this alignment. Note, guides are provided on the mounting plate to engage the shaft flange. Again, use drawing EEMC477 for reference.

Caution:

Do not allow the weight of the installation tool to hang on the bolts holding the box to the butch or extension plate. The installation tool can slide along two vertical shafts to indicate when its weight is being transferred to a butch or extension plate.

Rm8. Bolt the shaft flange to the box mounting plate using ½-13 hex head cap screws and washers.

Rm9. Lock the shaft from rotating using the shaft locking knobs (item 4 on drawing EEMC469).

Rm10. Unbolt the box from the butch or extension plate. Unlock the carriage and turn the upper handle to translate the carriage to the positions for **PMT** or **MAPMT** (depending on box being removed) until the installation tool and box assembly hangs plumb within one degree. Relock the carriage.

Rm11. Translate box horizontally using the crane and/or by pulling the box to disengage it from the mounting pins located on the butch or extension plate.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

Rm12. With the crane translate and raise or lower the installation tool and box to the drop-off location for the box.

Rm13. Loosen the shaft locking knobs enough to rotate the box to the approximate attitude it will have when left at the drop-off point. Relock the shaft knobs.

Rm14. Lower the box on its side onto a support table.

Rm15. Remove the ½-13 hex head cap screws and washers from the shaft flange to the box mounting plate.

Rm16. With the crane translate the installation tool a short distance from the box. Then unlock the carriage and turn the upper handle to translate the carriage to the **no-load** position, and lock the carriage.

Rm17. Return installation tool to storage location. Install storage legs and lower to floor. Return crane to stored position and lock-out the power.

Rm18. Remove box mounting plate and adapter block from box.

Rm19. Remove vacuum pipe protective covers when work over or near the vacuum beam pipe is completed.

Rm20. Inform STAR Shift Leader or Facilities Manager work is complete, crane is locked-out, and contact MCR to have C-A Vacuum Group open the STAR IR beam line vacuum sector isolation valves.

References:

The following is a list of the engineering drawings that describe the boxes, the lifting fixture and the box installation:

PMT Box Assembly	EEMC400-D-1
MAPMT Box Assembly	EEMC418-D-1
Box Lifting Fixture Assembly	EEMC460-E-1
Box Piggyback Installation	EEMC477-E-1
Box Mounting Locations	EEMC730-E-1&2

Read and Acknowledge:

Authorized personnel performing this procedure must read and acknowledge with there signature and date prior to start that they understand the requirements of this procedure and the means to avoid unnecessary risk to equipment and personnel. The completed procedure should be returned to the STAR Facilities Manager for archiving.

	Print Name	**Signature**	**Date**
1)			
2)			

APPENDIX III

PMT & MAPMT Box Piggyback Procedure

1) Purpose:

This procedure gives detailed step by step instruction for the piggyback positioning of PMT and MAPMT boxes, using the Box Lifting Fixture Assembly (EEMC460-E-1), on the West Pole Tip of the STAR Detector. This is accomplished to allow access to a box for maintenance purposes.

2) Responsibilities:

Only personnel approved by the STAR Technical Support Group Leader or STAR Liaison Engineer are authorized to perform this procedure. They must have a valid SAC card with practical training on the BLDG. 1006 IR Overhead Bridge Crane.

3) Prerequisites:

The performance of this procedure requires two trained, responsible and authorized personnel. Additional personnel can be trained by on- the-job-training with responsible personnel. Responsible personnel must insure the following prior to procedure commencement:

- Completion of Overhead Crane Operator training with a valid SAC card and practical training on the BLDG. 1006 IR Overhead Bridge Crane.
- Must read and acknowledge this procedure.
- Must have experience in the hands-on operation of the Box Lifting Fixture Assembly.
- Check with the STAR Shift Leader or Facilities Manager that the STAR Magnet Power Supply is Locked-out and Tagged-out.
- Call MCR operations coordinator and ask to have the C-A Vacuum Group close the STAR IR beam line vacuum sector isolation valves.

Note:

The valve status can be verified on the C-A PET Page in the STAR Control Room by going to RHIC/Vacuum/SectorValves/Sectors_5+6. This brings up the SectorValves/Sector_5+6 window where you can observe the status of valves g5-svx and g6-svx as either opened or closed.

Precautions:

Responsible personnel should inform the STAR Shift Leader or Facilities Manager of there intention to begin this procedure. Because of the critical nature of

rigging loads with the overhead crane near large stray magnetic fields and around the RHIC vacuum beam pipe, the following precautions must be adhered to:

Caution:
The overhead bridge crane must not be operated in the IR when the STAR Magnet is energized due to large stray magnetic fields. Insure that the magnet has been appropriately locked-out and tagged prior to energizing the crane.

Caution:
Accidental rupture of the STAR vacuum beam pipe would cause a shock wave to propagate along the pipe with the possibility of serious equipment damage. Insure that the C-A vacuum group has closed the STAR IR vacuum isolation valves.

Caution:
The rigging of loads over the top of or near the vacuum beam pipe is considered a critical lift and extreme caution must be used to insure the pipe is not damaged. Operating the overhead crane in this condition requires two responsible personnel; one as the crane operator and the second as a spotter.

Procedure:

Prior to box maintenance:

Pb1. Confirm with the STAR Facility Manager that the STAR Magnet has been locked-out and that the vacuum IR sector isolation valves are closed.

Pb2. Install vacuum beam pipe protective covers, when working over or near pipe.

Note:
PMT boxes can ONLY piggyback onto PMT boxes and MAPMT boxes can ONLY piggyback onto MAPMT boxes.

Pb3. For the box being removed, assemble the appropriate box mounting plate (EEMC462 for a PMT box and EEMC463 for a MAPMT box) and box mounting adapter block (EEMC461) to box using 3/8-16 hex head cap screws and washers. Assemble the two alignment cups (EEMC467) to the appropriate mounting plate using 3/8-16 hex head cap screws and washers. Use drawing EEMC477 for reference.

Pb4. For the box being piggybacked onto, assemble the appropriate box adapter plate (EEMC465 for a PMT box and EEMC466 for a MAPMT box) to the box using 3/8-16 socket head cap screws. Install the box mounting edge plates 1&2 (EEMC464 and EEMC479) to the adapter plate using 1/4-20 hex head cap screws and washers. Since the edge plates can mount to any of the corners of the adapter

plate, mount them edge to the corner of the adapter plate that has the most lateral clearance. Use drawing EEMC477 for reference.

Pb5. Install the 4-legged nylon bridle (Liftex: MC-QOS-EE291x3 ft.) onto the four hoist rings on the installation tool (EEMC460) and attach to overhead crane hook.

Pb6. Confirm that translating carriage on installation tool is locked in the **no-load** position.

Pb7. Attach a tag line and lift installation tool with crane approximately one foot off the floor and remove support legs.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

Pb8. With a crane operator and spotter translate and raise or lower the installation tool so that the flange on the end of the installation tool shaft aligns with the holes on the box mounting plate. Rotate the shaft as required to aid in this alignment. Note, guides are provided on the mounting plate to engage the shaft flange. Again, use drawing EEMC477 for reference.

Caution:

Do not allow the weight of the installation tool to hang on the bolts holding the box to the butch or extension plate. The installation tool can slide along two vertical shafts to indicate when its weight is being transferred to a butch or extension plate.

Pb9. Bolt the shaft flange to the box mounting plate using ½-13 hex head cap screws and washers.

Pb10. Lock the shaft from rotating using the shaft locking knobs (item 4 on drawing EEMC469).

Pb11. Unbolt the box from the butch or extension plate. Unlock the carriage and turn the upper handle to translate the carriage to the positions for **PMT** or **MAPMT** (depending on box being removed) until the installation tool and box assembly hangs plumb within one degree. Relock the carriage.

Pb12. Translate box horizontally using the crane and/or by pulling the box to disengage it from the mounting pins located on the butch or extension plate.

Pb13. With the crane translate and raise or lower the box and installation tool assembly to position the box at its mounting location on the adjoining piggybacked box. The edge plates will aid this alignment. Fine-tune the box rotation as required. Use drawing EEMC477 for reference.

Caution:

Do not allow the weight of the installation tool to hang on the bolts holding the box to the butch or extension plate. The installation tool can slide along two vertical shafts to indicate when its weight is being transferred to a butch or extension plate.

Pb14. Bolt the box to the adapter plate using 3/8-16 high strength 12 point flange head screws. To seat the box flange properly against the adapter plate, it may be necessary to jog the box/mounting tool assembly slightly up and down.

Pb15. Remove the ½-13 hex head cap screws and washers from the shaft flange to the box mounting plate.

Pb16. With the crane translate the installation tool a short distance from the box. Then unlock the carriage and turn the upper handle to translate the carriage to the **no-load** position, and lock the carriage.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

Pb17. With the crane return installation tool to storage location. Install storage legs and lower to floor. Return crane to stored position and lock-out the power.

Pb18. Perform maintenance on box as required.

<u>After box maintenance:</u>

Pb19. Confirm with the STAR Facility Manager that the STAR Magnet has been locked-out and that the vacuum IR sector isolation valves are closed.

Pb20. Install the 4-legged nylon bridle (Liftex: MC-QOS-EE291x3 ft.) onto the four hoist rings on the installation tool (EEMC460) and attach to overhead crane hook.

Pb21. Confirm that translating carriage on installation tool is locked in the **no-load** position.

Pb22. Attach a tag line and lift installation tool with the crane approximately one foot off the floor and remove support legs.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion

should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

Pb23. With a crane operator and spotter translate and raise or lower the installation tool so that the flange on the end of the installation tool shaft aligns with the holes on the box mounting plate. Rotate the shaft as required to aid in this alignment. Note, guides are provided on the mounting plate to engage the shaft flange. Again, use drawing EEMC477 for reference.

Caution:

Do not allow the weight of the installation tool to hang on the bolts holding the box to the butch or extension plate. The installation tool can slide along two vertical shafts to indicate when its weight is being transferred to a butch or extension plate.

Pb24. Bolt the shaft flange to the box mounting plate using ½-13 hex head cap screws and washers.

Pb25. Lock the shaft from rotating using the shaft locking knobs (item 4 on drawing EEMC469).

Pb26. Unbolt the box from the adapter plate. Unlock the carriage and turn the upper handle to translate the carriage to the positions for **PMT** or **MAPMT** (depending on box being removed) until the installation tool and box assembly hangs plumb within one degree. Relock the carriage.

Pb27. With the crane translate the installation tool and box a short distance away from the pole tip to clear the other boxes.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

Pb28. With the crane adjust the box and installation tool assembly to position the box at its desired mounting location.

Pb29. Translate box horizontally using the crane and/or by pushing the box to engage it onto the mounting pins located on the butch or extension plate. Fine-tune the box rotation as required.

Caution:

Do not allow the weight of the installation tool to hang on the bolts holding the box to the butch or extension plate. The installation tool

can slide along two vertical shafts to indicate when its weight is being transferred to a butch or extension plate.

Pb30. Bolt the box to the butch or extension plate using 3/8-16 high strength 12-point flange head screws. To seat the box flange properly against the butch or extension plate, it may be necessary to jog the box/mounting tool assembly slightly up and down.

Pb31. Remove the ½-13 hex head cap screws and washers from the shaft flange to the box mounting plate.

Pb32. With the crane translate the installation tool a short distance away from the box, and then translate the carriage on installation tool to the **no-load** position, and lock the carriage.

Caution:

When passing the load over the beam pipe the crane operator should first raise the hoist so the load has a minimum vertical height of 4 foot clearance above the beam pipe. The spotter should observe and confirm to the operator the adequate minimum clearance while controlling the load with the tag line. At no time in crane motion should the operator or spotter release tag line or hand hold of the load. At no time should the crane hook or load approach the beam pipe to within a 2 foot radius.

Pb33. With the crane return installation tool to storage location. Install storage legs and lower to floor. Return crane to stored position and lock-out the power.

Pb34. Remove box mounting plate and adapter block from the reinstalled box.

Pb35. Remove box adapter plate and edge blocks installed on piggybacked box.

Pb36. Remove vacuum pipe protective covers when work over or near the vacuum beam pipe is completed.

Pb37. Inform STAR Shift Leader or Facilities Manager work is complete, crane is locked-out, and contact MCR to have C-A Vacuum Group open the STAR IR beam line vacuum sector isolation valves.

References:

The following is a list of the engineering drawings that describe the boxes, the lifting fixture and the box installation:

PMT Box Assembly	EEMC400-D-1
MAPMT Box Assembly	EEMC418-D-1
Box Lifting Fixture Assembly	EEMC460-E-1
Box Piggyback Installation	EEMC477-E-1
Box Mounting Locations	EEMC730-E-1&2

Read and Acknowledge:

Authorized personnel performing this procedure must read and acknowledge with there signature and date prior to start that they understand the requirements of this

procedure and the means to avoid unnecessary risk to equipment and personnel. The completed procedure should be returned to the STAR Facilities Manager for archiving.

Print Name	Signature	Date
1)		
2)		

BROOKHAVEN
NATIONAL LABORATORY

Building 902A
P.O. Box 5000
Upton, NY 11973-5000
Phone 631 344-8236
Fax 631 344-2190
gaffney@bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

Memo

date: *July 14, 2003* *SE85SR03*

to: *W. Leonhardt*

from: *Michael Gaffney*

subject: ***Load Test for the STAR EEMC PMT Installation Device***

reference: *(a)* *DOE HDBK-1095-95, "U.S. Department of Energy Hoisting and Rigging Handbook,"*
(b) *Brookhaven National Laboratory Memorandum from M. Gaffney to W. Leonhardt, "**Safety Analysis for the STAR EEMC PMT Installation Device,**" dated April 21, 2003*

enclosure: (1) *Load Test Report*

The purpose of this memo is to document the load test, as required by reference (a), of the RHIC-STAR Endcap Electromagnetic Calorimeter (EEMC) Photo Multiplier Tube/Multi-Anode Photo Multiplier Tube (PMT/MAPMT) Box Installation Device.

The device is design to align and install the PMT/MAPMT assembly onto the STAR Endcap. The PMT assembly weight is 107-lbs and the MAPMT assembly weight is 87-lbs. The assemblies are bolted to the end of a movable shaft. Counterweights are required to keep the assembly level by balance the center of gravity,. The unit weighs 1,200-lbs (with counterweights). Using slings and four (4) swivels, the device is rigged using a crane. On June 16, 2003, a load test was performed on the assembly. The device was secured to a known lifting point in the STAR experimental hall using a sling. A load cell was attached and the device was raised so an additional 600-lbs. of force was applied to the lifting points of the device for ten (10) minutes. On July 14, 2003, a PMT box was installed on the shaft (as used in the installation). This section of the device is below the counterweights and not loaded under the original test. A 25-lbs load was then added on top of the PMT.

Conclusion:

The load test for the STAR EEMC PMT Installation Device was satisfactory completed. The unit needs to be marked with its weight, what it was designed for and maximum load (107-lbs). If you have any questions, I may be reached at extension 8236.

cc:

T. Monahan
A. Farland
J. Hynan
R. Brown
S. Kane
Y. Makdisi

LOAD TEST REPORT

BROOKHAVEN NATIONAL LABORATORY
PLANT ENGINEERING
CRANES / HOISTS, RINGING EQUIPMENT
AND BELOW THE HOOK LIFTING DEVICES

DATE	June 16, 2003
BUILDING NO.	Building 1006
EQUIPMENT MANUFACTURER	Brookhaven National Laboratory
EQUIPMENT LOCATION	Building 1006
EQUIPMENT MODEL & SERIAL NO.	EEMC460-E-1

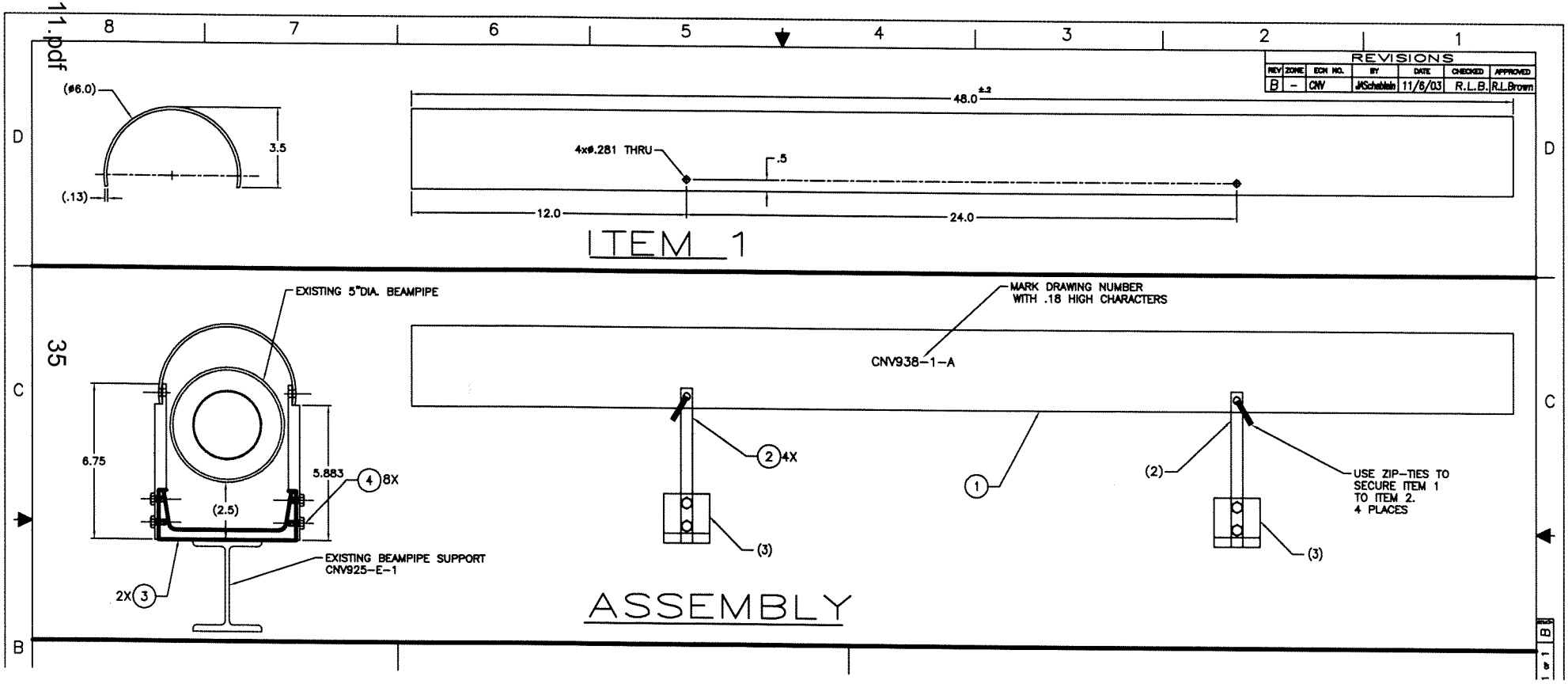
ITEMS

1. LOAD TEST INSPECTION REPORT CRANE, HOIST, & RIGGING EQUIPMENT INSPECTION PRIOR TO TEST	Satisfactory
2. RATED CAPACITY	1,400-lbs (under hook)
3. TEST WEIGHT ITEMS TO BE TESTED AS PER DOE HOISTING AND RIGGING MANUAL	600-lbs (measured via load cell)
4. EQUIPMENT OPERATOR	Ralph Brown
5. TEST CONDUCTED BY	William Leonhardt
6. TEST WITNESSED BY	Michael Gaffney
7. GROUP / DIVISION SAFETY REP	Michael Gaffney
8. COMPLETION OF LOAD TEST CRANE, HOIST, & RIGGING EQUIPMENT INSPECTION UPON COMPLETION OF LOAD TEST	Satisfactory

REMARKS

On 7/14/2003, the lower portion of the device was loaded to 132-lbs with no problems noted.

3.0/12919e011.pdf



35

(10/2005)

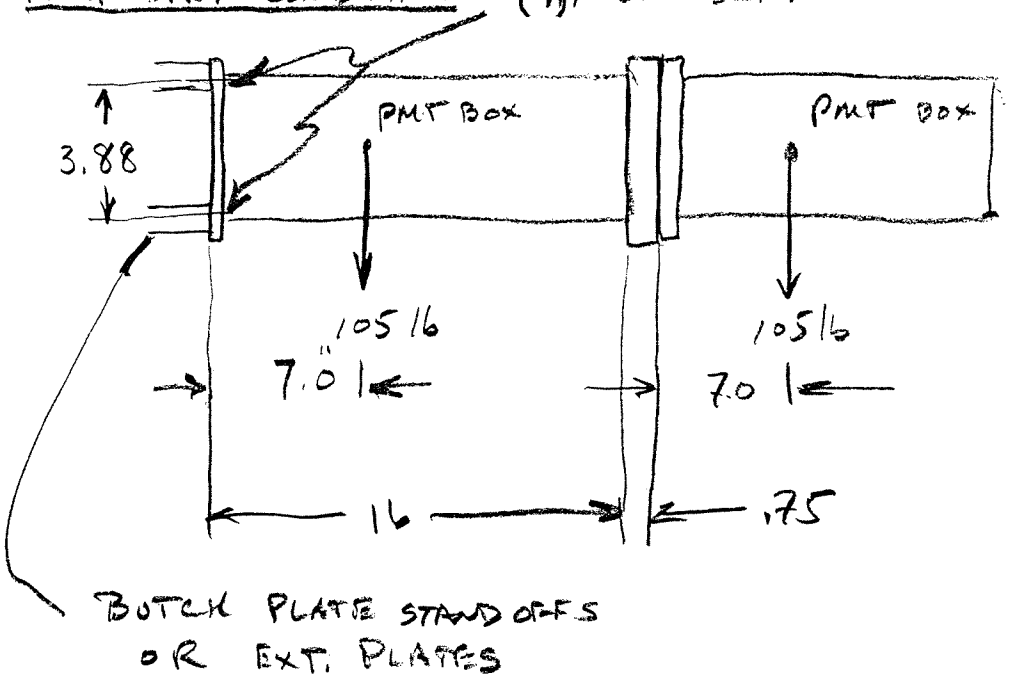
Beam Pipe Protective Cover
1 of 2

STRESS ANALYSIS

REF: STAR DWG EEMC 460

NOTE: ALTHOUGH BOTH PMT & MAPMT BOXES ARE SERVICED, ONLY PMT BOXES ARE ANALYZED AS THESE ARE THE "WORST" CASE

PIGGY BACK CONDITION (4) MOUNT SCR.



IF BOXES ROTATE ABOUT LOWER MOUNT SCREWS, FORCE ON UPPER 2 SCREWS IS

$$F_u = \frac{(105\text{ lb})(7\text{ in}) + (105\text{ lb})(23.75\text{ in})}{3.88\text{ in}} = 832\text{ lb}$$

$$\text{FORCE / SCREW} = \frac{832}{2} = 416\text{ lb}$$

SCREWS ARE 12 PT GRADE 8 MIN TS = 170 000 psi

3/8-16 $A_t = 0.0775\text{ in}^2$

TENSILE

$$\sigma = \frac{F}{A_s} = \frac{416}{.0775} = 5369 \text{ psi}$$

$$FS_u = \frac{170000}{5369} = 31.7$$

SHEAR

MIN SCREW DIA = 0.298 in
MIN SCREW A = 0.070 in^2

$$\tau = \frac{210 \text{ lb}}{(4)(0.070) \text{ in}^2} = 753 \text{ psi}$$

$$FS_u = 225$$

STRIP OUT OF INTERNAL THREADS

ASSUME 3 THREADS ENGAGE @ 16 TPI $l = 0.188$

$$A = \pi d l = \pi (.375) .188 = 0.221 \text{ in}^2$$

AGAIN F = 416 lb

$$\tau = \frac{416}{.221} = 1883 \text{ psi}$$

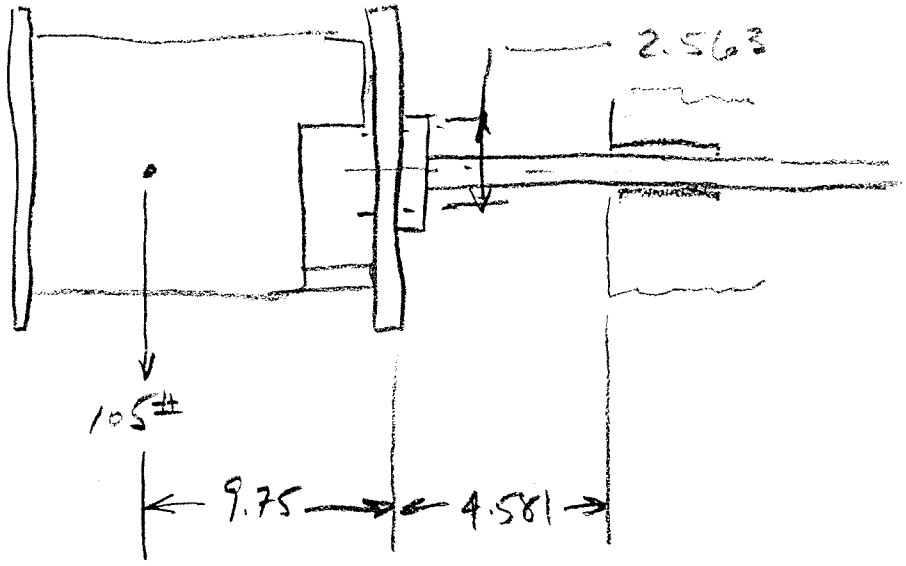
EXT PLATES ARE 6061-T6 ALUM

S_u = 45,000 psi
S_y = 40,000 psi

$$FS_u = 23.9$$

$$FS_y = 21.2$$

NOTE - IN BOX TO BOX CONNECTION, FASTENERS ARE THE SAME AS PREVIOUSLY ANALYZED, BUT LOAD IS ONE HALF.



AGAIN, ASSUME ~~Box~~ ROTATE ABOUT LOWER SCREWS

$$F = \frac{(105)(9.75)}{2.563} \approx 400\,lb \text{ OR } 200\,lb/\text{SCREW}$$

$$A_s = 0.1419\,in^2 \qquad \sigma = 1409\,psi$$

FOR UTS OF 70,000 PSI

$$FS_u = 49.6$$

BENDING OF SHAFT

(NOTE INCR BOX WT TO 120 lb TO INCL MOUNT PARTS)

MOMENT ARM = 9.75 + 4.581 = 14.331

$$M = (120)(14.331) = 1720 \text{ in lb}$$

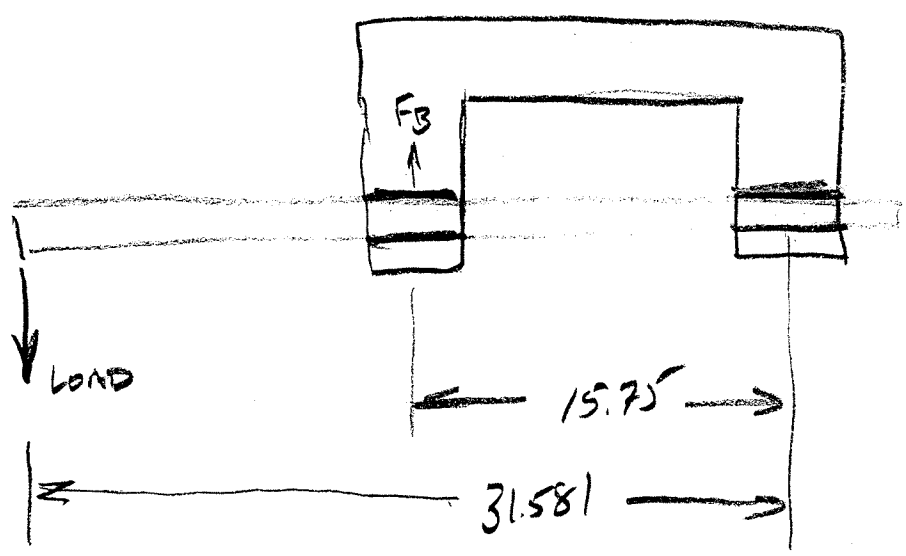
$$Z = \frac{\pi d^3}{32} = \frac{\pi (1.25)^3}{32} = 0.192 \text{ in}^3$$

$$\sigma_b = \frac{M}{Z} = \frac{1720}{0.192} = 8970 \text{ psi}$$

per McMaster $S_y = 75000$ psi $S_u = 100{,}000$ psi

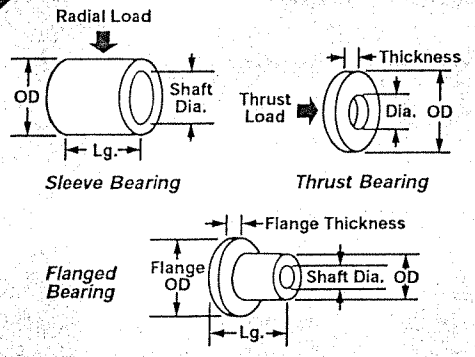
$$FS_y = \frac{75000}{8970} = 8.4 \qquad FS_u = 11.1$$

LOAD ON BRASS BRG



$$F_B = 120\left(\frac{31.581}{15.75}\right) = 241 \text{ lb}$$

About Plain Bearings, P max, V max, and PV max



Sleeve Bearing *Thrust Bearing*

Flanged Bearing

Plain bearings allow smooth, low-friction motion between two surfaces. The term "plain" simply means the load is supported through sliding motion between two solid surfaces (no moving parts such as ball bearings).

Sleeve bearings support loads perpendicular to their rotating axis (i.e. radial loads).

Thrust bearings support loads parallel to their axis of rotation (i.e. thrust loads).

Flanged bearings do the work of both sleeve and thrust bearings, handling radial *and* thrust loads.

For Shaft Hardness—Use bearing materials suitable for your shaft hardness. Usually, the harder and smoother the shaft, the longer the bearing will last. Some bearing materials will damage soft shaft materials. Use only with hard shafting.

Shaft Hardness

	Example	Rockwell Hardness
Hard	Hardened Steel	R_C 35 and higher
Medium	Mild Steel	R_B 85 to R_C 35
Soft	Aluminum	Lower than R_B 85

P max—The maximum load a bearing can carry at 0 rpm.

Formula: Maximum bearing load (psi for inch sizes; N/mm² for metric) = P max × bearing length × shaft diameter

To convert psi to N/mm², multiply psi value by 0.006894757. To convert N/mm² to psi, multiply N/mm² value by 145.032.

V max—The maximum velocity or speed (based on the maximum shaft rpm) that a bearing can carry at light loads. For inch bearings, maximum velocity is stated in surface feet per minute (fpm). For metric bearings, it is meters per second (m/s). To convert fpm to m/s, multiply fpm value by 0.00508. To convert m/s to fpm, multiply m/s value by 196.8504.

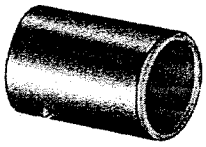
Formula: Maximum shaft rpm = $\dfrac{\text{V max}}{\text{Constant (0.262 for inch sizes; 19098.593 for metric)} \times \text{Shaft diameter}}$

PV max—Once you've selected a bearing based on P max and V max, use PV max (shown with product listings) as the final check to ensure that the bearing can sustain your combined load and speed requirements. If actual PV is less than PV max, the bearing should fit your application.

Formula: Actual PV = $\left(\dfrac{\text{Actual load (lbs. for inch sizes; Newtons for metric)}}{\text{Bearing length} \times \text{Shaft diameter}}\right) \times \left(\text{Actual rpm}\right) \times \left(\text{Constant (.262 for inch sizes; 19098.593 for metric sizes)}\right) \times \left(\text{Shaft diameter}\right)$

Bronze Plain Sleeve Bearings

Bronze Sleeve Bearings



SAE 841 Bronze—Similar to Oilite-style bushings with an alloy of copper, tin, and carbon, these porous sintered bronze bearings are vacuum-impregnated with 18-20% SAE-30 oil. Heat created by shaft movement draws the oil to bearing surface. The oil acts as a cushion between the shaft and bearing, reducing wear and increasing resistance to shock loads.

SAE 660 Bronze—An alloy of copper, tin, lead, and zinc, these nonporous bearings resist shock loads and wear. High-temperature lubricants are recommended over 250° F.

For Shaft Dia. Tolerance

For Shaft Dia.	Tolerance
SAE 841	
1/8"–1 1/2"	+.000" to –.001"
1 3/4"–2 1/2"	+.000" to –.0015"
3"	+.000" to –.002"
SAE 660	
All	±.0010"
Metric SAE 841	
All	+.006 to +.024 mm
Metric SAE 660	
All	±.0254 mm

OD Tolerance

OD	Tolerance
SAE 841	
1/4"–1 5/8"	+.000" to –.001"
1 3/4"–2 3/4"	+.000" to –.0015"
3"–3 1/2"	+.000" to –.002"
4"	+.000" to –.003"
SAE 660	
1/4"–3"	+.002" to +.003"
3 1/2"–4"	+.003" to +.005"
Metric SAE 841	
15–18 mm	+.028 to +.046 mm
19–22 mm	+.035 to +.056 mm
Metric SAE 660	
All	+.0508 mm to +.0762 mm

Length Tolerance

Length	Tolerance
SAE 841	
1/8"–1 1/2"	±.005"
1 3/4"–3"	±.0075"
4"	±.010"
5"–6"	±.015"
6 1/2"	Not rated
SAE 660	
All	±.005"
Metric SAE 841	
All	±1%
Metric SAE 660	
All	±.1270 mm

Bearing Material	Temperature Range	For Shaft Hardness	P max	V max	PV max
SAE 841	10° to 220° F	Medium and up	2,000	1,200	50,000
SAE 660	10° to 450° F	Medium and up	4,000	750	75,000
Metric SAE 841	10° to 220° F	Medium and up	13.79	6.10	1.75
Metric SAE 660	10° to 450° F	Medium and up	27.58	3.81	2.7

Lg.	SAE 841 Each	SAE 660 Each
For Shaft Dia.: 1/8"; Bearing OD: 1/4"		
1/8"	6391K113 $0.33	6381K405 $3.89
1/4"	6391K111 .30	6381K406 3.94
3/8"	6391K112 .33	6381K407 4.00
For Shaft Dia.: 3/16"; Bearing OD: 1/4"		
1/4"	6391K122 .30	6381K501 3.94
3/8"	6391K125 .33	6381K502 3.97
1/2"	6391K124 .37	6381K503 4.03
5/8"	6391K123 .37	6381K601 4.09
For Shaft Dia.: 3/16"; Bearing OD: 5/16"		
1/4"	6391K114 .30	6381K602 3.94
3/8"	6391K115 .27	6381K603 4.00
1/2"	6391K116 .27	6381K408 1.13
For Shaft Dia.: 1/4"; Bearing OD: 5/16"		
1/4"	6391K126 .23	6381K409 3.94
1/2"	6391K127 .37	6381K410 4.03
3/4"	6391K401 .40	6381K411 4.14
For Shaft Dia.: 1/4"; Bearing OD: 3/8"		
1/4"	6391K131 .37	6381K412 .87
3/8"	6391K136 .40	6381K413 .98
1/2"	6391K132 .43	6381K415 1.13
5/8"	6391K133 .43	6381K416 4.11
7/8"	6391K134 .43	6381K417 4.20
1"	6391K135 .43	6381K42 1.47

Lg.	SAE 841 Each	SAE 660 Each
For Shaft Dia.: 1/4"; Bearing OD: 1/2"		
1/2"	6391K141 $0.53	6381K421 $4.20
5/8"	6391K402 .63	6381K422 4.29
3/4"	6391K142 .67	6381K423 4.34
1"	6391K143 .73	6381K424 4.49
For Shaft Dia.: 5/16"; Bearing OD: 3/8"		
1/4"	6391K403 .37	6381K425 3.94
3/8"	6391K152 .37	6381K426 3.97
1/2"	6391K153 .37	6381K427 4.03
5/8"	6391K154 .40	6381K428 4.09
3/4"	6391K155 .40	6381K429 4.14
1"	6391K156 .77	6381K43 4.26
For Shaft Dia.: 5/16"; Bearing OD: 7/16"		
1/4"	6391K161 .23	6381K431 4.03
3/8"	6391K162 .27	6381K442 1.00
1/2"	6391K163 .33	6381K443 1.18
5/8"	6391K164 .39	6381K444 4.26
3/4"	6391K165 .43	6381K445 1.36
1"	6391K166 .47	6381K446 1.52
For Shaft Dia.: 5/16"; Bearing OD: 1/2"		
3/8"	6391K404 .50	6381K447 4.11
1/2"	6391K405 .50	6381K448 4.20
3/4"	6391K406 .57	6381K101 1.49
1"	6391K443 .67	6381K102 1.69
1 1/4"	6391K444 .94	6381K103 1.91

Lg.	SAE 841 Each	SAE 660 Each
For Shaft Dia.: 3/8"; Bearing OD: 1/2"		
1/4"	6391K171 $0.27	6381K449 $4.03
3/8"	6391K172 .30	6381K45 1.00
1/2"	6391K173 .33	6381K451 1.18
5/8"	6391K174 .40	6381K452 4.26
3/4"	6391K176 .70	6381K453 1.36
7/8"	6391K175 .53	6381K454 4.40
1"	6391K178 .50	6381K455 1.49
1 1/4"	6391K179 .52	6381K456 1.62
For Shaft Dia.: 3/8"; Bearing OD: 9/16"		
3/8"	6391K181 .39	6381K457 4.26
1/2"	6391K182 .43	6381K458 4.37
3/4"	6391K183 .52	6381K459 1.49
1"	6391K184 .70	6381K46 1.65
1 1/4"	6391K185 .73	6381K461 1.88
For Shaft Dia.: 3/8"; Bearing OD: 5/8"		
1/2"	6391K186 .60	6381K462 4.37
5/8"	6391K187 .50	6381K463 4.46
3/4"	6391K188 .60	6381K464 1.52
1"	6391K189 .87	6381K606 1.70
For Shaft Dia.: 7/16"; Bearing OD: 9/16"		
1/2"	6391K117 .40	6381K607 4.34
5/8"	6391K118 .33	6381K608 4.46
1"	6391K119 .53	6381K609 1.70
1 1/4"	6391K407 .97	6381K61 1.95

(Continued on following page)

PER McMASTER PAGE

$$\text{ACTUAL } PV = \left[\frac{241 \text{ lb}}{(3 \text{ in})(1.25 \text{ in})}\right] \frac{1 \text{ rev}}{6 \text{ sec}} \left[.267\right] (1.25 \text{ in})$$

GUESS

$= 3.5$

$PV_{ALLOW} = 50000$ $\qquad P_{ALLOW} = 2000$

$$FS_{P_{ALLOW}} = \frac{2000}{241} = 8.3$$

WT OF SHAFT ASSY	15
WT OF MOUNT PL	15
WT OF 2 BRG BLOCKS	15
	45
PMT BOX	105
	150 lb
WT OF BLOCK MTG PL	15
	165

STRESS IN SCREWS MOUNTING BLOCK MOUNT PL TO PIN BLOCK

8 EA 5/16-18 SCR $\qquad A_s = 8(0.0524) = 0.419 \text{ in}^2$

$$\sigma = \frac{165}{.419} = 394 \text{ psi}$$

FOR UTS = 70000

$$FS_U = \frac{70000}{394} = 178$$

STRESS IN COUNTER WT THRU RODS

WT:

2 PIN BLOCKS		165
		5
BOTTOM WT		170
MAIN WTS	4 @ 160	640
TOP WT		160
		1140

$$F = \frac{1140\ lb}{3\ ROD} = 380\ lb$$

$$A_\sigma = 0.606 \qquad \sigma = \frac{380}{.606} = 627\ psi$$

FOR GRADE B7, ASTM A193 UTS = 125,000 psi

$$FS_u = 199$$

STRESS IN SLIDE HANGER

ADD THD ROD WT = 1156

$$F = \frac{1156}{3} = 385\ lb \qquad A_\sigma = 0.334$$

$$\sigma = \frac{385}{.334} = 1154\ psi$$

FROM RYERSON, LOWEST STEEL #S

$$S_y = 62000 \qquad S_u = 89000$$

$$FS_y = 53.7 \qquad FS_u = 77.1$$

Date: Mon, 20 Jan 2003 17:23:06 -0500 (EST)
X-PH: V4.4@bnl.gov
From: James Sowinski <sowinski@iucf.indiana.edu>
To: "Scheblein, John A" <schebs@bnl.gov>
cc: "Leonhardt, William J" <wjleonhardt@bnl.gov>,
"Brown, Ralph L" <rlbrown@bnl.gov>,
"John M. Puskar-Pasewicz" <johnpp@iucf.indiana.edu>,
Steve Vigdor <vigdor@iucf.indiana.edu>,
Will Jacobs <jacobs@iucf.indiana.edu>
Subject: Re: CG of boxes.
X-MailScanner: Found to be clean, Found to be clean

John,

I have calculated the cg of the MAPMT boxes. The box is almost symmetric in the direction of the thickness (5.125) and I find that the cg is this direction is in the middle of the box (i.e. right in the center of the middle plate). In height off the bottom of the bottom plate I find it is 7.03" high. In the remaining direction I find the cg is 6.18 from the edge of the base plate nearest the end with all the fibers (the tall end) This puts it about 1.43" behind the plate that holds all the MAPMTs.

The box is not yet together. I'll double check these numbers when it is.

Regards,

Jim

On Fri, 20 Dec 2002, Scheblein, John A wrote:

> Jim,
> I would like the box to rotate about the CG for smooth rotation.
> Give me the calculated CG and I will use that and we can verify it
> later.
> thanks.
> Schebs...
>
>
>
> ----- Original Message -----
> From: "James Sowinski" <sowinski@iucf.indiana.edu>
> To: "Scheblein, John A" <schebs@bnl.gov>
> Cc: "Leonhardt, William J" <wjleonhardt@bnl.gov>; "Brown, Ralph L"
> <rlbrown@bnl.gov>; "John M. Puskar-Pasewicz" <johnpp@iucf.indiana.edu>;
> "Steve Vigdor" <vigdor@iucf.indiana.edu>; "Will Jacobs"
> <jacobs@iucf.indiana.edu>
> Sent: Friday, December 20, 2002 10:58 AM
> Subject: Re: CG of boxes.
>
>
> > Schebs,
> >
> > I am asking around to see if we have a box we can do the measurement on.
> > I suspect any spares may be out at BNL.
> >
> > The MAPMT boxes will be slightly different. We won't have the first one

From: Jeff Hammon <jeff.hammon@mcmaster.com>
To: "'WJLeonhardt@bnl.gov'" <WJLeonhardt@bnl.gov>
Subject: RE: Your message to McMaster-Carr
Date: Wed, 26 Feb 2003 16:02:21 -0500
X-Mailer: Internet Mail Service (5.5.2653.19)
X-MailScanner: Found to be clean

William,

The tensile is 100,000 psi on the core and 335,000 psi case. The yield strength is 75 ksi on the core and 250 ksi on the case.

Mitch Sommer

```
            | 2/26/03
+-----------------------------+                    |
+-----------------------------+ 01:13 PM CDT
                                              +-------------
```

Company Name: Brookhaven National Lab
Contact Name: William Leonhardt
Browser: Microsoft Internet Explorer v 6.0 on Windows NT
E-mail Address: WJLeonhardt@bnl.gov
Phone Number: 631-344-2378

Address: Bldg 510A

Upton, NY 11973
USA

Message:

I need the mechanical properties (tensile and yield strength) of the AISI 1566 steel used in McMaster part# 6061K56. Thank you.

EEMC
Box Lift Fixt

4-2-05

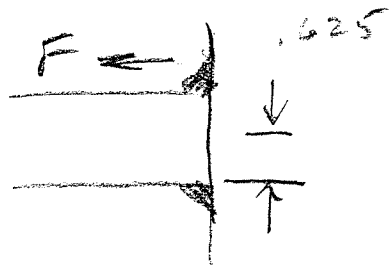
RECHECK OF WELD ON
PART EEMC468

FOR $\frac{}{1/4 V}$ $L_{THROAT} = (.25)(.707) = 0.177 in$

$A = \pi d L_T = \pi (1.25)(.177) = 0.694 in^2$

Box & ADAPT $P \simeq 120$ lb

$\tau = \frac{120}{.694} = 173$ psi OK



FROM PREV CALC

$M = 1720$ in lb

$F = \frac{1720}{.625} = 2752$ lb

$\sigma = \frac{2752}{0.694} = 3965$ psi

FOR $S_y = 50000$

$F_S = 12.6$