



PHENIX Muon Lampshade Panels Removal And Installation Procedure

procedure name

PHENIX Procedure No. PP-2.5.1.5-01

Revision: A

Date: 2-19-02

Hand Processed Changes

<u>HPC No.</u>	<u>Date</u>	<u>Page Nos.</u>	<u>Initials</u>
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Approvals

Peter Kim 2/19/02
PHENIX S E & I Date

Cognizant Scientist/Engineer Date
/Activity Manager

Willis Lynn 2-19-02
PHENIX Safety Date

W. J. ... 02/25/02
CA-D Safety Date
Phenix LP

PP-2.5.1.5-01

Muon Detector
Lampshade Panels
Removal and Installation

Procedure

HPC N°
1

DATE PG #'s
9/1/98 3 & 5

INIT.
W/S

Date: 1/27/97

Prepared by: W. Stokes 1/28/97
W. Stokes

Approved by: Peter Kroon 1/29/97
P. Kroon

REVISION CONTROL SHEET

LETTER	DESCRIPTION	DATE	WRITTEN BY	APPROVED BY	TYPED BY
A	First Issue (Note: original issue dated 1/27/97 has hand processed changes dated 9/1/98. There does not appear to be a reissued rev B., but rather a new rev A. title sheet with the indicated date.	2/19/02	W. Stokes	W. Lenz, Y. Makdisi, P. Kroon	n/a
	This procedure is no longer a PHENIX controlled operation. The task is now a CAD controlled task. Therefore this Procedure is retired at the Rev. A 2/19/02 version.	2/12/2007	(Retirement note written by. D.Lynch)	Retirement approved by D. Lynch, R. Pisani and P. Giannotti for the PHENIX experiment	n/a

I. Introduction: The Phenix detector has two muon detectors. One called the North Muon Detector and the other the South Muon Detector. Briefly described, they consist of a central, bullet shaped feature called the piston core, surrounded by an eight sided, hollow, conically shaped steel structure which serves as a yoke for flux return (see fig. 1). The eight sided conical shaped is oriented with two flats horizontal, two flats vertical, and four flats at 45° angles as can be seen in fig.1. This structure is constructed having the five upper, trapezoidal, sections which are removable. These panels, called lampshade panels, are the one horizontal, two vertical, and two 45° (biased) sections shown in Fig. 1. The three lower sections of the conically shaped structure are permanently installed and attached to the floor supports, rear frame, and to one another. To install and service the equipment that will be mounted inside this cone the lampshade panels must be removed and reinstalled. Due to factors such as size (12.7' x 13.1'), weight (16,000 lbs.), trapezoidal shape, angle of installation, and internal clearances to delicate devices (as little as .78") the exact, actual, center of gravity (CG) must be located and reproduced for lifting to maintain mounting orientations. This document is divided into three sections; 1.) actual CG identification, 2.) removal procedures, and 3.) installation procedures.

II. General Safety Statement: Due to the delicacy of interior components, value of components, size and shape of panels, and risk to component and physical harm, rigging safety and all other applicable safety procedures shall be adhered to. Any individual may cease operations if they feel unsafe or if they believe unsafe procedures are being followed.

III. Applicable Documents:

A. Engineering Drawings

1. Muon Detector - North Assembly; LLNL # 93-101858-OD
2. Muon Detector - South Assembly; TBD
3. Lampshade Panels
 - a. Horizontal; LLNL # RAA93-101892 TAB 01
 - b. Vertical (east); LLNL # RAA93-104174 TAB 01
 - c. Vertical (west); LLNL # RAA93-104174 TAB 02
 - d. Bias (east and west); LLNL # RAA93-101890
4. Lampshade Panels Rigging; BNL # 002-0504-020

B. Rigging Equipment:

1. Crane Specification; ACECO, 10T/40T, Tendon
2. Chain Hoist Specifications; Columbus McKinnon Corp. Series 622, 3 ton, 12' chain (or equiv.) Series 622, 5 ton, 14' chain (or equiv.)
3. Sling: Thimble & Thimble Type, 7 ton capacity min.
4. Shackles Specification; Crosby Type S-209 8.5 ton (or equiv.)
5. Swivel shackles Specification; McMaster-Carr 30,000 lb. capacity P/N 3052T69 (or equiv.)
6. Plumb-Bob Specification; BNL Stock # H-20980 (8 oz., steel)

C. Safety Regulations (but not limited to):

1. BNL ES&H
 - a. 1.5.1; Lockout/Tagout Requirements
 - b. 1.5.3; Interlock Safety for Protection of Personnel
 - c. 1.6.0; Material Handling Equipment
 - d. 1.16.0; Personal Protective Equipment
2. BNL SEAPPM
 - a. 1.5.1; Lockout/Tagout Requirements
 - b. 1.5.3; Interlock Safety
 - c. 1.6.0; Material Handling Equipment
 - d. 1.16.0; Personal Protective Equipment
3. RHIC SEAPPM
 - a. 1.5.1; Lockout/Tagout Requirements
 - b. 1.5.3; Interlock Safety
 - c. 1.6.0; Material Handling Equipment
 - d. 1.16.0; Personal Protective Equipment

IV. Locating Actual CG of Panels:

A. Horizontal (LLNL P/N RAA93-101892 TAB 01 and Bias (LLNL P/N RAA93-101890) Lampshade Panels:

1. Ascertain that the work area is safe to enter
2. Identify lampshade to be the correct part specified above.
3. Identify the following rigging components to be the correct parts specified in Section 3 Article B;
 - a. Chain Hoist
 - b. Shackles
 - c. Swivel shackles
 - d. Plumb-Bob
4. Locate the calculated CG of the panel, with a temporary marking instrument, using dimensions indicated on BNL engineering drawing # 002-0504-020.
5. Install swivel shackles to panel at points A, B, and C as shown on BNL engineering drawing # 002-0504-020.
6. Attach the sling and chain hoists to the crane hook.
7. Attach the plumb-bob to the crane hook using cord and allowing for length adjustment. The location of the plumb-bob must fall directly below, and in-line with, the center line of the hook's block.
8. Move the crane hook over the previously mounted panel to locate the plumb-bob, hanging from the hook, directly above the temporary CG cross hair marked in step 3.

NOTE: Once the plumb-bob is positioned directly above the CG cross hair DO NOT reposition the crane until step 12.

9. Attach the sling or chain hoist to the swivel shackle at point A

and the two chain hoists to the swivel shackles at points B and C using shackles as shown on BNL engineering drawing 002-0504-020.

10. Adjust chain hoist lengths until chains and sling are snug and the plumb-bob settles over the CG cross hairs again.

NOTE: DO NOT move crane to achieve this step.

11. Remove all fasteners attaching the panel to the lampshade assembly.

12. Slowly lift the panel until the panel's perimeter clears the assembly by a minimum distance (<1" if possible).

13. With the panel hanging above its' installed position set the chain hoist lengths until the gap around the perimeter of the plate is consistent to <.250".

NOTE: The crane position may need to be relocated at this step to reposition the panel back above its' original installed position due to the adjustment of the chain hoist lengths.

14. Trial fit the panel back into the installed position.

15. Once again, lift the panel to a minimum gap as in step 12.

16. Verify perimeter gap to be consistent to <.250". If not return to step 12.

17. Using a permanent marker draw a circled cross hair (⊕) directly below the new plumb-bob position. Allow cross hair to dry, center punch crosshair intersection, and cover with a coat of clear protectant.

18. Move panel to a position that is safe for accurately measuring distances between swivel shackles and crane hook.

19. Accurately measure and record distances from swivel eye to crane hook so that set-up may be reproduced at a later date. ^{13.5T SHACKLE CONNECTED TO}

a. Horizontal Panel:

Hook to A: 113.5 Hook to B: 75"

Hook to C: 75"

b. Bias Panel (east):

Hook to A: _____ Hook to B: _____

Hook to C: _____

c. Bias Panel (west):

Hook to A: _____ Hook to B: _____

Hook to C: _____

20. Store panel and hardware to proceed with the next panel CG identification.

B. Vertical Lampshade Panels (East)(LLNL P/N RAA93-104174
TAB 01) (west)(LLNL P/N RAA93-104174 TAB 02):

1. Ascertain that the work area is safe to enter
2. Identify lampshade to be the correct part as specified above.
3. Identify the following rigging components to be the correct parts specified in Section 3 Article B;
 - a. Chain Hoist
 - b. Shackles
 - c. Swivel shackles
 - d. Plumb-Bob
4. Locate the calculated CG of the panel, with a temporary marking instrument, using dimensions indicated on BNL engineering drawing # 002-0504-020.
5. Install swivel shackles to panel at points A and B (east panel) and points A and C (west panel) as shown on BNL engineering drawing # 002-0504-020.
6. Attach the sling and chain hoist to the crane hook.
7. Attach the plumb-bob to the crane hook using cord and allowing for length adjustment. The location of the plumb-bob must fall directly below, and in-line with, the center line of the hook's block.
8. Move the crane hook over the previously mounted panel to locate the plumb-bob, hanging from the hook, directly above the temporary CG cross hair marked in step 3.

NOTE: Once the plumb-bob is positioned directly above the CG cross hair DO NOT reposition the crane until step 12.

9. Attach the sling or chain hoist to the panel shackle at point A and chain hoist to the swivel shackle at point B (east panel) or at point C (west panel) using shackles as shown on BNL engineering drawing 002-0504-020.
10. Adjust chain hoist lengths until the sling and chain hoist are snug and the plumb-bob settles over the CG cross hairs again.

NOTE: DO NOT move crane to achieve this step.

11. Remove all fasteners attaching the panel to the lampshade assembly.
12. Slowly lift the panel until the panel's perimeter clears the assembly by a minimum distance (<1" if possible).
13. With the panel hanging above its' installed position set the chain hoist lengths until the gap around the perimeter of the plate is consistent to <.250".

NOTE: The crane position may need to be relocated at this step to reposition the panel back above its' original installed position due to the adjustment of the chain hoist lengths.

14. Trial fit the panel back into the installed position.

15. Once again, lift the panel to a minimum gap as in step 12.
16. Verify perimeter gap to be consistent to $<.250"$. If not return to step 12.
17. Using a permanent marker draw a circled cross hair (⊙) directly below the new plumb-bob position. Allow cross hair to dry, center punch crosshair intersection, and cover with a coat of clear protectant.
18. Move panel to a position that is safe for accurately measuring distances between swivel shackles and crane hook.
19. Accurately measure and record distances from swivel eye to crane hook so that slings may be purchased to replace chain hoists.
 - a. Vertical Panel (east):
Hook to A: _____ Hook to C: _____
 - b. Vertical Panel (west):
Hook to B: _____ Hook to B: _____
20. Store panel and hardware to proceed with the next panel CG identification.

V. Panel Removal

A. Horizontal (LLNL P/N RAA93-101892 TAB 01) and Bias (LLNL P/N RAA93-101890) Lampshade Panels:

1. Ascertain that the work area is safe to enter
2. Identify lampshade to be the correct part as specified above.
3. Identify the following rigging components to be the correct parts specified in Section 3 Article B;
 - a. Chain Hoist
 - b. Shackles
 - c. Swivel shackles
 - d. Plumb-Bob
4. Install swivel shackles to panel at points A, B, and C as shown on BNL engineering drawing # 002-0504-020.
5. Attach sling and chain hoists to crane hook.
6. Attach plumb-bob to crane hook in line with the centerline of the hook block.
7. Set chain hoist lengths as described in Section IV, Article A, Paragraph 19.
8. Attach ~~sling or chain hoist~~ ^{SLINGS} to swivel shackle at point A and ~~chain hoists~~ ^{SLINGS} to swivel shackles at points B and C with shackles as shown on BNL engineering drawing # 002-0504-020.
9. Adjust crane hook position to locate plumb-bob directly over the prelocated panel CG and raise hook until all straps are taught. Check, by hand, to ascertain that tension in all straps is equal.
10. Detach panel from the cone assembly by removing all fasteners.

11. Slowly lift panel to clear the cone assembly.
NOTE: If panel does not lift evenly from the assembly discontinue lift until the cause of unevenness is determined.

D. Vertical Lampshade Panels (East)(LLNL P/N RAA93-104174 TAB 01) and (west)(LLNL P/N RAA93-104174 TAB 02):

1. Ascertain that the work area is safe to enter
2. Identify lampshade to be the correct part as specified above.
3. Identify the following rigging components to be the correct parts specified in Section 3 Article B;
 - a. Chain Hoist
 - b. Shackles
 - c. Swivel shackles
 - d. Plumb-Bob
4. Install swivel shackles to panel at points A and B (east panel) or points A and C (west panel) as shown on BNL engineering drawing # 002-0504-020.
5. Attach sling and chain hoist to crane hook.
6. Attach plumb-bob to crane hook in line with the centerline of the hook block.
7. Set chain hoist lengths as described in Section IV, Article B, Paragraph 19.
8. Attach sling or chain hoist to swivel shackle at point A and chain hoist to swivel shackle at point B (east panel) or point C (west panel) with shackles as shown on BNL engineering drawing # 002-0504-020.
9. Adjust crane hook position to locate plumb-bob directly over the prelocated panel CG and raise hook until all straps are taught. Check, by hand, to ascertain that tension in all straps is equal.
10. Detach panel from the cone assembly by removing all fasteners.
11. Slowly lift panel to clear the cone assembly.
NOTE: If panel does not lift evenly from the assembly discontinue lift until the cause of unevenness is determined.

VI. Panel Installation

A. Horizontal (P/N RAA93-101892 TAB 01) and Bias (LLNL P/N RAA93-101890) Lampshade Panels:

1. Ascertain that the work area is safe to enter
2. If any rigging hardware/equipment has been removed from the panel since the panel removal sequence proceed with steps a through h. If not, go directly to step 3.
 - a. Identify lampshade to be the correct part as described above.
 - b. Identify the following rigging components to be the correct parts specified in Section 3 Article

B;

- a. Chain Hoist
- b. Shackles
- c. Swivel shackles
- d. Plumb-Bob
- c. Install swivel shackles to panel at points A, B and C as shown on BNL engineering drawing # 002-0504-020.
- d. Attach sling and chain hoists to crane hook.
- e. Attach plumb-bob to crane hook in line with centerline of hook block.
- f. Attach sling or chain hoist to swivel shackle at point A and chain hoists to swivel shackles at points B and C, with shackles as shown on BNL engineering drawing # 002-0504-020.
- g. Set chain hoist lengths as described in Section IV, Article A, Paragraph 19.
- 3. Lift panel to a position hovering above its installation position.
- 4. Slowly lower the panel to a position approximately 1" above its mating panel.
- 5. Check alignment with the mating panel and reposition if necessary.
- 6. Lower panel into its final resting position while still maintaining sling tension.
- 7. Install all fasteners snugly.
- 8. Remove rigging hardware.
- 9. Torque all screws to specification.

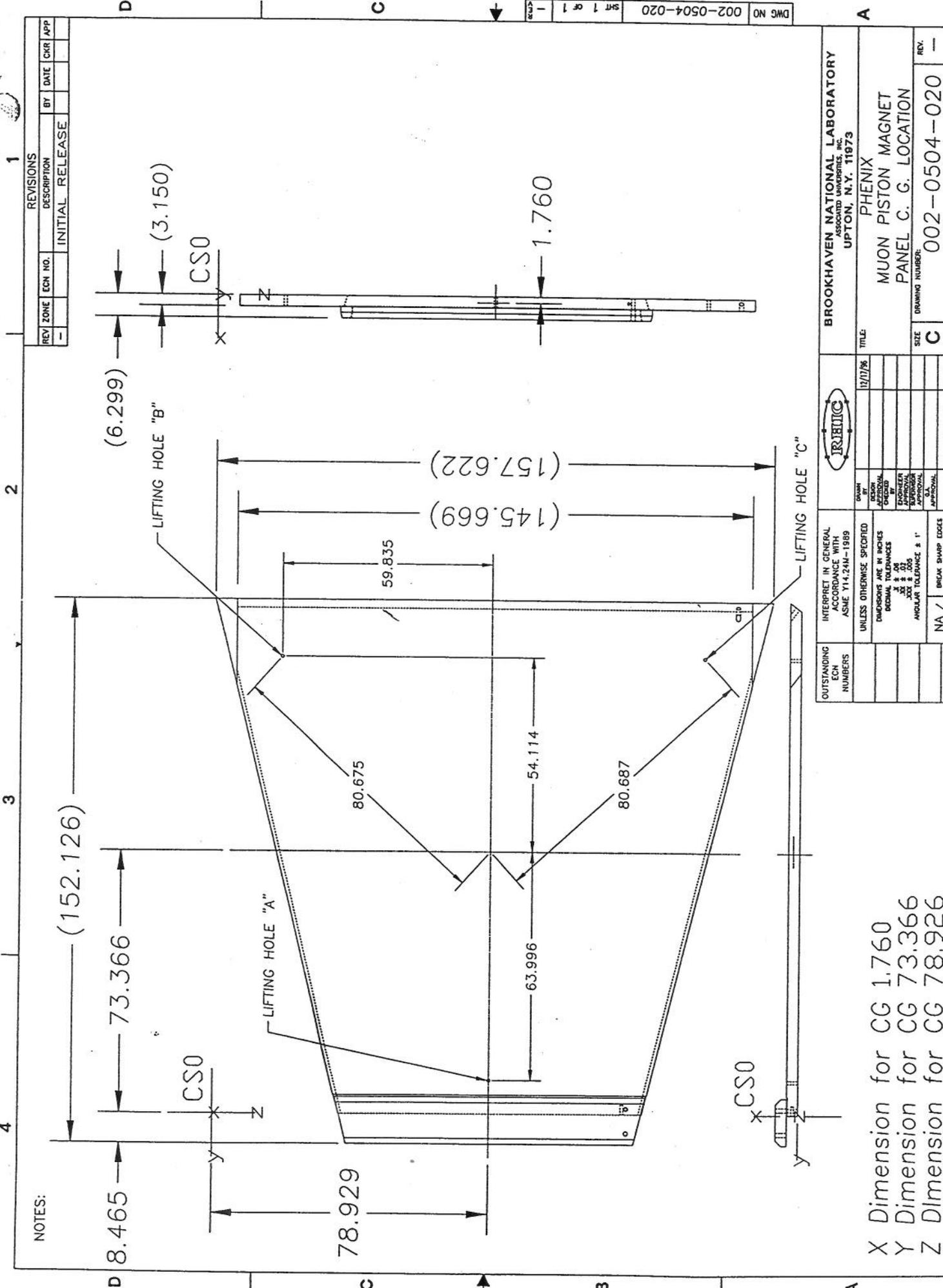
B. Vertical Lampshade Panels (East)(LLNL P/N RAA93-104174 TAB 01) and (west) (LLNL P/N RAA93 104174 TAB 02):

- 1. Ascertain that the work area is safe to enter
- 2. If any rigging hardware/equipment has been removed from the panel since the panel removal sequence proceed with steps a through h. If not, go directly to step 3.
 - a. Identify lampshade to be the correct part as specified above.
 - b. Identify the following rigging components to be the correct parts specified in Section 3 Article B;

- a. Chain Hoist
- b. Shackles
- c. Swivel shackles
- d. Plumb-Bob
- c. Install swivel shackles to panel at points A and B (east panel) or points A and C (west panel) as shown on BNL engineering drawing # 002-0504-020.
- d. Attach sling and chain hoist assembly to crane hook.
- e. Attach plumb-bob to crane hook in line with

- centerline of hook block.
- f. Attach sling or chain hoist to swivel shackle at point A and chain hoist to swivel shackle at point B (east panel) or point C (west panel) with shackles as shown.
 - g. Set chain hoist lengths as described in Section IV, Article B, Paragraph 19.
on BNL engineering drawing # 002-0504-020.
3. Lift panel to a position hovering above its installation position.
 4. Slowly lower the panel to a position approximately 1" above its mating panel.
 5. Check alignment with the mating panel and reposition if necessary.
 6. Lower panel into its final resting position while still maintaining sling tension.
 7. Install all fasteners snugly.
 8. Remove rigging hardware.
 9. Torque all screws to specification.

**NOTE: IF ANY PANEL HAS ANY
MODIFICATION MADE TO IT
THE PANEL MUST UNDERGO
ACTUAL CG POSITION
DETERMINATION AGAIN.**



NOTES:

X Dimension for CG 1.760
 Y Dimension for CG 73.366
 Z Dimension for CG 78.926

REV	ZONE	ECN NO.	DESCRIPTION	BY	DATE	CHKR	APP
-			INITIAL RELEASE				

DWC NO 002-0504-020		SHT 1 OF 1		REV. ---	
BROOKHAVEN NATIONAL LABORATORY ASSOCIATED UNIVERSITIES, INC. UPTON, N.Y. 11973		IRJETIC		DATE: 12/17/78	
TITLE: PHENIX		DRAWING NUMBER: C		REV. ---	
MUON PISTON MAGNET		PANEL C. G. LOCATION		SIZE: 002-0504-020	
UNLESS OTHERWISE SPECIFIED		DIMENSIONS ARE IN INCHES		DECIMAL TOLERANCES	
FRACTIONS		± .005		± .005	
DECIMALS		± .005		± .005	
ANGULAR TOLERANCE		± 1°		± 1°	
FINISH: NA		BREAK SHARP EDGES		MAX. .03 MIN. .01	
OUTSTANDING ECN NUMBERS		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989		DRAWN BY: [blank]	
		UNLESS OTHERWISE SPECIFIED		CHECKED BY: [blank]	
		DIMENSIONS ARE IN INCHES		ENGINEER APPROVAL: [blank]	
		DECIMAL TOLERANCES		U.S. APPROVAL: [blank]	
		FRACTIONS ± .005			
		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
		FINISH: NA			
		BREAK SHARP EDGES		MAX. .03 MIN. .01	
		OUTSTANDING ECN NUMBERS			
		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989			
		UNLESS OTHERWISE SPECIFIED			
		DIMENSIONS ARE IN INCHES			
		DECIMAL TOLERANCES			
		FRACTIONS ± .005			
		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
		FINISH: NA			
		BREAK SHARP EDGES		MAX. .03 MIN. .01	
		OUTSTANDING ECN NUMBERS			
		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989			
		UNLESS OTHERWISE SPECIFIED			
		DIMENSIONS ARE IN INCHES			
		DECIMAL TOLERANCES			
		FRACTIONS ± .005			
		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
		FINISH: NA			
		BREAK SHARP EDGES		MAX. .03 MIN. .01	
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		DECIMALS ± .005			
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		ANGULAR TOLERANCE ± 1°			
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		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
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		UNLESS OTHERWISE SPECIFIED			
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		FRACTIONS ± .005			
		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
		FINISH: NA			
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		ANGULAR TOLERANCE ± 1°			
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		DECIMALS ± .005			
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		UNLESS OTHERWISE SPECIFIED			
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		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
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		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989			
		UNLESS OTHERWISE SPECIFIED			
		DIMENSIONS ARE IN INCHES			
		DECIMAL TOLERANCES			
		FRACTIONS ± .005			
		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
		FINISH: NA			
		BREAK SHARP EDGES		MAX. .03 MIN. .01	
		OUTSTANDING ECN NUMBERS			
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		UNLESS OTHERWISE SPECIFIED			
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		FRACTIONS ± .005			
		DECIMALS ± .005			
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		UNLESS OTHERWISE SPECIFIED			
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		DECIMALS ± .005			
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		ANGULAR TOLERANCE ± 1°			
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		UNLESS OTHERWISE SPECIFIED			
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		BREAK SHARP EDGES		MAX. .03 MIN. .01	
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		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989			
		UNLESS OTHERWISE SPECIFIED			
		DIMENSIONS ARE IN INCHES			
		DECIMAL TOLERANCES			
		FRACTIONS ± .005			
		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
		FINISH: NA			
		BREAK SHARP EDGES		MAX. .03 MIN. .01	
		OUTSTANDING ECN NUMBERS			
		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989			
		UNLESS OTHERWISE SPECIFIED			
		DIMENSIONS ARE IN INCHES			
		DECIMAL TOLERANCES			
		FRACTIONS ± .005			
		DECIMALS ± .005			
		ANGULAR TOLERANCE ± 1°			
		FINISH: NA			
		BREAK SHARP EDGES		MAX. .03 MIN. .01	
		OUTSTANDING ECN NUMBERS			
		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989			
		UNLESS OTHERWISE SPECIFIED			
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		DIMENSIONS ARE IN INCHES			
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		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989			
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		OUTSTANDING ECN NUMBERS			
		INTERPRET IN GENERAL ACCORDANCE WITH ASME Y14.2M-1989			
		UNLESS OTHERWISE SPECIFIED			
		DIMENSIONS ARE IN INCHES			

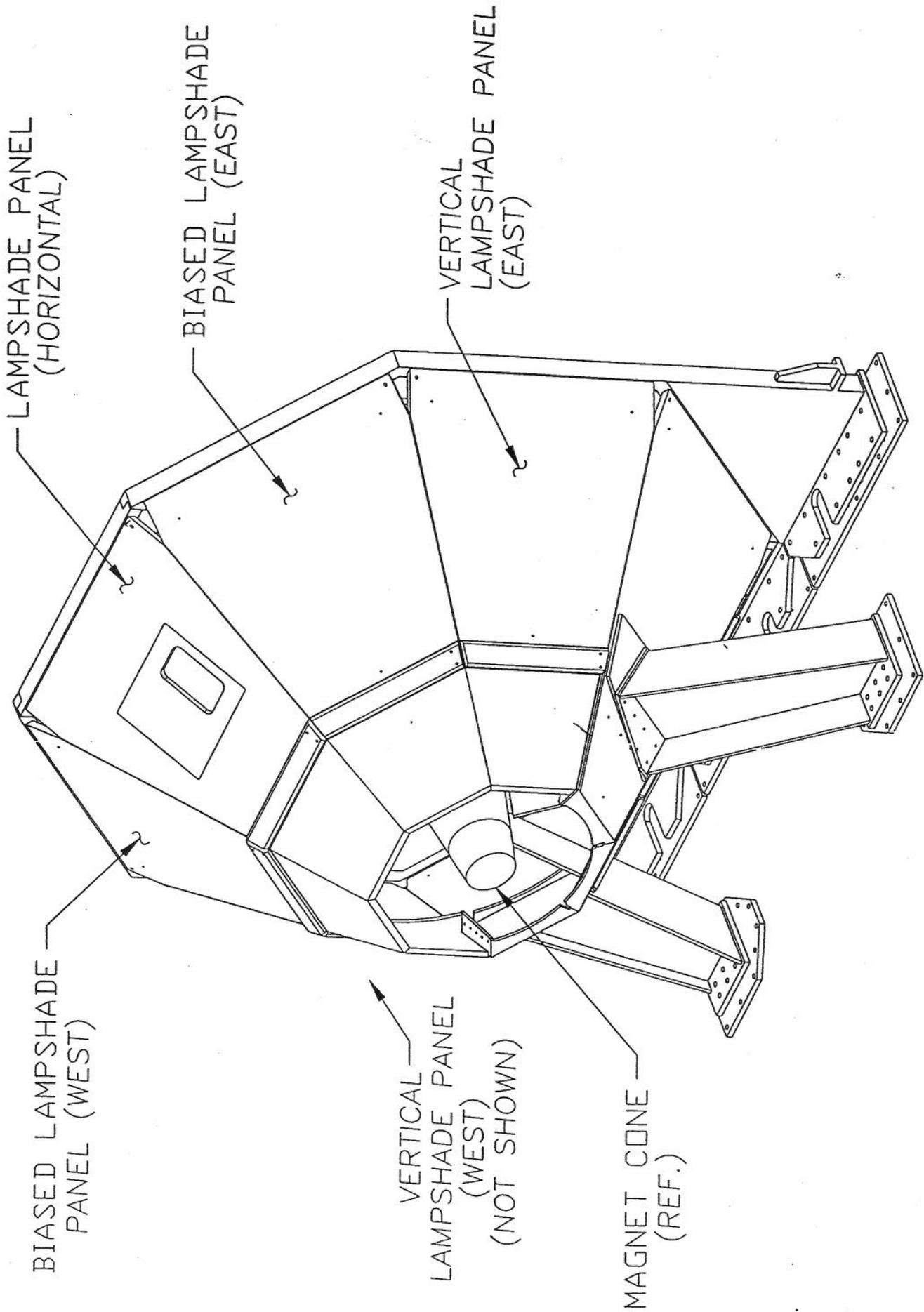
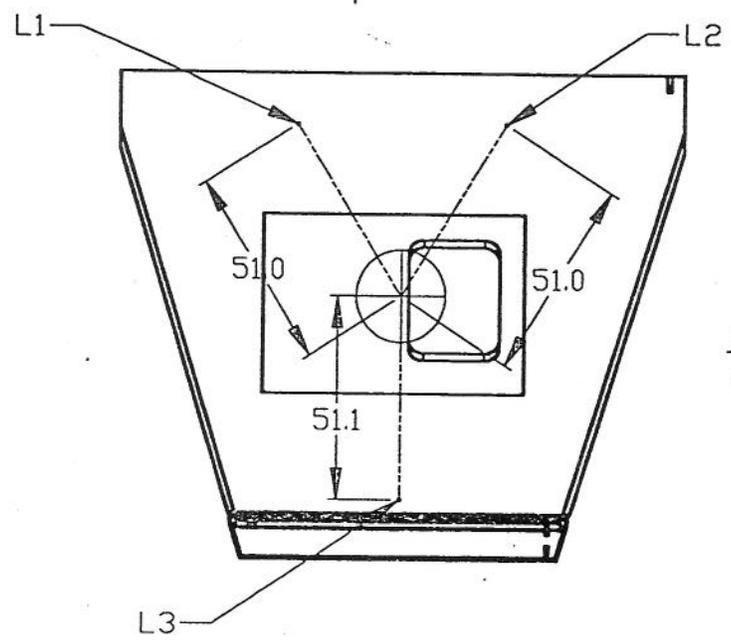


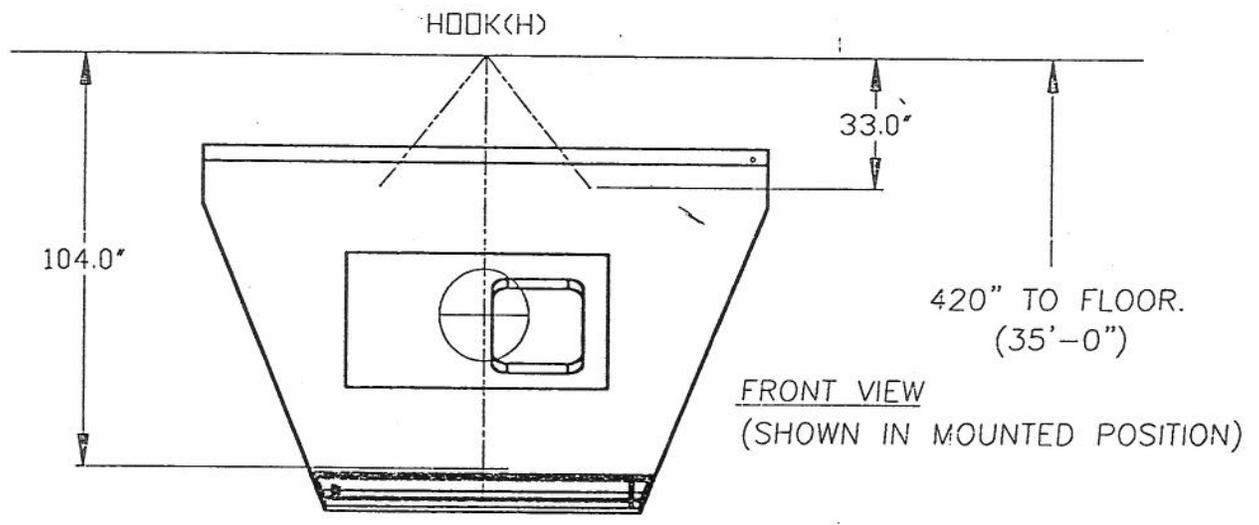
FIG. 1

HORIZONTAL PANEL SLING SCHEMATIC

⊕ = CG.

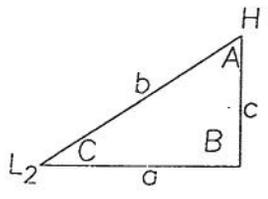


TOP VIEW
(SHOWN IN MOUNTED POSITION)

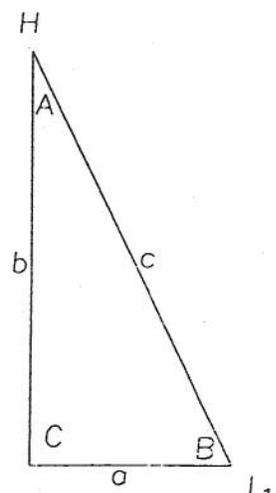


FRONT VIEW
(SHOWN IN MOUNTED POSITION)

RIGGING GEOMETRIES

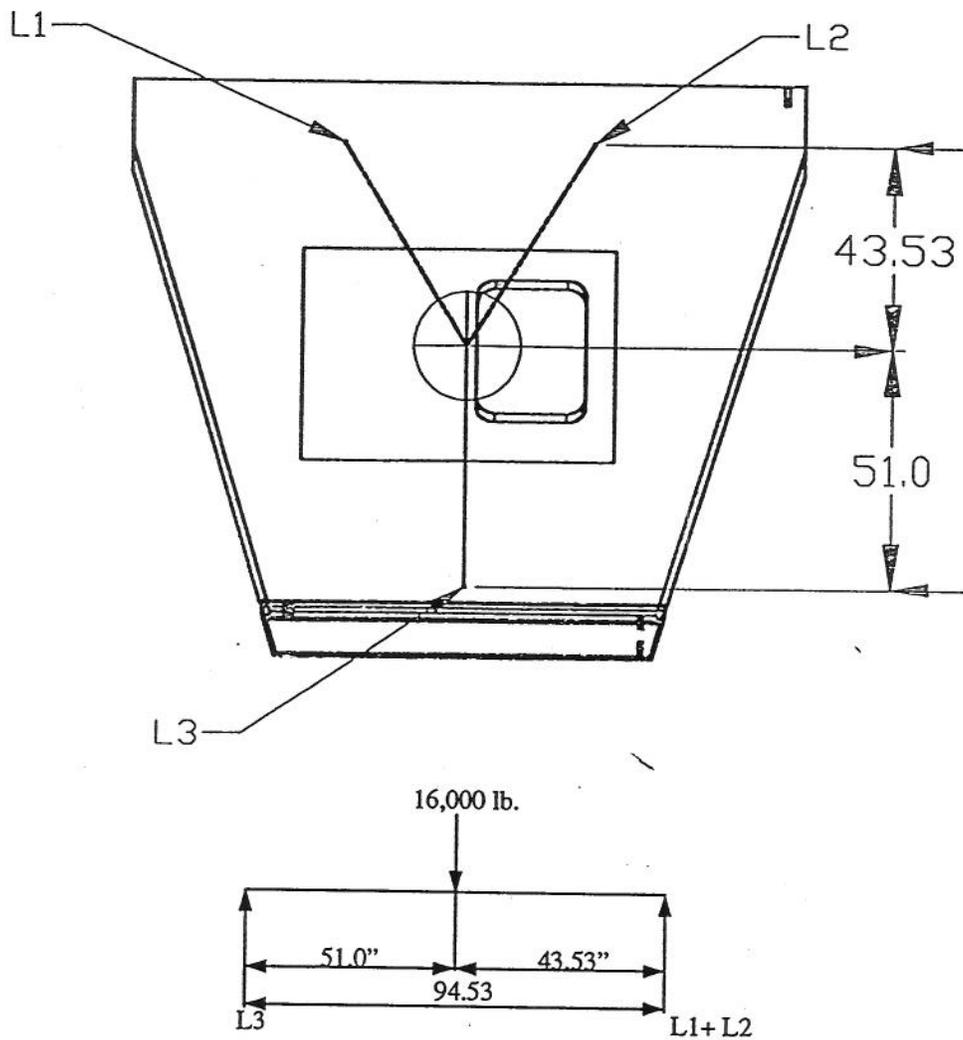


GEOMETRY H1



GEOMETRY H2

HORIZONTAL PANEL LIFT POINTS WEIGHT DISTRIBUTION



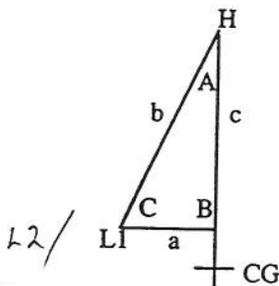
$$\text{Reaction Load L3} = 16,000 \text{ lb.} \cdot (43.53") / 94.53" = 7367.8 \text{ lb.}$$

$$\text{Reaction Load L1+L2} = 16,000 \text{ lb.} - 7367.8 \text{ lb.} = 8632.2 \text{ lb.}$$

$$\text{Reaction Loads L1 and L2} = 8632.2 \text{ lb.} / 2 = 4316.1 \text{ lb.}$$

HORIZONTAL PANEL RIGGING SLING LOAD VECTOR CALCULATIONS

GEOMETRY H1:



Given: $B = 90^\circ$, Length $a = 51.0''$, Length $c = 33.0''$, Load $c = 4316.0$ lb.

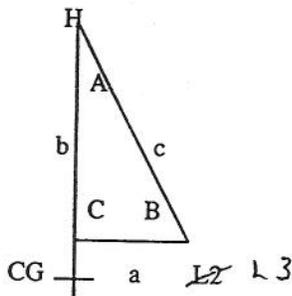
Calculations:

$$\text{Length } b = \sqrt{a^2 + c^2} = 60.75''$$

$$\text{TAN } C = c / a = 0.647 = \text{TAN } 32.91^\circ$$

$$\text{Sling Load } b = \text{Load } c / \text{SIN } C = 7943.7 \text{ lb.}$$

GEOMETRY H2:



Given: $C = 90^\circ$, Length $a = 51.0''$, Length $b = 104.0''$, Load $b = 7368.0$ lb.

Calculations:

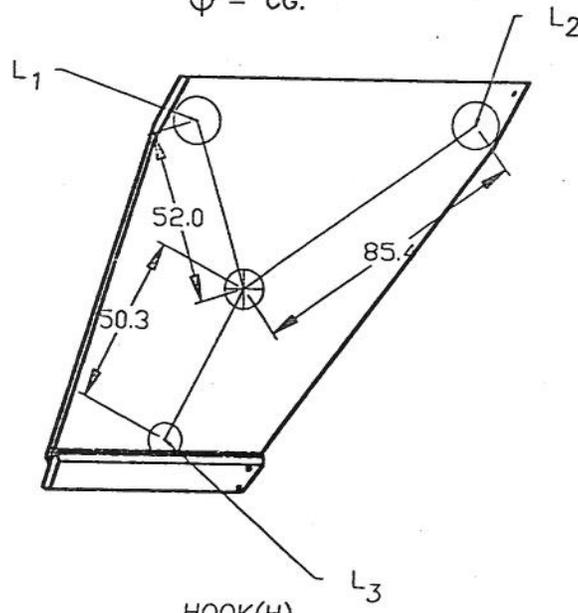
$$\text{Length } c = \sqrt{a^2 + b^2} = 115.8''$$

$$\text{TAN } B = b / a = 2.039 = \text{TAN } 63.88^\circ$$

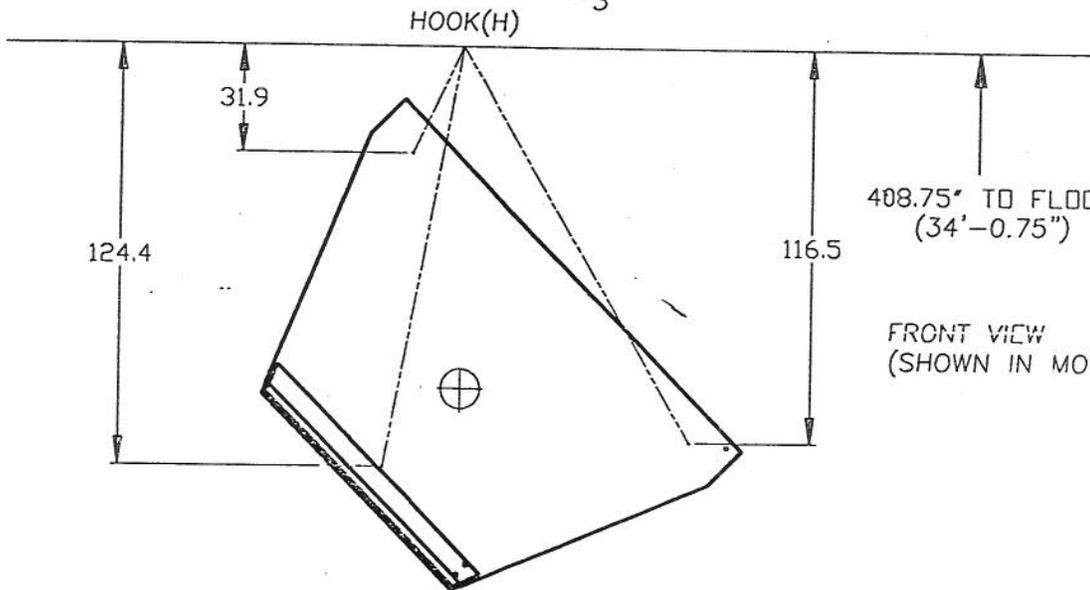
$$\text{Sling Load } c = \text{Load } b / \text{SIN } B = 8206.0 \text{ lb.}$$

BIAS PANELS SLING SCHEMATIC

$\oplus = \text{CG.}$

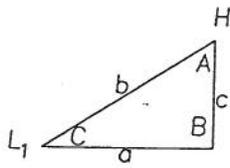


TOP VIEW
(SHOWN IN MOUNTED POSITION)

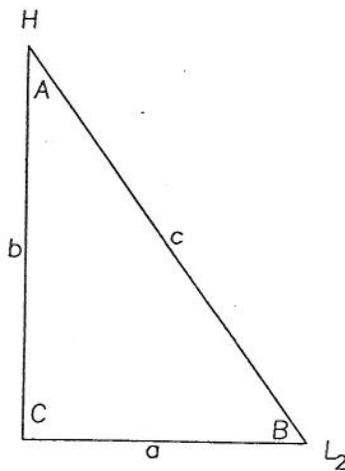


FRONT VIEW
(SHOWN IN MOUNTED POSITION)

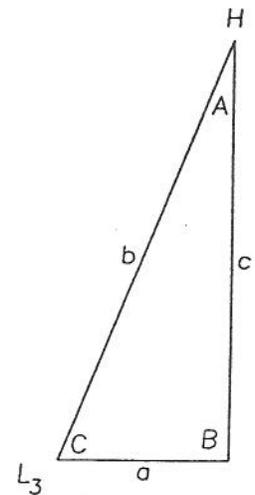
RIGGING GEOMETRIES



GEOMETRY B1

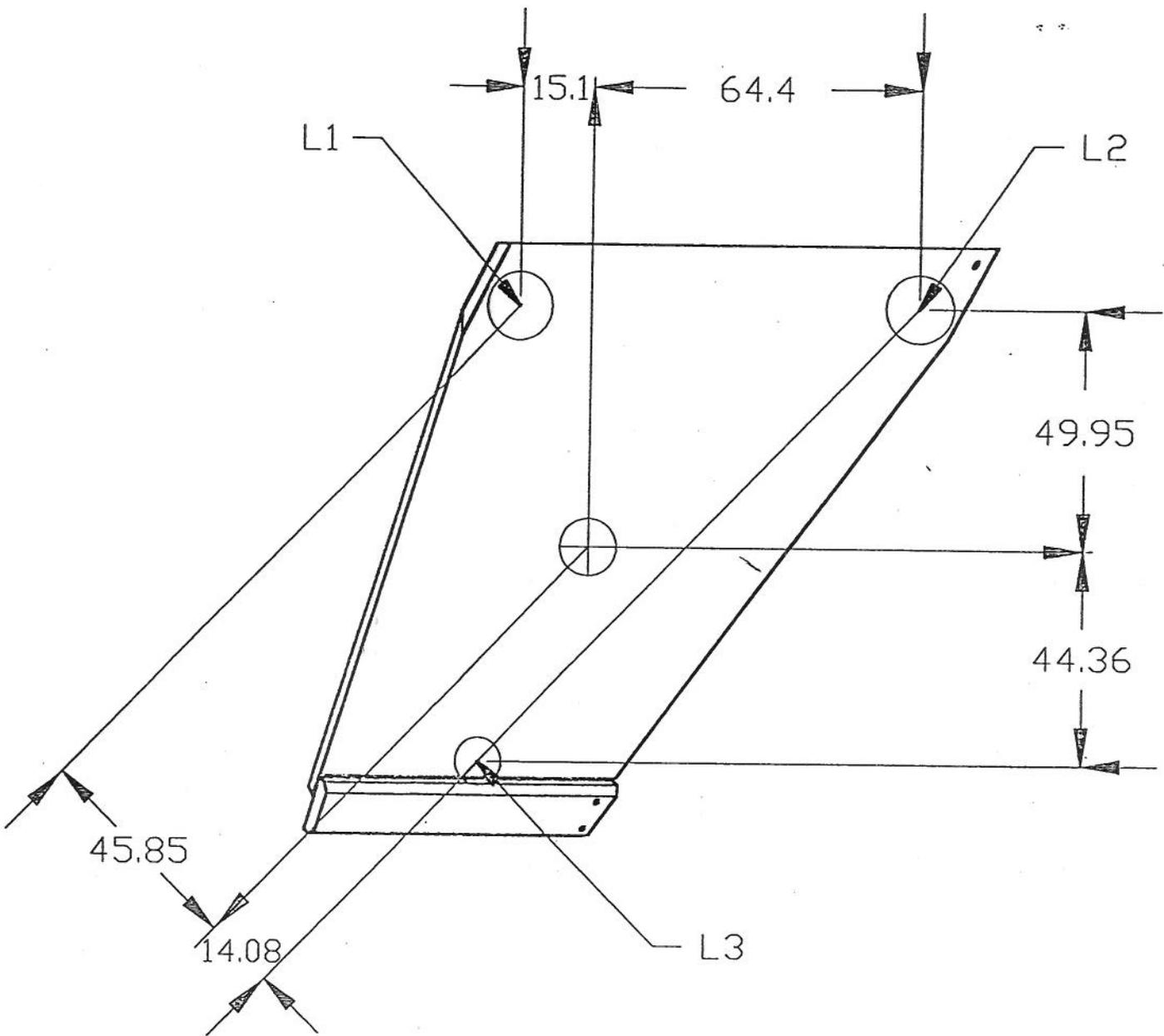


GEOMETRY B2



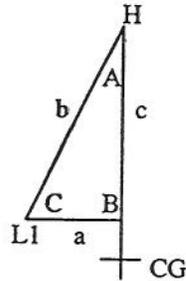
GEOMETRY B3

BIAS PANELS
LIFT POINTS
WEIGHT DISTRIBUTION
SCHEMATIC



BIAS PANELS RIGGING SLING LOAD VECTOR CALCULATIONS

GEOMETRY B1:



Given: $B = 90^\circ$, Length $a = 52.0''$, Length $c = 31.9''$, Load $c = 3937.9$ lb.

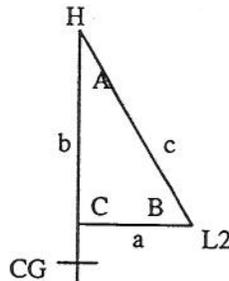
Calculations:

$$\text{Length } b = \sqrt{a^2 + c^2} = 131.96''$$

$$\text{TAN } C = c / a = 0.613 = \text{TAN } 31.53^\circ$$

$$\text{Sling Load } b = \text{Load } c / \text{SIN } C = 8441.0 \text{ lb.}$$

GEOMETRY B2:



Given: $C = 90^\circ$, Length $a = 85.4''$, Length $b = 116.4''$, Load $b = 3183.8$ lb.

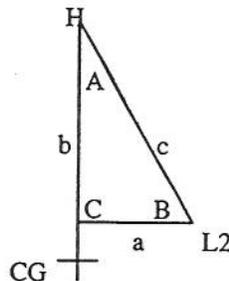
Calculations:

$$\text{Length } c = \sqrt{a^2 + b^2} = 144.37''$$

$$\text{TAN } B = b / a = 1.363 = \text{TAN } 53.73^\circ$$

$$\text{Sling Load } c = \text{Load } b / \text{SIN } B = 3949.0 \text{ lb.}$$

GEOMETRY B3:



Given: $C = 90^\circ$, Length $a = 50.3''$, Length $b = 124.4''$, Load $b = 8878.3$ lb.

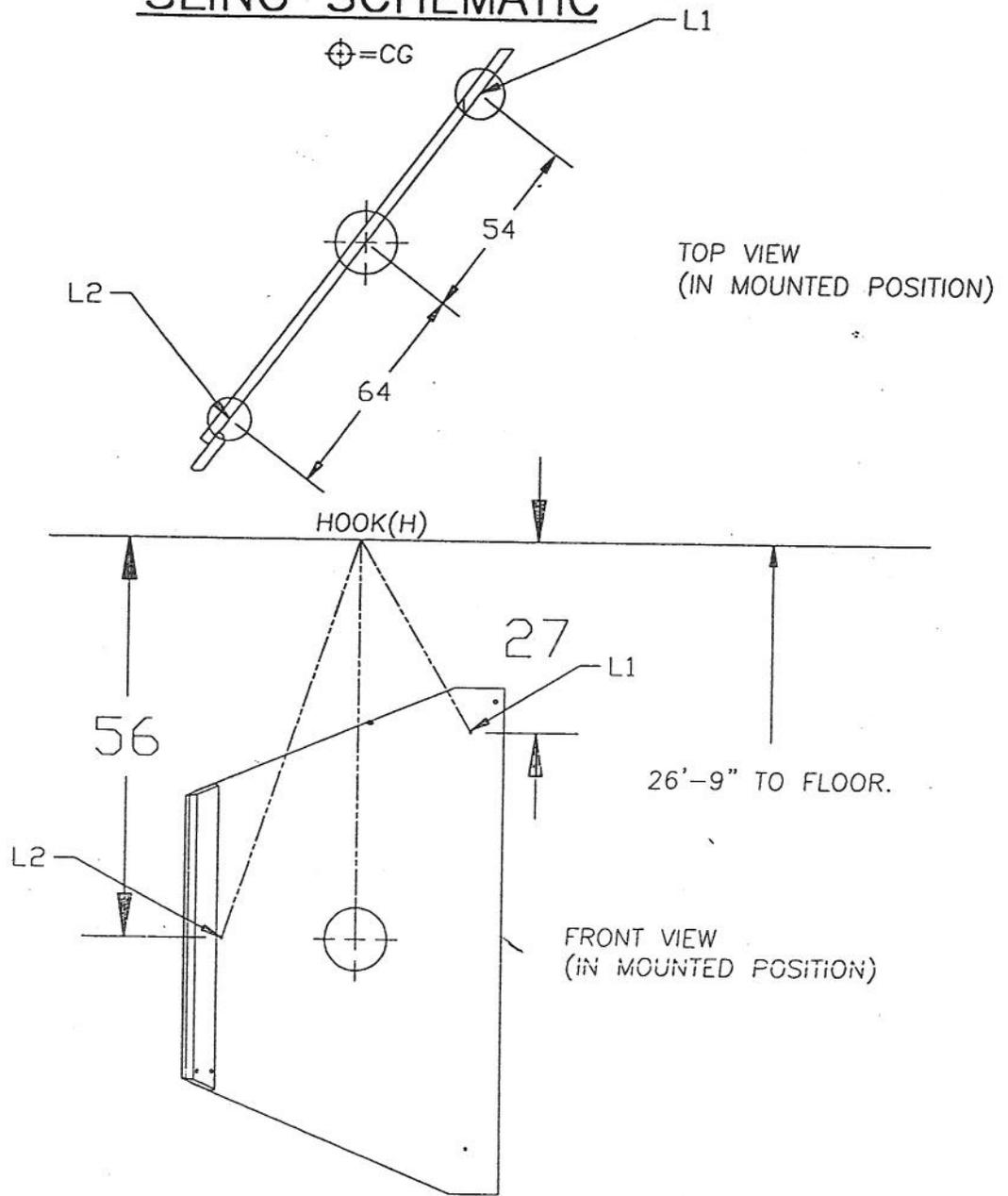
Calculations:

$$\text{Length } c = \sqrt{a^2 + b^2} = 144.37''$$

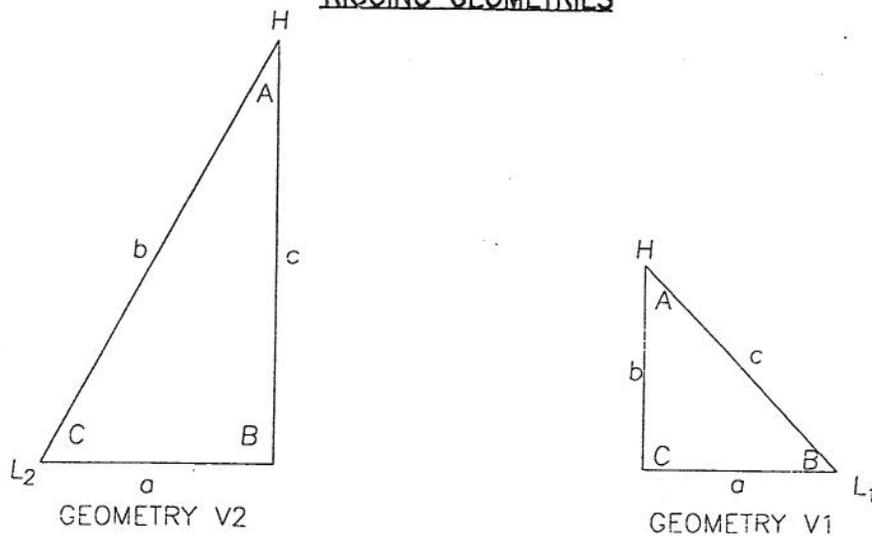
$$\text{TAN } B = b / a = 2.473 = \text{TAN } 67.98^\circ$$

$$\text{Sling Load } c = \text{Load } b / \text{SIN } B = 9576.9 \text{ lb.}$$

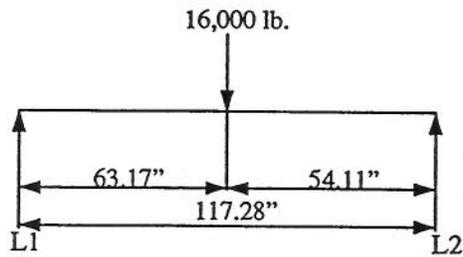
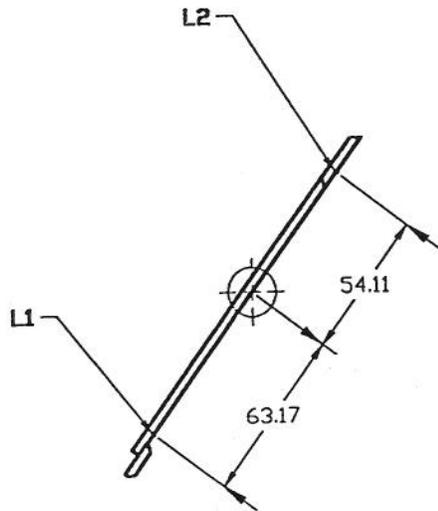
VERTICAL PANELS SLING SCHEMATIC



RIGGING GEOMETRIES



VERTICAL PANELS LIFT POINTS WEIGHT DISTRIBUTION

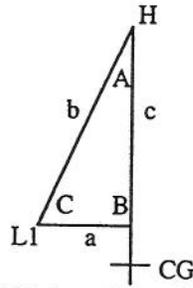


$$\text{Reaction Load L1} = 16,000 \text{ lb.} \cdot (54.11") / 117.28" = 7382.0 \text{ lb.}$$

$$\text{Reaction Load L2} = 16,000 \text{ lb.} - 7382.0 \text{ lb.} = 8618.0 \text{ lb.}$$

VERTICAL PANELS RIGGING SLING LOAD VECTOR CALCULATIONS

GEOMETRY V1:



Given: $B = 90^\circ$, Length $a = 64.0''$, Length $c = 115.4''$, Load $c = 7382.0$ lb.

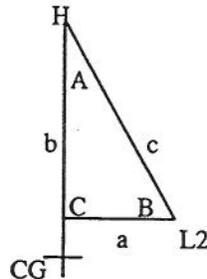
Calculations:

$$\text{Length } b = \sqrt{a^2 + c^2} = 131.96''$$

$$\text{TAN } C = c / a = 1.803 = \text{TAN } 60.99^\circ$$

$$\text{Sling Load } b = \text{Load } c / \text{SIN } C = 8441.0 \text{ lb.}$$

GEOMETRY V2:



Given: $C = 90^\circ$, Length $a = 54.0''$, Length $b = 55.0''$, Load $b = 8618.0$ lb.

Calculations:

$$\text{Length } c = \sqrt{a^2 + b^2} = 77.08''$$

$$\text{TAN } B = b / a = 1.018 = \text{TAN } 45.53^\circ$$

$$\text{Sling Load } c = \text{Load } b / \text{SIN } B = 12,076.5 \text{ lb.}$$