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ANALYSIS OF THE 241SY101 PUMP REMOVAL TRAILER &
THE 241SY101 STRONGBACK

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This document was reviewed following the procedures described in WHC-CM-3-4 and is:

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WHC Information Release Administration Specialist:

T.L. Ontiveros — September 13, 1995

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SUPPORTING DOCUMENT

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7. Abstract

The purpose of the calculations contained in the attached appendix is to determine the vibrational stability of the following combination (The Combination); shipping container, strongback and trailer. The vibrational stability of The Combination will be determined with the shipping container and strongback in the upright position. If the natural frequency of The Combination coincides with the input frequency and no damping is present, resonance will occur. The result of this is that the natural frequency of The Combination must be calculated as well as the input frequency. The input frequency in this case is caused by wind.

Due to their geometrical complexity the upper and lower hydraulic clevises were analyzed for structural adequacy by using finite-element analysis (FEA). The FEA software COSMOS/M version 1.70 was used to model the upper and lower hydraulic clevis.

All designs are in accordance with *Standard Architectural-Civil Design Criteria, Design Loads for Facilities* (DOE-RL 1989) and are safety class 3. The design and fabrication of each component is in accordance with American Institute of Steel Construction, *Manual of Steel Construction*, (AISC, 1989). The analyses contained in this document reflects the "as-built" condition of the 241SY101 hydraulic trailer.

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Analysis of the 241SY101 Pump Removal Trailer and the 241SY101 Strongback

July 31, 1995

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APPROVED BY: Per R.M. Boger 7-31-95
R. M. Boger, Manager
Analytical Services

CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed: Frequency Analysis of 241SY101 Pump Removal Trailer and Stress Analysis of Upper and Lower Hydraulic Clevis

Author: B. L. Coverdell

Yes	No	N/A	
[✓]	[ ]	[ ]	Problem completely defined.
[✓]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[✓]	[ ]	[ ]	Computer codes and data files documented.
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[✓]	[ ]	[ ]	Hand calculations checked for errors.
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[✓]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[✓]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[✓]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.

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R. L. Jorissen Randy Jorissen
Reviewer

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CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed: Shipping Container, Strongback and Trailer Frequency Analysis (Appendix A)

Author: B. L. Coverdell

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MANDATORY Software QA Log Number BLC-95-012

J. S. Burgess J. S. Burgess
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SOFTWARE REPORT FORM

SOFTWARE APPLICATION: COSMOS/M 1.71

SOFTWARE LOG #: BLC-95-012

ANALYST: B. L. Coverdell

DOCUMENT #: WHC-SD-WM-DA-194

MANAGER: R. M. Boger

DATE: May 8, 1995

DESCRIPTION OF ANALYSIS:

The use of the finite-element (FE) analysis program COSMOS/M version 1.71 permitted a quick, easy, and detailed frequency analysis of the entire strongback, shipping container and trailer combination in the upright position. From these calculations the overall stability of the combination can be determined. The element types used in these analyses were BEAM3D, RBAR, MASS and SPRING. The input and output files for these analyses are called KAMP11.GFM and KAMP11.OUT.

Electronic copies of the input and output files can be found on the attached tape.

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SIGNATURE OF ANALYST: B L Coverdell DATE: 5-8-95

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Document Reviewed: Wind Induced Vibrational Calculations (Appendix B)

Author: R. L. Jorissen

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MANDATORY Software QA Log Number NA

B. L. Coverdell B. L. Coverdell 2-24-95
Reviewer Date

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Document Reviewed Upper Hydraulic Clevis Analysis (Appendix C)

Author B. L. Coverdell

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[✓]	[ ]	[ ]	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
[✓]	[ ]	[ ]	Safety margins consistent with good engineering practices.
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[✓]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.

MANDATORY Software QA Log Number GLC-95-013

J.A. Tuck
~~T. K. Peterson~~ James A Tuck — 23 Mar. '95

Reviewer — Date

SOFTWARE REPORT FORM

SOFTWARE APPLICATION: COSMOS/M 1.71

SOFTWARE LOG #: BLC-95-013

ANALYST: B. L. Coverdell

DOCUMENT #: WHC-SD-WM-DA-194

MANAGER: R. M. Boger

DATE: May 8, 1995

DESCRIPTION OF ANALYSIS:

The use of the finite-element analysis (FEA) program COSMOS/M version 1.71 permitted a quick, easy, and detailed linear static analysis of the upper hydraulic clevis.

A single analysis was performed using the SHELL4 element type inconjuction with spring elements for the boundary conditions. The input and output files for the analysis are called TOP_CLV2C.GFM and TOP_CLV2C.OUT. Electronic copies of the input and output files can be found on the attached tape.

SIGNATURE OF ANALYST: B L Coverdell

DATE: 5-8-95

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Document Reviewed: Lower Hydraulic Clevis Analysis (Appendix D)

Author: B. L. Coverdell

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[✓]	[ ]	[ ]	Problem completely defined.
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[✓]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
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[✓]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[ ]	[ ]	[✓]	Hand calculations checked for errors.
[✓]	[ ]	[ ]	Code run streams correct and consistent with analysis documentation.
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MANDATORY Software QA Log Number BLC-95-014

~~T. K. Peterson~~ James A Tuck — 10 MARCH '95

Reviewer — Date

J.A. Tuck

SOFTWARE REPORT FORM

SOFTWARE APPLICATION: COSMOS/M 1.71

SOFTWARE LOG #: BLC-95-014

ANALYST: B. L. Coverdell

DOCUMENT #: WHC-SD-WM-DA-194

MANAGER: R. M. Boger

DATE: May 8, 1995

DESCRIPTION OF ANALYSIS:

The use of the finite-element analysis (FEA) program COSMOS/M version 1.71 permitted a quick, easy, and detailed stress analysis of the lower hydraulic clevis.

The element type used in this analysis was TETRA10. The input and output files for this analysis are called BTMCLEV3.GFM and BTMCLEV3.OUT. Electronic copies of the input and output files can be found on the attached tape.

SIGNATURE OF ANALYST: B L Coverdell

DATE: 5-8-95

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CHECKLIST FOR INDEPENDENT REVIEW

Document Reviewed: Real Constant Calculations for 241SY101 Trailer Finite-Element Analysis

Author: J. A. Tuck

Yes	No	N/A	
[✓]	[ ]	[ ]	Problem completely defined.
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[ ]	[ ]	[✓]	Computer codes and data files documented.
[✓]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[✓]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[✓]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
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[✓]	[ ]	[ ]	Acceptability limits on analytical results applicable and supported. Limits checked against sources.
[✓]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[✓]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
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B. L. Coverdell BLC
Reviewer

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SOFTWARE LOG #: BLC-95-021

ANALYST: B. L. Coverdell

DOCUMENT #: WHC-SD-WM-DA-194

MANAGER: R. M. Boger

DATE: May 8, 1995

DESCRIPTION OF ANALYSIS:

The use of the finite-element (FE) analysis program COSMOS/M version 1.71 permitted a quick, easy, and detailed frequency analysis of the entire strongback, shipping container and trailer combination in the upright position. From these calculations the overall stability of the combination can be determined. The element types used in this analyses were BEAM3D, RBAR, MASS and SPRING. The input and output files for these analyses are called KAMP11A.GFM and KAMP11A.OUT. Please note that the only difference between this finite-element model and the model KAMP11 is that four torsional resistance tubes have been removed.

Electronic copies of the input and output files can be found on the attached tape.

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SIGNATURE OF ANALYST: B. L. Coverdell DATE: 7-26-95

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APPENDICES

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1.0 Introduction

The purpose of the calculations contained in the attached appendix is to determine the vibrational stability of the following combination (The Combination); shipping container, strongback and trailer. The vibrational stability of The Combination will be determined with the shipping container and strongback in the upright position. If the natural frequency of The Combination coincides with the input frequency and no damping is present, resonance will occur. The result of this is that the natural frequency of The Combination must be calculated as well as the input frequency. The input frequency in this case is caused by wind.

Due to their geometrical complexity the upper and lower hydraulic clevises were analyzed for structural adequacy by using finite-element analysis (FEA). The FEA software COSMOS/M version 1.71 was used to model the upper and lower hydraulic clevis.

All designs are in accordance with *Standard Architectural-Civil Design Criteria, Design Loads for Facilities* (DOE-RL 1989) and are safety class 3. The design and fabrication of each component is in accordance with American Institute of Steel Construction, *Manual of Steel Construction*, (AISC, 1989). The analyses contained in this document reflect the "as-built" condition of the 241SY101 hydraulic trailer.

2.0 Discussion

Appendix A contains real constant calculations for input into the 241SY101 trailer FEA model. Appendix B contains frequency output from the FEA model and hand calculations determining the frequency of The Combination. The plots in Appendix C and D are for checking of upper and lower hydraulic clevis FEA models and as demonstration of the maximum Von Mises stress in each model. The calculations in Appendix E are from the manufacture of the 241SY101 trailer and are included here to provide traceability of documentation as well as showing complete analysis of the 241SY101 pump removal system. Appendix F contains an evaluation of potential tractor/trailer combinations that can be used to transport the container/pump from the 241SY Tank Farm to the Central Waste Complex. The evaluation In Appendix F is included here for traceability of documentation.

An as-built walk down of the S241SY101 trailer found minor deviations from the drawings and the finite-element model. The deviations in question are four missing torsional reinforcement tubes. Two of the tubes are located directly behind the front outriggers and the other two are between the strongback support and the rear wheel bogie. At both locations, a tube was to diagonally connect the top flanges of either I-beam and the bottom flanges of either I-beam. All four tubes were eliminated from the final trailer design due to space limitations. To determine the effect of the eliminated tubes on the FEA model, the original FEA model KAMP11 was copied and renamed to KAMP11A. The tubes in the KAMP11 model, but not on the trailer, were removed and a frequency analysis was run. The result of that analysis is a natural frequency 1.03 hz (Appendix G) for the trailer verses 1.06 hz for the original trailer frequency analysis. The difference between these two is inconsequential and no further analysis is necessary.

2.1 Discussion of Natural Frequency Calculations

Initially a FEA model was developed to determine the natural frequency of The Combination, however, due to the geometry of The Combination, gravity may significantly effect the natural frequency of The Combination provided the strongback and shipping container are in the upright position. FEA does not account for the effect of gravity when doing a frequency analysis. Therefore, it was necessary to develop the equation of motion of the structure. Figure 1 shows this equation. This

$$\theta'' + \left(\frac{k_t}{m \cdot l^2} - \frac{g}{l}\right) \cdot \theta = 0$$

Figure 1 Equation of motion for The Combination.

equation models the shipping container and strongback as a lumped mass "m" on a rod of negligible mass and length "l" and k_t is the torsional stiffness of the trailer. This is a linear nonhomogeneous second order differential equation of the form shown in Figure 2 were ω is the period of oscillation. From the period of oscillation the natural frequency can be found and is shown in Figure 3. All

$$\theta'' + \omega^2 \cdot \theta = 0$$

Figure 2 Form of Differential Equations

$$f := \frac{1}{2 \cdot \pi} \cdot \sqrt{\frac{k_t}{m \cdot l^2} - \frac{g}{l}}$$

Figure 3 Natural Frequency Equation

variables for this equation are known except the torsional stiffness "k_t". Figure 4 shows the equation for the determination of this stiffness where "P" is a lateral force applied at a distance "l" and "C" is the angle of rotation caused by the load "P".

$$k_t := \frac{P \cdot l}{C}$$

Figure 4 Stiffness Equation

A FEA model of The Combination was created using the software COSMOS/M. A lateral load "P" was placed on the model at the center of gravity (C_g) of the strongback and shipping container. A linear static analysis was then run to determine the deflection of the C_g. Given the deflection, the angle of rotation of the shipping container and strongback can be found using simple trigonometry. Calculations in Appendix A using the equations shown above determined the natural frequency of The Combination to be 1.15 hz.

A frequency analysis of the same FEA model was completed using COSMOS/M ver 1.71 the results of which are shown in Appendix B. This analysis determined the natural frequency of The Combination to be 1.03 hz.

2.2 Discussion of Wind Induced Vibration Calculations

It is known that wind vortex shedding can cause resonance to occur in structures. Resonance occurs when the input frequency, in this case caused by the maximum design wind speed, coincides with the natural frequency of the structure, and there is no damping. For this reason, the natural frequency of a structure must be compared to the input frequency due to wind. The calculations in Appendix B determined that for a 15 mi/hr wind speed the corresponding induced frequency is 0.85 hz.

2.3 Discussion of Upper Hydraulic Clevis Stress Analysis

The upper hydraulic clevis supports a large load (210 kips) and has a complex geometry that makes hand calculations difficult and unreliable. Appendix C contains a geometry plot as well as a Von Mises stress plot of the FEA model named TOPCLV2C. Two-dimensional shell elements (SHELL4) were used to construct the three-dimensional model of the upper hydraulic clevis. In the model, spring elements were used to represent the boundary condition in the Y direction caused by the strongback. The remaining boundary conditions were modeled using the displacement boundary condition within COSMOSM/M. The 210 kip load was modeled by placing a linear pressure loading on a curve that stretches over a 45 deg arc.

2.4 Discussion of Lower Hydraulic Clevis Stress Analysis

The lower hydraulic clevis supports a large load (210 kips) and has a complex geometry that makes hand calculations difficult and unreliable. For this reason, an FEA was completed on this component. A geometry plot of the lower hydraulic clevis FEA model is shown in Appendix D. Since this clevis is constructed from a 36 in. x 8 in. x 24 in. block of low carbon steel, the FEA model was created using true three dimensional elements (TETRA10).

3.0 Conclusions of Analyses

3.1 Conclusions of Frequency Analysis

From the comparison of the excitation frequency (0.85 hz) to the natural frequency (1.03 hz - 1.15 hz) it is apparent that The Combination is adequately stiff to prevent excitation of The Combination at its natural frequency.

3.2 Conclusions of Upper Hydraulic Clevis Analysis

The von Mises stress plot from the TOP_CLV2C model (Appendix C) shows the maximum stress in the upper hydraulic clevis. This stress is 28,200 lbf/in^2 and occurs around the clevis hole. This stress is a stress concentration and is not applicable since it is caused by the small area in which the two 105,000 lb. loadings are applied (an FEA modeling problem). Stress levels taken away from the loaded area, about 0.5 in. show that the maximum stress is below 18,000 lb/in^2.

Since the stresses in the upper hydraulic clevis are within allowables, the clevis is adequate for the rated load of 210,000 lb.

3.3 Conclusions of Lower Hydraulic Clevis Analysis

The von Mises stress plot in Appendix D shows the highest stress in the lower hydraulic clevis (8,530 lb/in^2). The maximum stress occurs at the bottom of the hole for the hydraulic pin. The 210,000 kip load is applied by placing a pressure load over a 180 degree arc of the hydraulic pin hole. The load configuration results in an unrealistic stress concentration around the hole, however, the remainder of the model is accurate.

Since the stresses in the lower hydraulic clevis are within allowables, the clevis is adequate for the rated load of 210,000 lb.

4.0 Requirements

Below is a list of requirements that must be adhered to for safe operation of the 241SY101 mixer pump removal trailer based on the analysis in this document:

- the trailer must be operated in a wind speed of less than 15 mph and
- the hydraulic load of 210,000 lb. must not be surpassed.

Failure to adhere to the requirements stated above could result in catastrophic failure of the trailer.

5.0 References

AISC, 1989, *Manual of Steel Construction*, ninth Edition, American Institute of Steel Construction, Chicago, Illinois.

SRAC, 1994, *COSMOS/M*, Version 1.71, Structural Research and Analysis Coroporation, Santa Monica, California.

DOE-RL, 1993, *Standard Architectural-Civil Design Criteria, Design Loads for Facilities*, DOE-RL-SDC 4.1 Revision 12, Westinghouse Hanford Company, Richland, Washington.

Hartog, J. P., 1956, *Mechanical Vibrations*, 4th Edition, McGraw-Hill Book Company, New York, New York.

Thomson, W. T., 1981, *Theory of Vibration with Applications*, second Edition, Prentice-Hall Incorporated, Englewood Cliffs New Jersey.

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APPENDIX A

Calculations for Development of FEA Model

ANALYTICAL CALCULATIONS

Doc. No. _____ Rev. 0 Page ___ of ___

Subject _____

Originator B.L. Coverdell Date February 3, 1995

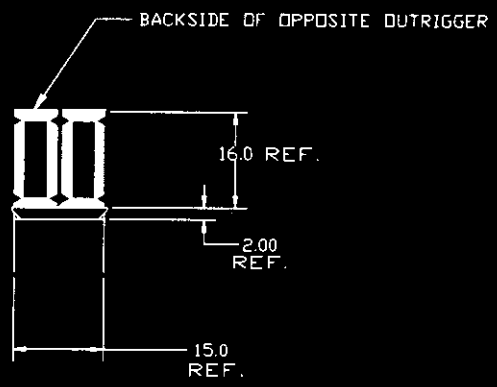
Checker James A Tuck Date 23 Feb 95

REAL CONSTANT CALCULATIONS FOR 241SY101 TRAILER FINITE-ELEMENT ELEMENT MODEL

This section of calculations determines the section properties of the 241SY101 trailer at several locations. The section properties are then used in a finite-element program to determine the mode shape of the first natural frequency. When the shipping container and strongback are in the upright position they act like an inverse pendulum. For this reason the frequencies returned by the finite-element program may be incorrect. However, the stiffness calculated by the finite-element program is correct. By using this stiffness in conjunction with hand calculations the first natural frequency can be determined using hand calculations. Additional calculations were necessary to adjust the density of the components of the trailer to reflect the proper mass of the system.

Section 1: Outrigger Section Properties Calculations

Determine the following section properties given the sketch at right: cross sectional area, the centroid, Ixx, yy, and the torsional resistance.



CALCULATE THE CROSS-SECTIONAL AREA OF THE SECTION

$A_{7x1.5} := 7 \cdot in \cdot 1.5 \cdot in$ $A_{7x1.5} = 10.5 \cdot in^2$

$A_{13x1.5} := 13 \cdot in \cdot 1.5 \cdot in$ $A_{13x1.5} = 19.5 \cdot in^2$

$A_{outrig} := 2 \cdot (A_{7x1.5} + A_{13x1.5})$ $A_{outrig} = 60 \cdot in^2$ Cross sectional area of an outrigger.

FIND THE LOCATION OF THE SECTION CENTROID

Due to symmetry, the centroid is located at the center section.

DETERMINE THE MOMENT OF INERTIA ABOUT Ixx AND Iyy.

(Ixx)

$$I_{7x1.5} := \frac{7 \cdot in \cdot (1.5 \cdot in)^3}{12} + A_{7x1.5} \cdot \left(\frac{16 \cdot in - 1.5 \cdot in}{2}\right)^2 \qquad I_{7x1.5} = 553.875 \cdot in^4$$

Moment of inertia of 7x1.5 plate about x-axis.

ANALYTICAL CALCULATIONS

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Originator B.L. Coverdell BLC Date February 3, 1995

Checker JAT Date 23 Feb 95

$I_{13x1.5} := \frac{1.5 \cdot in \cdot (13 \cdot in)^3}{12}$ $I_{13x1.5} = 274.625 \cdot in^4$ Moment of inertia of 10X1.5 plate about x-axis.

$I_{xx} := 2 \cdot (I_{7x1.5} + I_{13x1.5})$ $I_{xx} = 1657 \cdot in^4$ Total moment of inerta of section about x-axis.

(Iyy)

$I_{7x1.5} := \frac{1.5 \cdot in \cdot (7 \cdot in)^3}{12}$ $I_{7x1.5} = 42.875 \cdot in^4$ Moment of inertia of 7x1.5 plate about y-axis.

$I_{13x1.5} := \frac{10 \cdot in \cdot (1.5 \cdot in)^3}{12} + A_{13x1.5} \cdot \left(\frac{7 \cdot in - 1.5 \cdot in}{2}\right)^2$ $I_{13x1.5} = 150.281 \cdot in^4$ Moment of inertia of 10X1.5 plate about y-axis.

$I_{xx} := 2 \cdot (I_{7x1.5} + I_{13x1.5})$ $I_{xx} = 386.313 \cdot in^4$ Total moment of inerta of section about y-axis.

DETERMINE THE TORSIONAL RESISTANCE OF THE SECTION.

$b_1 := 7 \cdot in$ $d_1 := 1.5 \cdot in$ Respective width and depth of 7x1.5 plates.

$\frac{b_1}{d_1} = 4.667$ $\alpha_1 := .29$ *Design of Welded Structures* 1991, Page 2.10-2, Table 1

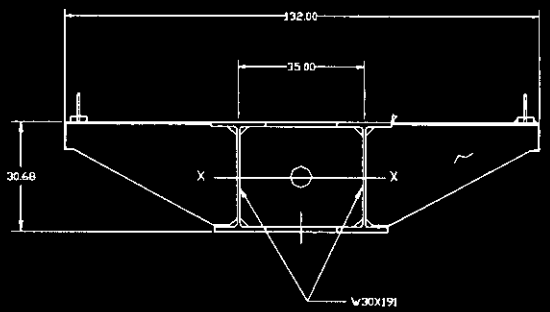
$b_2 := 13 \cdot in$ $d_2 := 1.5 \cdot in$ Respective width and depth of 10x1.5 plates.

$\frac{b_2}{d_2} = 8.667$ $\alpha_2 := .31$ *Design of Welded Structures* 1991, Page 2.10-2, Table 1

$R := 2 \cdot (\alpha_1 \cdot b_1 \cdot d_1^3 + \alpha_2 \cdot b_2 \cdot d_2^3)$ $R = 40.905 \cdot in^4$ Torsional resistance of section.

Section 2: (from Kamp 1994, sheet 2, section D-D)

Given the sketch at right, determine the cross sectional area, the centroid , Ixx, Iyy and the polar moment for a single W30X191. Neglect any effects due to the outer deck plates and note that the two W30X191s are not connect to each other at this cross section.



CALCULATE THE CROSS-SECTIONAL AREA OF THE SECTION

$A_{w30x191} := 56.1 \cdot in^2$ $A_{w30x191} = 56.1 \cdot in^2$ Cross sectional area of W30X191 (AISC 1989)

ANALYTICAL CALCULATIONS

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Subject _____

Originator B.L. Coverdell BLC Date February 3, 1995

Checker JAT Date 23 Feb. '95

FIND THE LOCATION OF THE SECTION CENTROID

Due to symmetry, the centroid is located at the center section.

DETERMINE THE MOMENT OF INERTIA ABOUT Ixx AND Iyy.

(Ixx)

$I_{w30x191} := 9170 \cdot in^4$ $I_{w30x191} = 9170 \cdot in^4$ Moment of inertia of single W30X191 about X-axis (AISC 1989)

(Iyy)

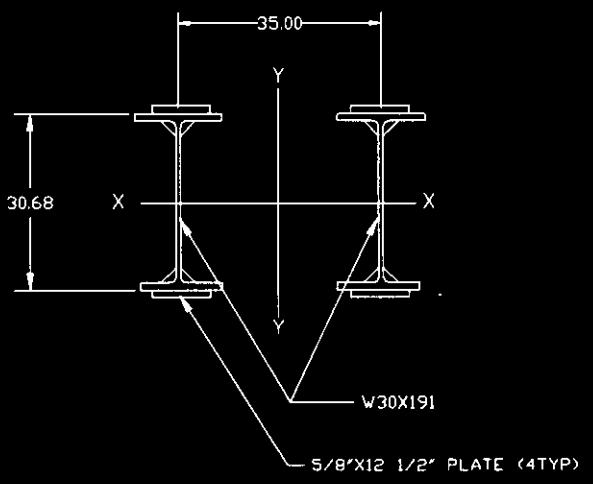
$I_{w30x191} := 673 \cdot in^4$ $I_{w30x191} = 673 \cdot in^4$ Moment of inertia of single W30X191 about Y-axis (AISC 1989)

DETERMINE THE POLAR MOMENT OF INERTIA FOR THE SECTION.

$J := 20.6 \cdot in^4$ $J = 20.6 \cdot in^4$ Polar moment for two W30x191s (AISC 1989).

Section 3: (from Kamp 1994, sheet 2, section F-F)

Given the sketch at right, determine the following: cross sectional area, the centroid, Ixx, Iyy, and the torsional resistance factor. Neglect any effects due to the outer deck plates.



CALCULATE THE CROSS-SECTIONAL AREA OF THE SECTION

$A_{w30x191} := 56.1 \cdot in^2$ $A_{w30x191} = 56.1 \cdot in^2$ Area of single I-Beam (AISC 1989)

$A_{rein} := \frac{5}{8} \cdot in \cdot 12.5 \cdot in$ $A_{rein} = 7.813 \cdot in^2$ Area of 1 reinforcement plates.

$A_{total} := A_{w30x191} + 2 \cdot A_{rein}$ $A_{total} = 71.725 \cdot in^2$ Total area of section

FIND THE LOCATION OF THE SECTION CENTROID

Due to symmetry, the centroid is located at the center section.

ANALYTICAL CALCULATIONS

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Subject _____

Originator B.L. Coverdell Date February 3, 1995

Checker JHT Date 23 Feb 95

DETERMINE THE MOMENT OF INERTIA ABOUT Ixx AND Iyy.

(Ixx)

$I_{w30x191} := 9170 \cdot in^4$ $I_{w30x191} = 9170 \cdot in^4$ Moment of inertia of W30X191 about x-axis (AISC 1989).

$$I_{rein} := \frac{12.5 \cdot in \cdot \left(\frac{5}{8} \cdot in\right)^3}{12} + \left(\frac{30.68 \cdot in + \frac{5}{8} \cdot in}{2}\right)^2 \cdot A_{rein} \qquad I_{rein} = 1914.323 \cdot in^4$$

Moment of inertia of plate and additional moment due to distance from neutral axis (parallel axis theorem).

$I_{xx} := I_{w30x191} + 2 \cdot I_{rein}$ $I_{xx} = 12998.645 \cdot in^4$ Total moment of inertial at section F-F about x-x axis.

(Iyy)

$I_{w30x191} := 673 \cdot in^4$ $I_{w30x191} = 673 \cdot in^4$ Moment of inertia of W30X191 about y-axis (AISC 1989).

$$I_{rein} := \frac{\frac{5}{8} \cdot in \cdot (12.5 \cdot in)^3}{12} \qquad I_{rein} = 101.725 \cdot in^4$$

Moment of inerta due to reinforcement plates.

$I_{yy} := I_{w30x191} + 2 \cdot I_{rein}$ $I_{yy} = 876.451 \cdot in^4$ Total moment of inertia of section about y-axis.

DETERMINE THE TORSIONAL RESISTANCE OF THE SECTION.

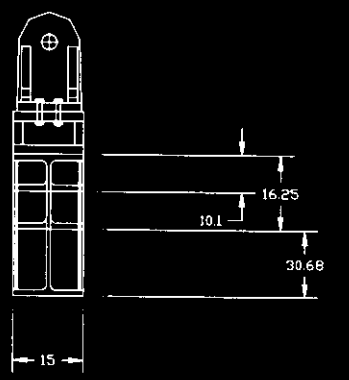
$b_1 := 12.5 \cdot in$ $d_1 := .625 \cdot in$ Respective width and depth of reinforcement plates.

$\frac{b_1}{d_1} = 20$ $\alpha_1 := .333$ *Design of Welded Structures* 1991, Page 2.10-2, Table 1

$R := J + 2 \cdot \alpha_1 \cdot b_1 \cdot d_1^3$ $R = 22.632 \cdot in^4$ Torsional resistance of section.

Section 4: Section Properties of Strongback Support.

Determine the following section properties are for the tapered beam shown in the sketch at right: cross sectional area, the centroid, Ixx, Iyy, and the torsional resistance. The section properties must be found at the two locations shown above. The flanges are constructed from 1.1875 in. plate and the web is 0.5 in. plate.



ANALYTICAL CALCULATIONS

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Originator B.L. Coverdell BLC Date February 3, 1995

Checker JAT Date 23 Feb 95

CALCULATE THE CROSS-SECTIONAL AREA OF SECTION 1

$t_{1\_flange} := 1.1875 \cdot in$ $w_{1\_flange} := 15 \cdot in$ $t_{1\_web} := 0.5 \cdot in$

$w_{1\_web} := 16.25 \cdot in - 2 \cdot t_{1\_flange}$ $w_{1\_web} = 13.875 \cdot in$

$A_{1\_flange} := t_{1\_flange} \cdot w_{1\_flange}$ $A_{1\_flange} = 17.813 \cdot in^2$

$A_1 := 2 \cdot A_{1\_flange} + t_{1\_web} \cdot w_{1\_web}$ $A_1 = 42.563 \cdot in^2$ Cross sectional area of section 1.

FIND THE LOCATION OF THE SECTION CENTROID

Due to symmetry, the centroid is located at the center section.

DETERMINE THE MOMENT OF INERTIA ABOUT Ixx AND Iyy.

(Ixx)

$$I_{xx\_flange} := \frac{w_{1\_flange} \cdot t_{1\_flange}^3}{12} + A_{1\_flange} \cdot \left(\frac{16.25 \cdot in - t_{1\_flange}}{2}\right)^2$$

$I_{xx\_flange} = 1012.413 \cdot in^4$ Section 1 x-axis moment of inertia due to flanges.

$$I_{xx\_web} := \frac{t_{1\_web} \cdot w_{1\_web}^3}{12}$$ $I_{xx\_web} = 111.298 \cdot in^4$ Section 1 x-axis moment of inertia due to web.

$I_{xx} := 2 \cdot I_{xx\_flange} + I_{xx\_web}$ $I_{xx} = 2136.125 \cdot in^4$ Total moment of inertia about x-axis for section 1.

(Iyy)

$$I_{yy\_flange} := \frac{t_{1\_flange} \cdot w_{1\_flange}^3}{12}$$ $I_{yy\_flange} = 333.984 \cdot in^4$ Section 1 y-axis moment of inertia due to flanges.

$$I_{yy\_web} := \frac{w_{1\_web} \cdot t_{1\_web}^3}{12}$$ $I_{yy\_web} = 0.145 \cdot in^4$ Section 1 y-axis moment of inertia due to web.

$I_{yy} := 2 \cdot I_{yy\_flange} + I_{yy\_web}$ $I_{yy} = 668.113 \cdot in^4$ Total moment of inerta of section 1 about y-axis.

DETERMINE THE TORSIONAL RESISTANCE OF SECTION 1.

$\frac{w_{1\_flange}}{t_{1\_flange}} = 12.632$ $\alpha_1 := .313$ *Design of Welded Structures* 1991, Page 2.10-2, Table 1

$\frac{w_{1\_web}}{t_{1\_web}} = 27.75$ $\alpha_2 := .313$ *Design of Welded Structures* 1991, Page 2.10-2, Table 1

ANALYTICAL CALCULATIONS

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Checker JAT Date 23 Feb. 95

$R_1 := 2 \cdot \alpha_1 \cdot w_{1\_flange} \cdot t_{1\_flange}^3 + \alpha_2 \cdot w_{1\_web} \cdot t_{1\_web}^3$ $R_1 = 16.267 \cdot in^4$ Torsional resistance of section 1.

CALCULATE THE CROSS-SECTIONAL AREA OF SECTION 2

$t_{2\_flange} := 1.1875 \cdot in$ $w_{2\_flange} := 15 \cdot in$ $t_{2\_web} := 0.5 \cdot in$

$w_{2\_web} := 10.1 \cdot in - 2 \cdot t_{1\_flange}$ $w_{2\_web} = 7.725 \cdot in$

$A_{2\_flange} := t_{2\_flange} \cdot w_{2\_flange}$ $A_{2\_flange} = 17.813 \cdot in^2$

$A_2 := 2 \cdot A_{2\_flange} + t_{2\_web} \cdot w_{2\_web}$ $A_2 = 39.487 \cdot in^2$ Cross sectional area of section 2.

FIND THE LOCATION OF THE SECTION CENTROID

Due to symmetry, the centroid is located at the center section.

DETERMINE THE MOMENT OF INERTIA ABOUT Ixx AND Iyy.

(Ixx)

$$I_{xx\_flange} := \frac{w_{2\_flange} \cdot t_{2\_flange}^3}{12} + A_{2\_flange} \cdot \left(\frac{10.1 \cdot in - t_{2\_flange}}{2}\right)^2$$

$I_{xx\_flange} = 355.817 \cdot in^4$ Section 2 x-axis moment of inertia due to flanges.

$$I_{xx\_web} := \frac{t_{2\_web} \cdot w_{2\_web}^3}{12}$$ $I_{xx\_web} = 19.208 \cdot in^4$ Section 2 x-axis moment of inertia due to web.

$I_{xx} := 2 \cdot I_{xx\_flange} + I_{xx\_web}$ $I_{xx} = 730.842 \cdot in^4$ Total moment of inertia about x-axis for section 2.

(Iyy)

$$I_{yy\_flange} := \frac{t_{2\_flange} \cdot w_{2\_flange}^3}{12}$$ $I_{yy\_flange} = 333.984 \cdot in^4$ Section 2 y-axis moment of inertia due to flanges.

$$I_{yy\_web} := \frac{w_{2\_web} \cdot t_{2\_web}^3}{12}$$ $I_{yy\_web} = 0.08 \cdot in^4$ Section 2 y-axis moment of inertia due to web.

$I_{yy} := 2 \cdot I_{yy\_flange} + I_{yy\_web}$ $I_{yy} = 668.049 \cdot in^4$ Total moment of inerta of section 2 about y-axis.

DETERMINE THE TORSIONAL RESISTANCE OF SECTION 1.

$\frac{w_{2\_flange}}{t_{2\_flange}} = 12.632$ $\alpha_1 := .313$ *Design of Welded Structures* 1991, Page 2.10-2, Table 1

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Originator B.L. Coverdell BLC Date February 3, 1995

Checker VAT Date 23 Feb '95

$\frac{w_{2\_web}}{t_{2\_web}} = 15.45$ $\alpha_2 := .313$ *Design of Welded Structures* 1991, Page 2.10-2, Table 1

$R_2 := 2 \cdot \alpha_1 \cdot w_{2\_flange} \cdot t_{2\_flange}^3 + \alpha_2 \cdot w_{2\_web} \cdot t_{2\_web}^3$ $R_2 = 16.026 \cdot in^4$ Torsional resistance of section 2.

Determine the density change needed to reflect the proper weight of the strongback, shipping container, and trailer. The FEA model does not reflect the proper weight of all three components. By calculating a proper density the proper weights can be achieved. The densities will be used in the FEA model to determine the natural frequencies of the system.

STRONGBACK

$A_c := 47 \cdot in^2$	$A_c = 47 \cdot in^2$	Original cross-sectional area of the strongback.
$L := 351.3 \cdot in$	$L = 351.3 \cdot in$	Length of the strongback.
$V := A_c \cdot 2 \cdot L$	$V = 33022.2 \cdot in^3$	Total volume of steel in strongback.
$\rho_{steel} := .00073 \cdot \frac{lb \cdot sec^2}{in^4}$	$\rho_{steel} = 0.00073 \cdot \frac{lb \cdot sec^2}{in^4}$	Density of steel.
$g := 386.4 \cdot \frac{in}{sec^2}$	$g = 32.2 \cdot \frac{ft}{sec^2}$	Acceleration due to gravity.
$W_o := V \cdot \rho_{steel} \cdot g$	$W_o = 9314.638 \cdot lb$	Model weight of strongback.
$W_a := 30000 \cdot lb - 10000 \cdot lb$	$W_a = 20000 \cdot lb$	Actual weight of strongback minus 10000 lb at hydraulic attachment point. A mass of 10000 lb will be used to model the hydraulic beam.
$\rho_{new} := \frac{W_a}{V \cdot g}$	$\rho_{new} = 0.00157 \cdot \frac{lb \cdot sec^2}{in^4}$	New density of strongback.

SHIPPING CONTAINER

$A_c := 165.7 \cdot in^2$	$A_c = 165.7 \cdot in^2$	Original cross-sectional area of the shipping container.
$L := 652.5 \cdot in$	$L = 652.5 \cdot in$	Length of the shipping container.
$V := A_c \cdot L$	$V = 1.081 \cdot 10^5 \cdot in^3$	Total volume of steel in shipping container.
$W_o := V \cdot \rho_{steel} \cdot g$	$W_o = 30497.413 \cdot lb$	Model weight of shipping container.

ANALYTICAL CALCULATIONS

Subject _____

Originator B.L. Coverdell BJC Date February 3, 1995

Checker JAT Date 23 Feb 95

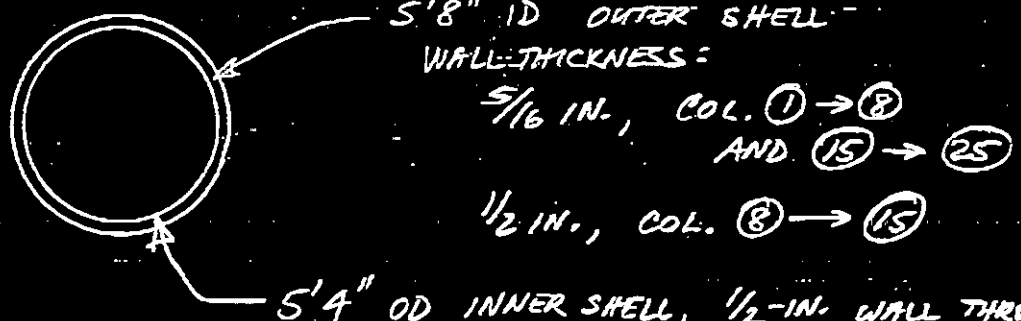
$W_a := 55000 \cdot lb$	$W_a = 55000 \cdot lb$	Actual weight of shipping container.
$\rho_{new} := \frac{W_a}{V \cdot g}$	$\rho_{new} = 0.00132 \cdot \frac{lb \cdot sec^2}{in^4}$	New density of shipping container.

TRAILER

$A_c := 56.1 \cdot in^2$	$A_c = 56.1 \cdot in^2$	Original cross-sectional area of the trailer (used maximum cross-sectional area of trailer).
$L := 2 \cdot 833.77 \cdot in$	$L = 1667.54 \cdot in$	Length of W30x191 that makeup the trailer. The factor of two accounts for the weight of trailer components not modeled.
$V := A_c \cdot L$	$V = 93548.994 \cdot in^3$	Total volume of steel in trailer.
$W_o := V \cdot \rho_{steel} \cdot g$	$W_o = 26387.552 \cdot lb$	Model weight of trailer.
$W_a := 120000 \cdot lb - 23000 \cdot lb$	$W_a = 97000 \cdot lb$	Actual weight of trailer minus the axles.
$\rho_{new} := \frac{W_a}{V \cdot g}$	$\rho_{new} = 0.00268 \cdot \frac{lb \cdot sec^2}{in^4}$	New density of trailer.

(1) Drawing H-2-83739 (2) ~~Doc. No.~~ Rev 0 (3) Page 1 of ____
(4) Building 200-G (5) Rev. ____ (6) Job No. ____
(7) Subject SECTIONAL PROPERTIES OF STORAGE CONTAINER
(8) Originator JA TUCK Date ____
(9) Checker BJ Cornwall Date 2-3-95

(10) PERTINENT DIMENSIONS SHOWN ON SH. 3, ZONE D-1, AND SH. 1, VAR. ZONES, OR AS FOLLOWS:



FOR ANY SECTION, $I = I_{xx} = I_{yy}$ (IGNORE STIFFENER RINGS).

∴ FOR COL. ① → ⑧ AND ⑮ → ㉕, SECTION PROPERTIES ARE:

$$I = \Sigma t\pi r^3 = \left(\tfrac{1}{2}\right)(\pi)\left(\tfrac{63}{2}\right)^3 + \left(\tfrac{5}{16}\right)(\pi)\left(\tfrac{68}{2}\right)^3$$

$$= \underline{87{,}683 \text{ IN}^4}$$

$$\text{AREA} = \Sigma 2\pi r t = (63\pi)\left(\tfrac{1}{2}\right) + (68\pi)\left(\tfrac{5}{16}\right)$$

$$= \underline{165.7 \text{ IN}^2}$$

∴ FOR COL ⑧ → ⑮, SECTION PROP'S ARE:

$$I = \tfrac{1}{2}\pi\left[\left(\tfrac{63}{2}\right)^3 + \left(\tfrac{68}{2}\right)^3\right] = \underline{110{,}835 \text{ IN}^4}$$

$$\text{AREA} = \tfrac{1}{2}\pi(63+68) = \underline{205.8 \text{ IN}^2}$$

BD-5400-060.1 (12/87)
12/06/94 16:08 ☎509 373 5262 MO-047 / 200E →→ ESA 002

(1) Drawing H-2-83736 (2) ~~Doc. No.~~ REV. 0 (3) Page 1 of ____

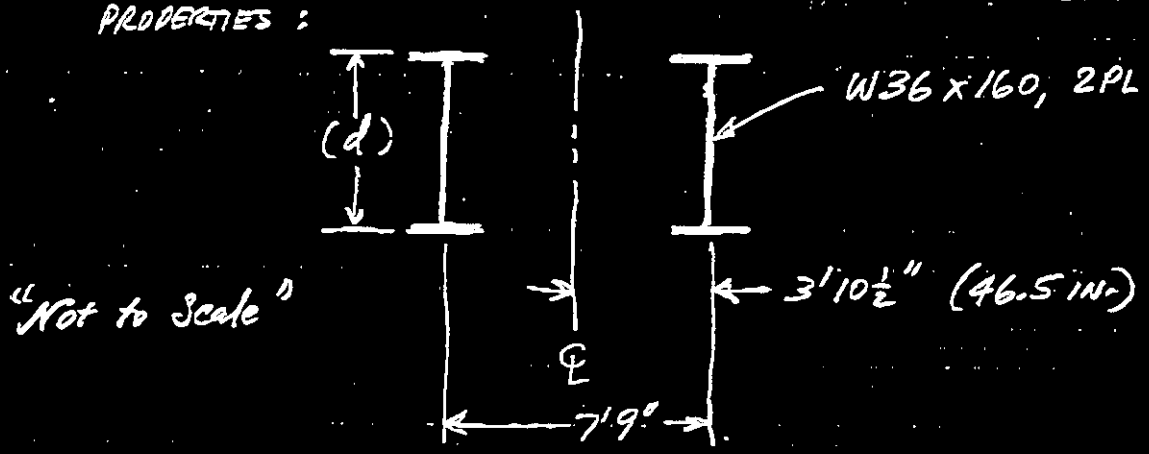
(4) Building 200-C (5) Rev. ____ (6) Job No. ____

(7) Subject STRONGBACK SECTIONAL PROPERTIES.

(8) Originator JA TUCK Date 6 DEC. '94

(9) Checker BJ Loverdell Date 2-3-95

(10) DETAILS OF CONSTRUCTION ARE SHOWN ON SH. 1 OF DWG. TRANSVERSE SECTIONS (OTHER SHEETS) SHOW PRIMARILY A STRUCTURE CONSISTING OF 2 PARALLEL I-BEAMS (SEE SKETCH BELOW). OTHER MEMBERS, INCLUDING DIAGONALS AND STIFFENER PLATES, PROVIDE LATERAL BRACING BUT DO NOT CONTRIBUTE SIGNIFICANTLY TO SECTIONAL PROPERTIES:



FROM AISC, PROPERTIES OF W36 x 160 I-BEAM ARE:

AREA = 47 IN^2 DEPTH "d" = 36 IN.

FLANGE WIDTH = 12 IN.

I_{xx} = 9750 IN^4 I_{yy} = 295 IN^4

∴ FOR COMBINED SECTION,

$A = 2(47) = \underline{94\ IN^2}$

$I_{xx} = 2(9750) = \underline{19{,}500\ IN^4}$

DISTANCE, CENTROID TO EXTREME FIBER FOR I_{xx}, $\underline{c = 18\ IN.}$

$I_{yy} = 2\left[295 + (47)(46.5)^2\right] = \underline{203{,}842\ IN^4}$

DISTANCE, CENTROID TO EXTREME FIBER FOR I_{yy}, $c = 46.5 + 6 = \underline{52.5\ IN.}$

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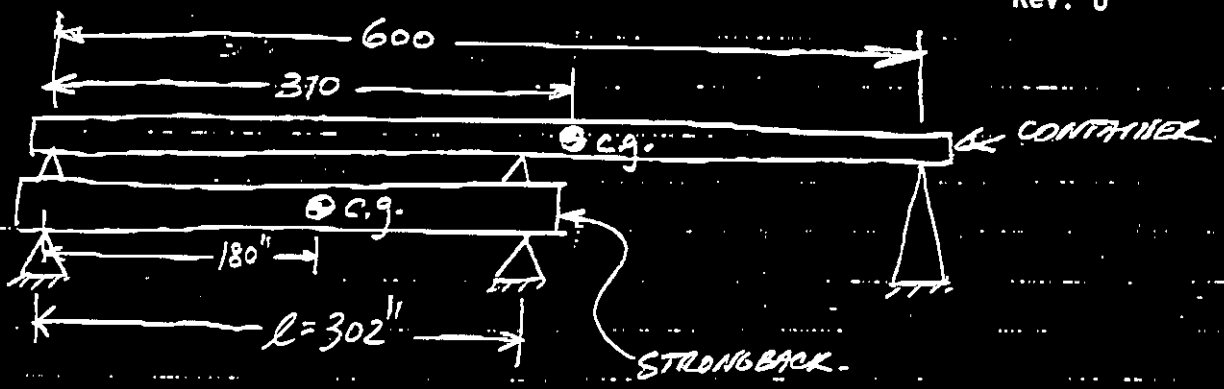

BRAD: OVERALL SYSTEM, STRONGBACK + CONTAINER, LOOKS SOMETHING LIKE THIS; DIMENSIONS NEED TO BE VERIFIED. VIBRATORS ARE LOCATED: ON STRONGBACK (NEAR SUPPORTS AT EITHER END) AND ON END SUPPORT FOR CONTAINER (FABRICATED BY TRAILER MANUF.).

JOHN SISK HAS CALC'S FOR WEIGHTS AT C.G. POINTS.

JIM TUCK

BEST AVAILABLE COPY

Reference WHC-SD-WM-DA-165

12/06/94 16:08 ☎509 373 5262 MO-047 / 200E →→ ESA 004

ANALYTICAL CALCULATIONS

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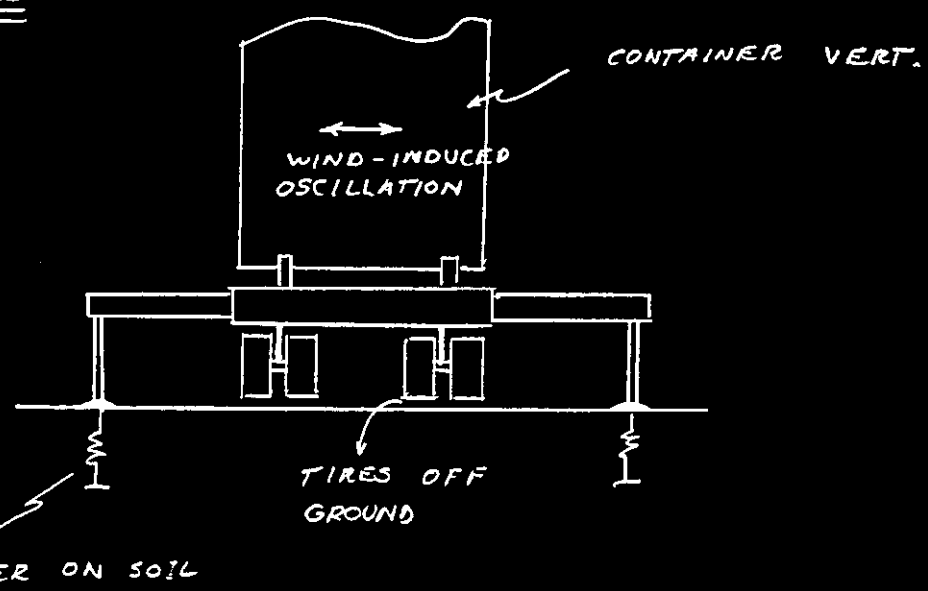
Subject: SOIL SPRINGS - FOR USE IN SY101 TRAILER FREQ. ANALYSIS

Originator: CALCS FOR INDEPENDENT REVIEW Date: 2/6/95

Checker: R. L. JORISSEN Date:

SOIL SPRINGS



$$K_s = \text{SPRING RATE} = K_1 \frac{(m + 0.5)}{1.5\ m} \left(\frac{B + 1}{2B}\right)^2$$

REF - TERZAGHI, "EVALUATION OF COEFF. OF SUBGRADE REACTION," GEOTECHNIQUE, V.5, 1955 AS QUOTED IN DAMES - MOORE "REPORT OF GEOTECH. INVESTIGATION - PROCESS CONDENSATE TREATMENT FACILITY (10805-391-016 - 8/17/89)

1" THK?

4' x 6' STEEL PL AS MAT FOR OUTRIGGER

TEST WT. FOR HYDRAULICS TEST

$$K_s = \left[200\ \text{pci} \times \frac{(1.5 + 0.5)}{1.5 \times 1.5}\right] \times \left[\frac{3' + 1}{2(3')}\right]^2 = 136.53\ \text{K/ft}^3$$

$200 = 345.6\ \text{K/ft}^3$

DAMES + MOORE RECOMMENDATION

$$m = \frac{L}{B} = \frac{4.5'}{3'} = 1.5$$

ASSUME 3' x 4.5' EFFECTIVE SIZE

$$K_s = 24\ \text{ft}^2 \left(136.53\ \text{K/ft}^3\right) = 3.276\ E6\ \text{lb/ft} = \underline{\underline{273{,}000\ \text{lb/in}}}$$

ANALYTICAL CALCULATIONS

Subject SOIL SPRINGS - FOR USE IN ST101 TRAILER FREQ. ANALYSIS

Originator CALCS FOR INDEPENDENT REVIEW Date

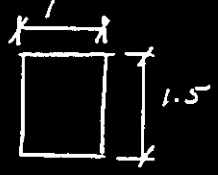
Checker R.L. JORISSEN Date

IF OUTRIGGER FOOT IS GROUNDED W/O 4'x6' PL:

~2' DIA. FOOT

$A = \frac{\pi 2^2}{4} = 3.1\ ft^2$ ← ASSUME 1/2 OF PL EFFECTIVE

$A \approx 1.5\ ft^2$ ← ASSUME SHAPE



$K_s = 1.5\ (136.53\ ^{k}/_{ft^3}) = 204.80\ ^{k}/_{ft}$

↳ PREVIOUS PG. - CONSERVATIVE

$= \underline{17{,}060\ ^{lb}/_{in}}$

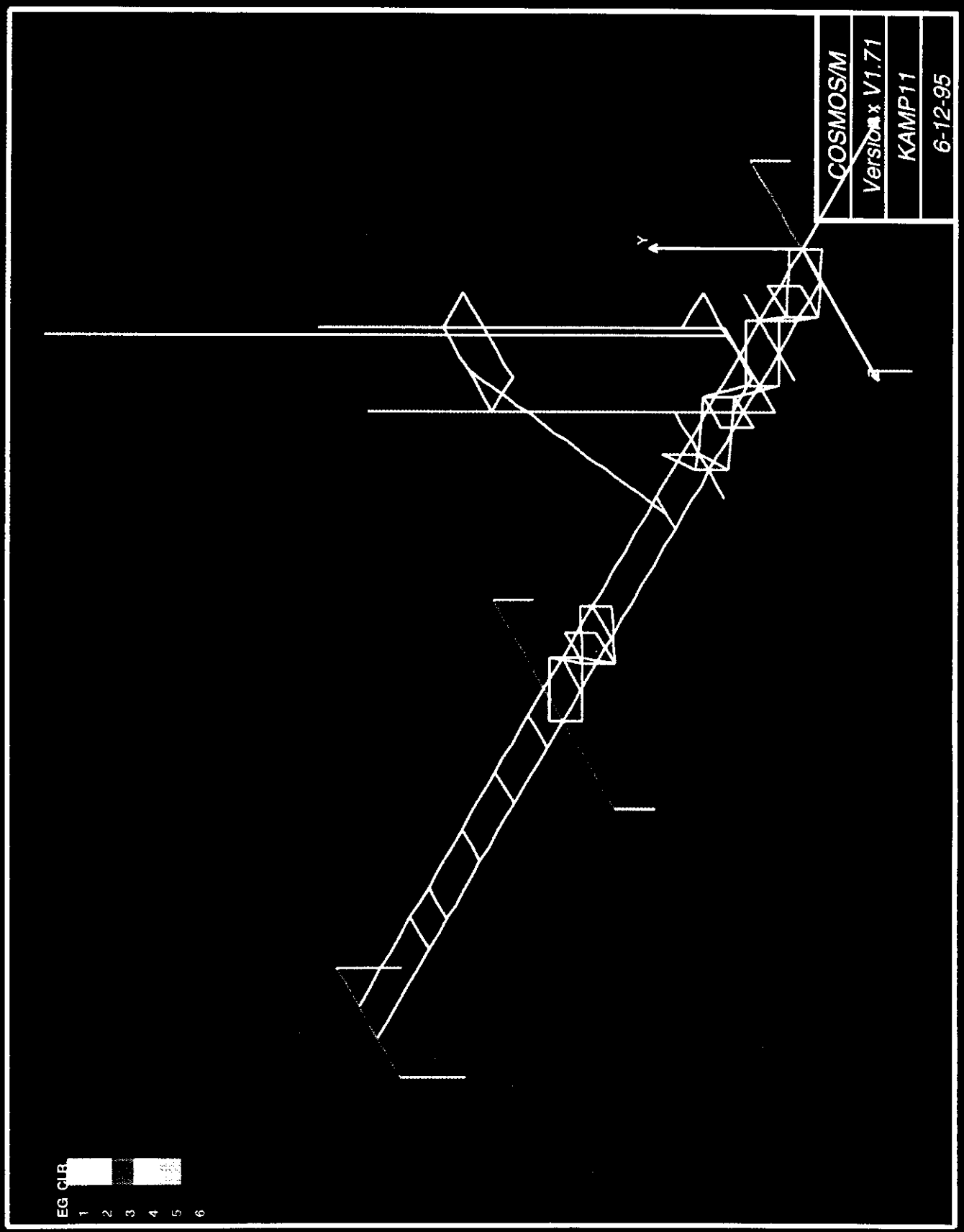
USE 2 SPRING RATES TO BOUND PROBLEM:

4'x6' OUTRIGGER PAD - $K = 273{,}000\ ^{lb}/_{in}$ ←

2' ϕ FOOT ~ $K = 17{,}000\ ^{lb}/_{in}$

The strongback, shipping container and trailer were represented in the finite-element model by the components listed in the first column. Each component must be represented by a specific element group, real constant and material property which are listed below. The following three pages are color plots showing the location of each element group, real constant and material property.

COMPONENT	ELEMENT GROUP	REAL CONSTANT	MATERIAL PROP.
Outriggers	3	1	2
W30X191	2	2	5
Front W30X191 Outrigger	3	3	1
W30X191 + 12.5X0.625PL	2	4	5
Shipping Container	2	5	4
Strongback	2	6	3
Rigid Elements	1	7	1
Stabilizers & hydraulic cylinder	2	8	1
Strongback Support	4	9	1
axles	5	11	1
hydraulic cylinder (changed end release 1 to 100111)	2	12	1
hydraulic cylinder (changed end release 2 to 100111)	2	13	1
W30X90	2	14	1
hydraulic beam on strongback	5	15	1
Added Diagonal Beam Stiffeners	1	16	1
Soil Springs Stiffness	6	17	1
Longitudinal & Lateral Soil Spring Stiffness	6	18	1
Wheel Springs Stiffness	6	19	1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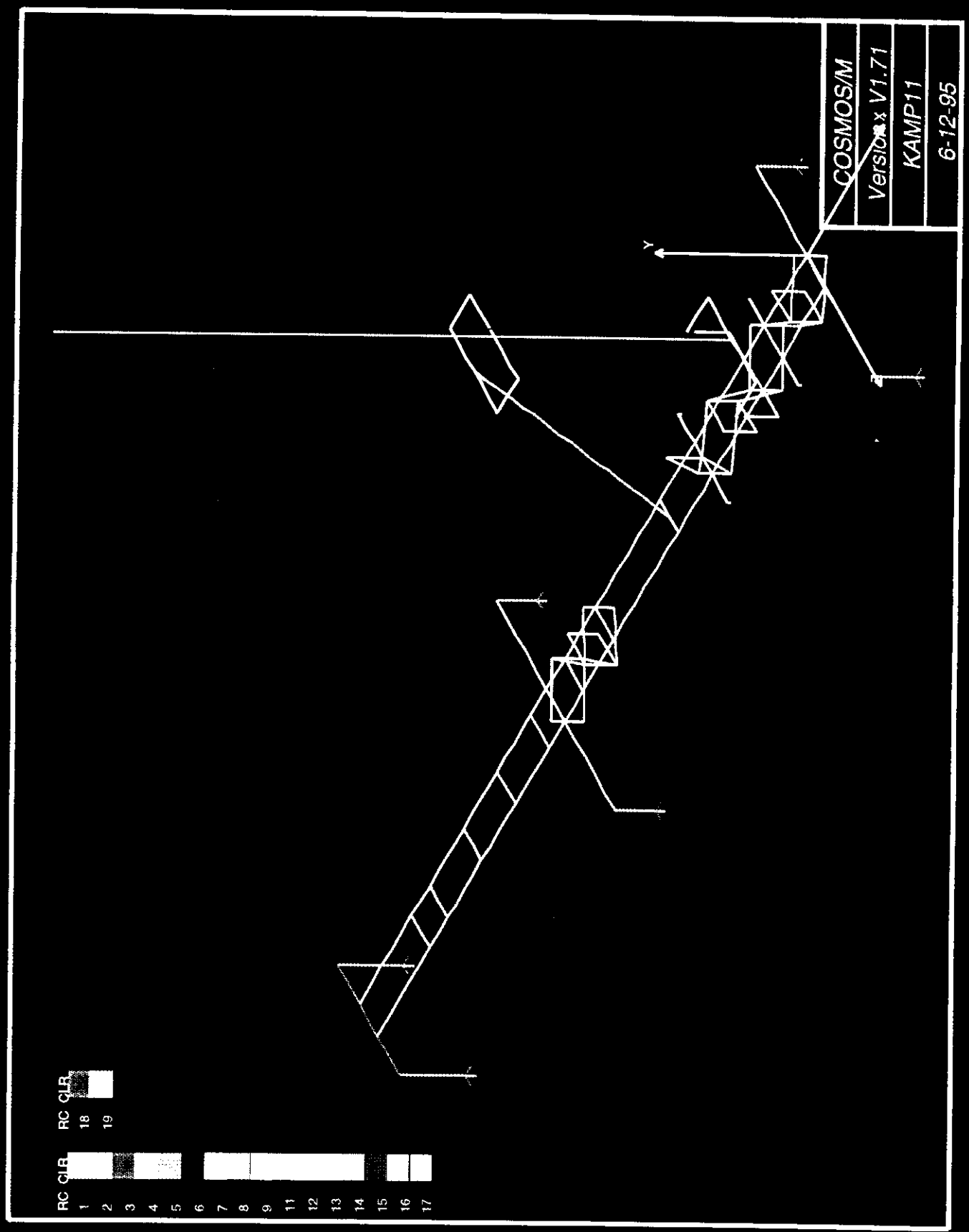
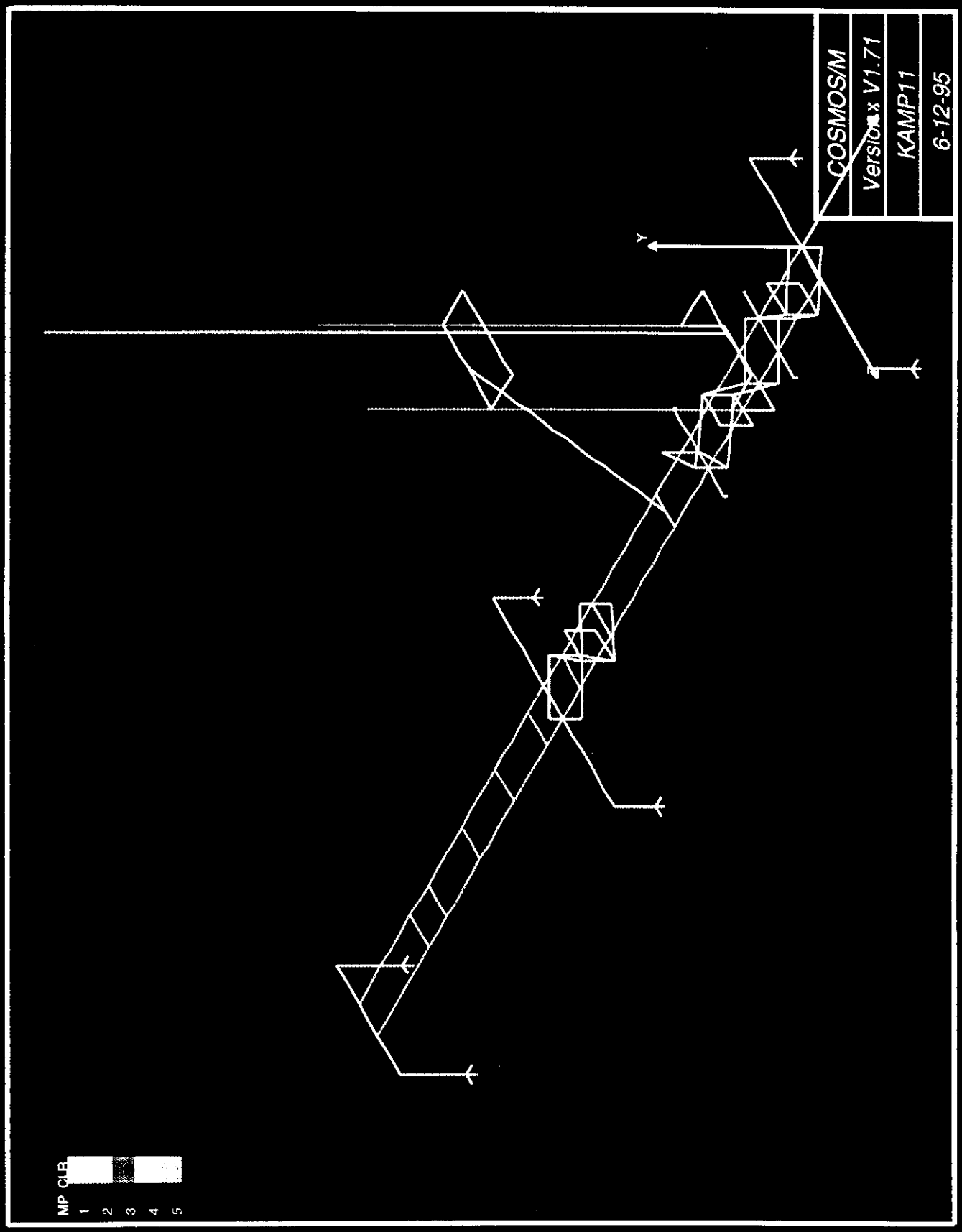
Version x V1.71
KAMP11
6-12-95
Y
EG GLB
1 2 3 4 5 6


COSMOS/M
Version x V1.71
KAMP11
6-12-95
Y
RC CLR
18 19
RC CLR
1 2 3 4 5 6 7 8 9 11 12 13 14 15 16 17


COSMOS/M
Version x V1.71
KAMP11
6-12-95
Y
MP CLR
1
2
3
4
5

APPENDIX B

Hand Calculations and FEA Model Output for Wind Induced Vibration

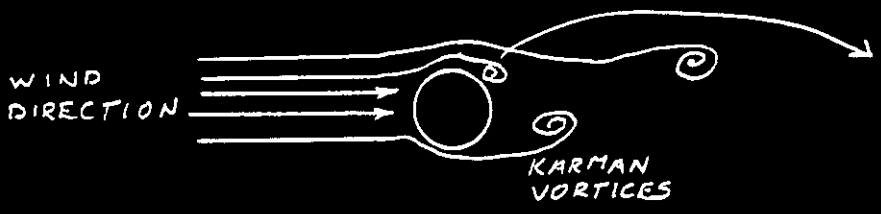
ANALYTICAL CALCULATIONS

Subject WIND-INDUCED OSCILLATION - SY-101 CONTAINER

Originator CALCS FOR INDEPENDENT REVIEW Date 1/12/95

Checker R. L. JORISSEN Date

WIND-INDUCED OSCILLATION OF CONTAINER



WHEN VORTEX FREQ. COINCIDES WITH NATURAL FREQ. OF STRUCTURE, HARMONIC EXCITATION RESULTS. IF VORTEX FREQ IS MULTIPLE OF STRUCTURE'S NATURAL FREQ., RESULTING EXCITATION IS SUBHARMONIC.
(REF. - ASCE TRANSACTIONS - PAPER NO. 3269 - p. 1175)

STRUCTURE FREQ. -

BRAD COVERDELL F.E.M. - 0.56 Hz (LATERAL MOTION)
" " HAND CALC - 0.662 Hz

→ $f \approx 0.6$ Hz

VORTEX FREQ -

STROUHAL NO. $= 0.22 = \frac{fD}{V}$ (REF. - "MECANICAL VIBRATIONS" J.P. DEN HARTOG - 4th ED. 1956)

f = VORTEX FREQ

D = CYLINDRICAL STRUCTURE ϕ

V = WIND VEL.

$f = 0.22 \frac{V}{D}$ $D = 68$" (CONTAINER)

	WIND VEL.	f = FREQ.
VEL. CORRESPOND. TO 10 psf DESIGN PRESS →	30 mph = 528 ips	1.71 Hz
	20 mph = 352 ips	1.14 Hz
MAX. VEL. DURING SUMP REMOVAL →	15 = 264 ips	0.85 Hz
	10.5 = 184.3 ips	0.60 Hz → SAME AS STRUCT. FREQ. 10.5 mph

∴ CONCLUSION - INCREASE FREQ. OF STRUCTURE

```
**********************************************************************
**********************************************************************
**                                                                  **
**                                                                  **
**  CCCC   0000   SSSS   M     M   0000   SSSS     / M     M  **
**  C      0  0   S      MM   MM   0  0   S       /  MM   MM  **
**  C      0  0   SSSS   M M M M   0  0   SSSS   /   M M M M  **
**  C      0  0      S   M  M  M   0  0      S  /    M  M  M  **
**  CCCC   0000   SSSS   M     M   0000   SSSS /     M     M  **
**                                                                  **
**                                                                  **
**                        VERSION:  1.71                            **
**                      DISTRIBUTED BY:                             **
**      STRUCTURAL  RESEARCH  AND  ANALYSIS  CORPORATION            **
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**                TEL. NO.   (310)  452-2158                        **
**               COPYRIGHT  1994   S. R. A. C.                      **
**                                                                  **
**********************************************************************
**********************************************************************

 Licensed to:
 Date       :  1/20/1995    Time:    9:47:16
 Title      :
 |
 Subtitle   :

   C O N T R O L   I N F O R M A T I O N
    NUMBER OF LOAD CASES  . . . . . (NLCASE)  =        1
    SOLUTION MODE . . . . . (MODEX)   =        2
       EQ. 0, STATIC ANALYSIS
       EQ. 1, BUCKLING ANALYSIS
       EQ. 2, DYNAMIC ANALYSIS
    THERMAL LOADING FLAG . . . . . .(ITHERM)  =        0
       EQ. 0, NO THERMAL EFFECTS CONSIDERED
       EQ. 1, ADD TEMPERATURE EFFECT
    GRAVITY LOADING FLAG . . . . . .(IGRAV)   =        1
       EQ. 0, NO GRAVITY LOADING CONSIDERED
       EQ. 1, ADD GRAVITY LOADING EFFECT
    CENTRIFUGAL LOADING FLAG . . . . . .(ICNTRF)  =        0
       EQ. 0, NO CENTRIFUGAL LOADING CONSIDERED
       EQ. 1, ADD CENTRIFUGAL LOADING EFFECT
    IN-PLANE STIFFENING FLAG . . . . . .(INPLN)   =        0
       EQ. 0, NO IN-PLANE EFFECTS CONSIDERED
       EQ. 1, IN-PLANE EFFECTS CONSIDERED
    SOFT SPRING ADDITION FLAG . . . . . (ISOFT)   =        0
       EQ. 0, NO SOFT SPRING OPTION
```

```
   EQ. 1, SOFT SPRING ADDED

 SAVE DECOMPOSED STIFFNESS MATRIX FLAG . . . (ISAVK)   =        0
   EQ. 0, DO NOT SAVE DECOMPOSED K
   EQ. 1, SAVE DECOMPOSED K
 FORM STIFFNESS MATRIX FLAG . . . . . .(IFORMK)  =        0
   EQ. 0, FORM STIFFNESS MATRIX
   EQ. 1, USE EXIST DECOMPOSED STIFFNESS MATRIX

T O T A L  S Y S T E M  D A T A
 NUMBER OF EQUATIONS . . . . . .(NEQ)  =     2092
 NUMBER OF MATRIX ELEMENTS . . . . . .(NWK)  =    77793
 MAXIMUM HALF BANDWIDTH . . . . . (MK )  =       78
 MEAN HALF BANDWIDTH . . . . . .(MM )  =       37
 NUMBER OF ELEMENTS. . . . . .(NUME) =      419
 NUMBER OF NODAL POINTS. . . . . .(NUMNP)=      396
 ADJUSTED BLOCK SIZE . . . . . .(MTBLK)=    77794
 NUMBER OF STIFFNESS BLOCKS. . . . . (NBLK) =        1


 MAXIMUM DIAGONAL STIFFNESS MATRIX VALUE =  0.182228E+15 (  1186)
 MINIMUM DIAGONAL STIFFNESS MATRIX VALUE =  0.295733E+07 (  1022)
1
```

M A S S M O M E N T I N F O R M A T I O N		
MASS 0.597703E+03	VOLUME 0.293431E+06	WEIGHT 0.230952E+06
MASS MOMENT OF INERTIA W.R.T. C.G.		
IX 0.196524E+08	IY 0.340368E+08	IZ 0.529009E+08
MASS PRODUCT OF INERTIA W.R.T. C.G.		
PXY 0.116515E+08	PXZ -0.602500E+02	PYZ -0.375000E+00
RADII OF GYRATION W.R.T. C.G.		
RX 0.181328E+03	RY 0.238634E+03	RZ 0.297501E+03
CENTER OF GRAVITY		
CGx -0.268188E+03	CGy 0.109783E+03	CGz 0.175000E+02
PRINCIPAL MASS MOMENT OF INERTIA		

P1	0.529009E+08	P2	0.405371E+08	P3	0.131521E+08
PRINCIPAL RADII OF GYRATION					
R1	0.297501E+03	R2	0.260426E+03	R3	0.148339E+03
PRINCIPAL AXES (DIRECTION COSINES IN ROWS W.R.T C.G)					
N_11	0.230380E-05	N_12	-0.140307E-05	N_13	0.100000E+01
N_21	0.487203E+00	N_22	-0.873289E+00	N_23	-0.234770E-05
N_31	0.873289E+00	N_32	0.487203E+00	N_33	-0.132830E-05

S O L U T I O N P A R A M E T E R S

NUMBER OF EIGENVALUES.	(NFR)=	1
MASS TYPE: 1-LUMPED,2-CONSISTENT. . . .	(MASS)=	1
MODE SHAPE PRINT FLAG.	(MPRNT)=	0
INTERMEDIATE SOLUTION PRINT FLAG	(IFPR)=	0
STURM SEQUENCE CHECK FLAG.	(IFSS)=	0
MAXIMUM NUMBER OF ITERATIONS	(ITMAX)=	16
FREQUENCY SHIFT FLAG	(IFRSH)=	0
FREQUENCY SHIFT.	(FRSH)=	0.0000000E+00
CONVERGENCE TOLERANCE.	(RTOL)=	0.1000000E-04
COMPOSITE MODAL DAMPING CALC. FLAG . . .	(IMDC)=	0
MODAL ACCELERATION FLAG.	(IMAM)=	0

S U B S P A C E I T E R A T I O N

ITERATION NUMBER 1

ITERATION NUMBER 2

ITERATION NUMBER 3

ITERATION NUMBER 4

CONVERGENCE REACHED FOR RTOL 0.1000E-04

F R E Q U E N C Y A N A L Y S I S
by
S U B S P A C E A L G O R I T H M

FREQUENCY NUMBER	FREQUENCY (RAD/SEC)	FREQUENCY (CYCLES/SEC)	PERIOD (SECONDS)
1	0.6751878E+01	0.1074595E+01	0.9305834E+00

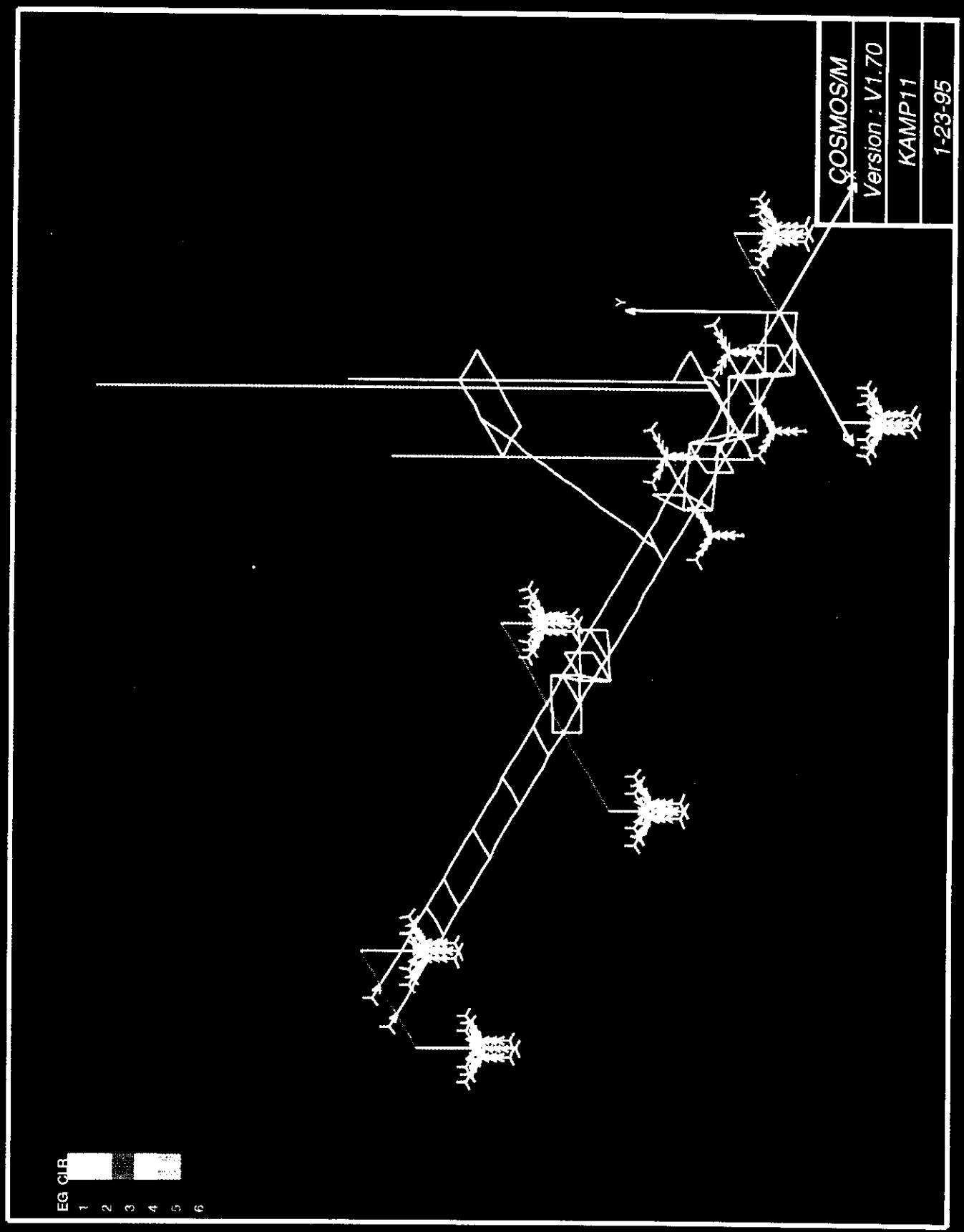


Figure 1. Plot Of Element Groups By Color.

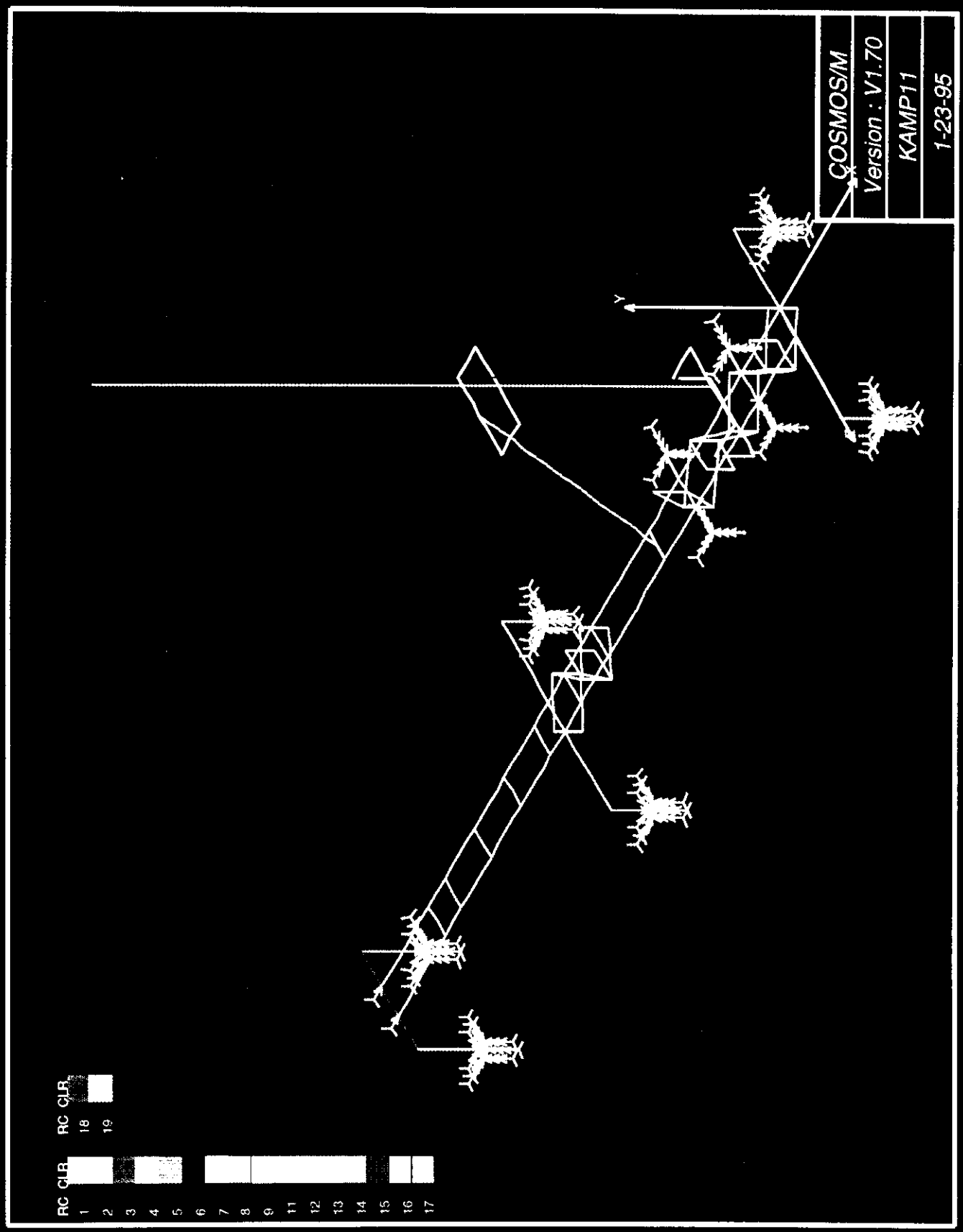


Figure 2. Plot Of Real Constants By Color.

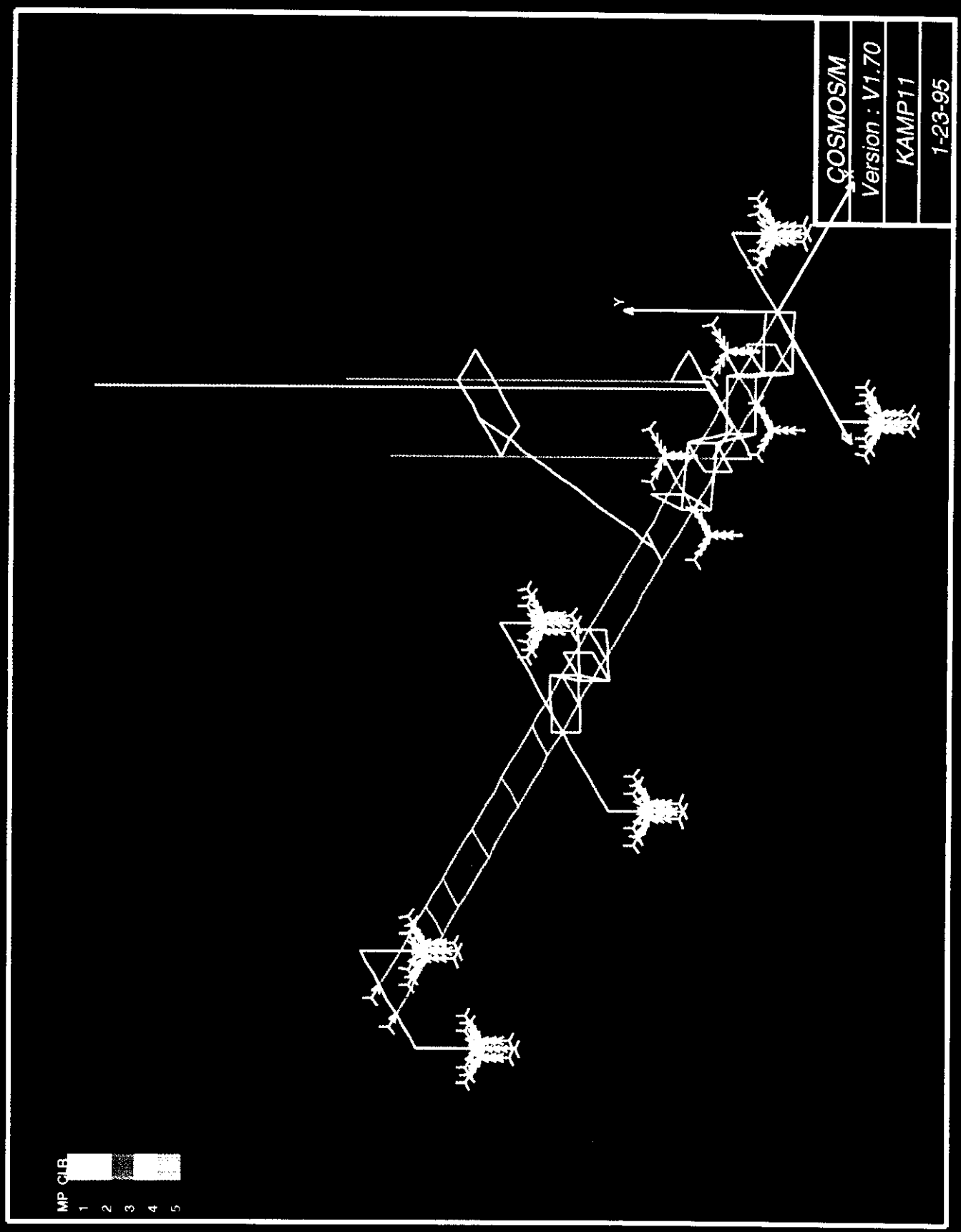


Figure 3. Plot Of Material Properties By Color.

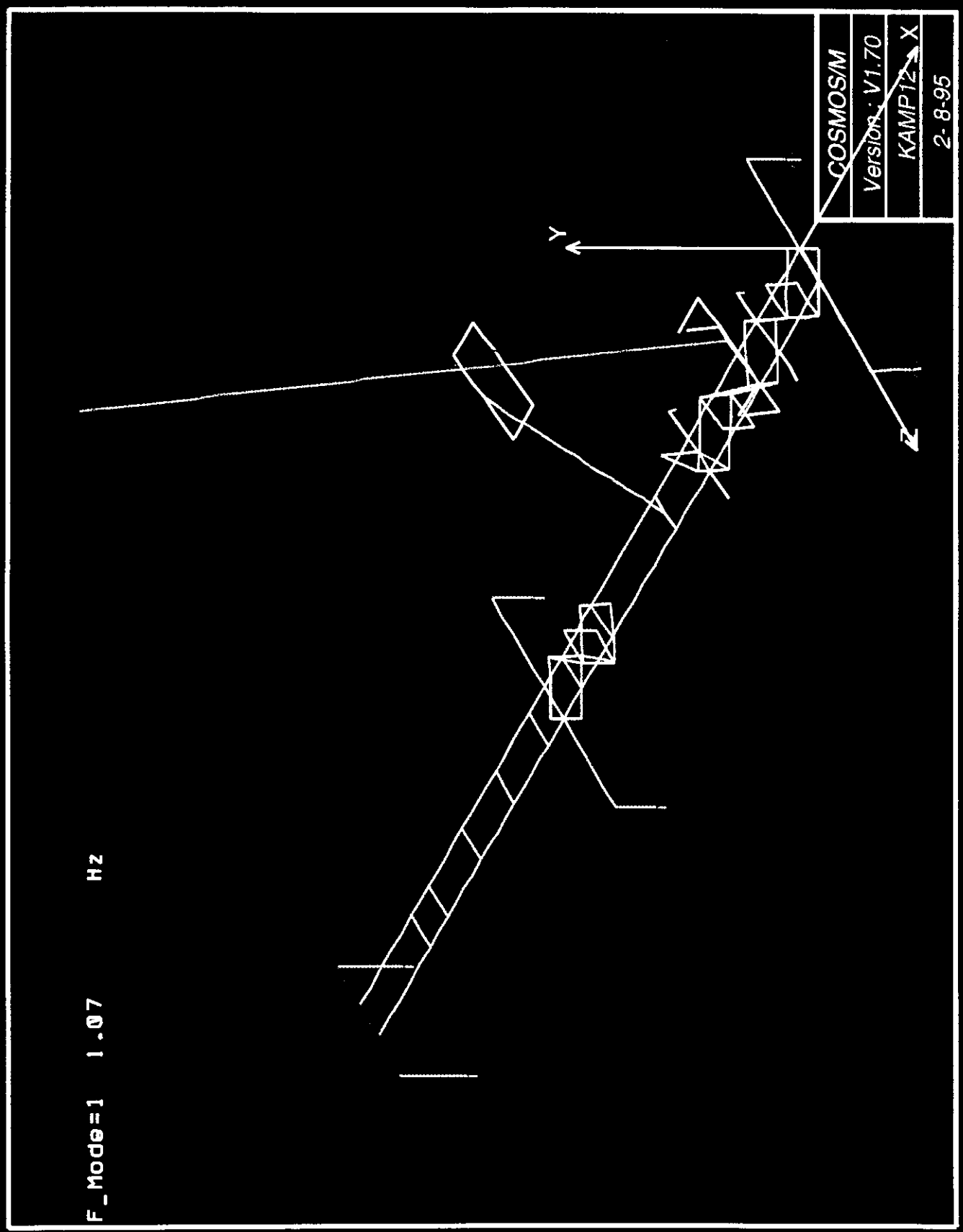


Figure 4. Frequency Plot.

ANALYTICAL CALCULATIONS

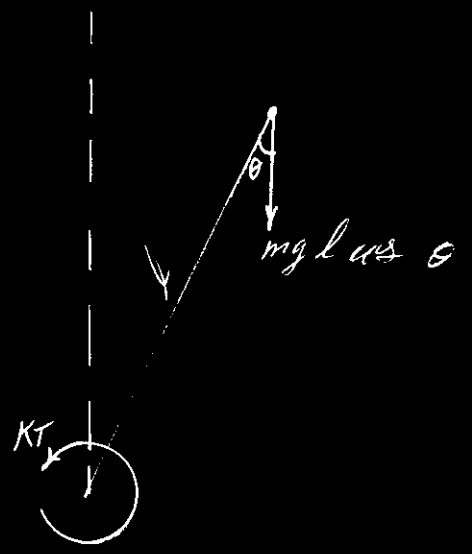
Page ____ of ____

Subject: Frequency Hand Calcs for SY101 Trailer

Originator: B L Coverdell Date: 2-24-95

Checker: E O Weiss Date: 5-11-95

Single degree of freedom model of SY101 trailer. This model is to be used in determining the natural frequency of the trailer.



$J\ddot{\theta} = -K\theta$ theory of vibrations with applications (pg. 17)

$J = ml^2$

$K = K_T\theta - mgl\cos\theta$

$ml^2\ddot{\theta} = -(K_T\theta - mgl\cos\theta)$

$\ddot{\theta} + \left(\frac{K_T}{ml^2} - \frac{g\cos\theta}{l}\right)\theta = 0$

if $\theta \approx 0$ then $\cos\theta = 1$

$\ddot{\theta} + \left(\frac{K_T}{ml^2} - \frac{g}{l}\right)\theta = 0$

ANALYTICAL CALCULATIONS

Doc. No. _____ Rev. 0 Page ___ of ___

Subject _____

Originator B.L. Coverdell BLC Date February 3, 1995

Checker J.A. Tucic Date 16 MAY 95

FREQUENCY ANALYSIS OF 241SY101 SHIPPING CONTAINER, STRONGBACK AND TRAILER COMBINATION

This section of calculations determines the natural frequency of the shipping container in the upright position. A finite-element (FE) model was created to determine the natural frequency of the combination but FE analysis does not consider the effects due to gravity. Hand calculations have been completed that show that as long as the angle of deflection is small, the effect of gravity is insignificant. The results of these calculations can be used to check the FE analysis.

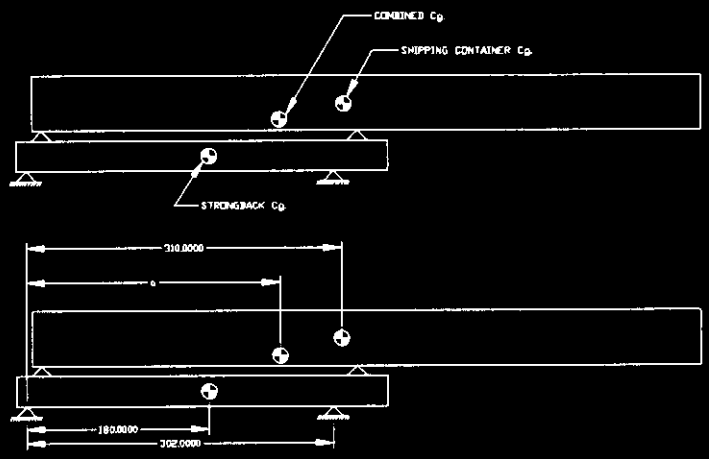
$P := 1000 \cdot lbf$

Force placed on end of shipping container. The resulting deflection from the finite-element model is then used to calculate

$m := 55000 \cdot lb + 30000 \cdot lb$

Weight of shipping container and strongback.

From the sketch at right determine the location of the combined Cg. The weight of the shipping container and strongback are 55000 lb and 30000 lb respectively.

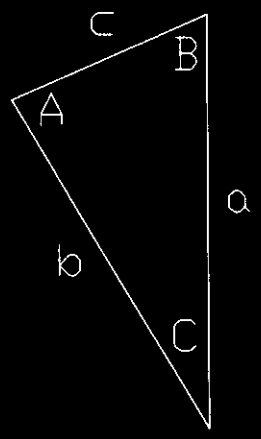


$$l := \frac{180 \cdot in \cdot 30000 \cdot lbf + 310 \cdot in \cdot 55000 \cdot lbf}{30000 \cdot lbf + 55000 \cdot lbf}$$

$l = 264.118 \cdot in$

Distance to combined Cg used for placement of force on FEA model.

Given the dimensions below, determine angle C using the law of cosines.



$a := 305.13 \cdot in$

$b := a$

a and b represent the distance to the center of mass of the shipping container and strongback combination.

$c := .0976 \cdot in$

c represents the deflection of the shipping container due to the load P as determined from the finite-element analysis.

$$C := \operatorname{acos}\left(1 - \frac{c^2}{2 \cdot a^2}\right)$$

$C = 0.018 \cdot deg$

Determination of angle C using the law of cosines.

ANALYTICAL CALCULATIONS

Doc. No. _____ Rev. 0 Page ___ of ___

Subject _____

Originator B.L. Coverdell BLC Date February 3, 1995

Checker JA Tuck JA Tuck Date 16 MAY 95

$k_t := \frac{P \cdot l}{C}$ $k_t = 8.257 \cdot 10^8 \cdot \frac{lbf \cdot in}{rad}$ Stiffness of torsional spring.

$f := \frac{1}{2 \cdot \pi} \cdot \sqrt{\frac{k_t}{m \cdot l^2} - \frac{g}{l}}$ $f = 1.151 \cdot hz$ Frequency of shipping container, strongback and trailer combination.

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APPENDIX C

Upper Hydraulic Clevis Analysis

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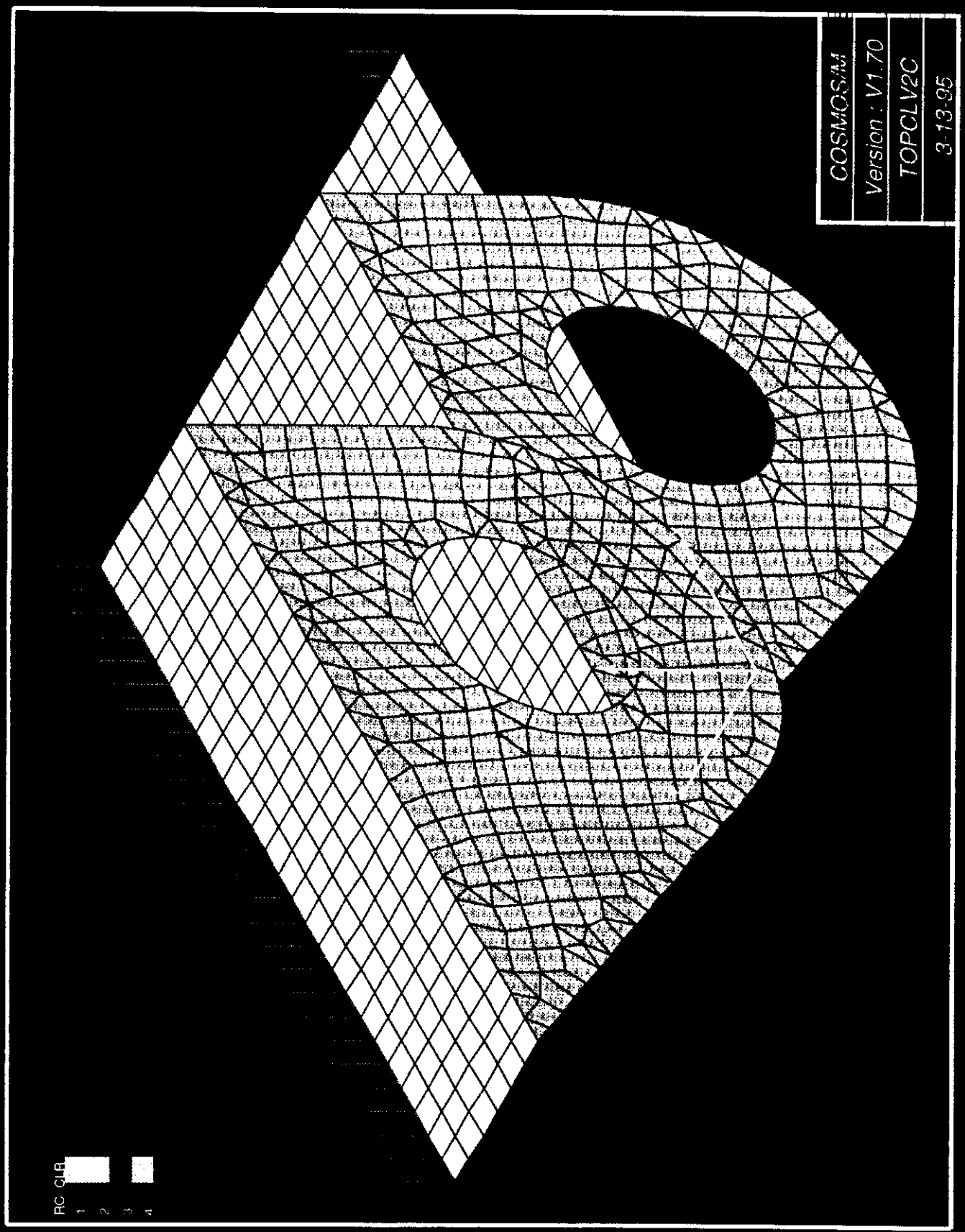
COSMOS/M
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TOPCLV2C
3-13-95
RC GLB
1
2
3
4

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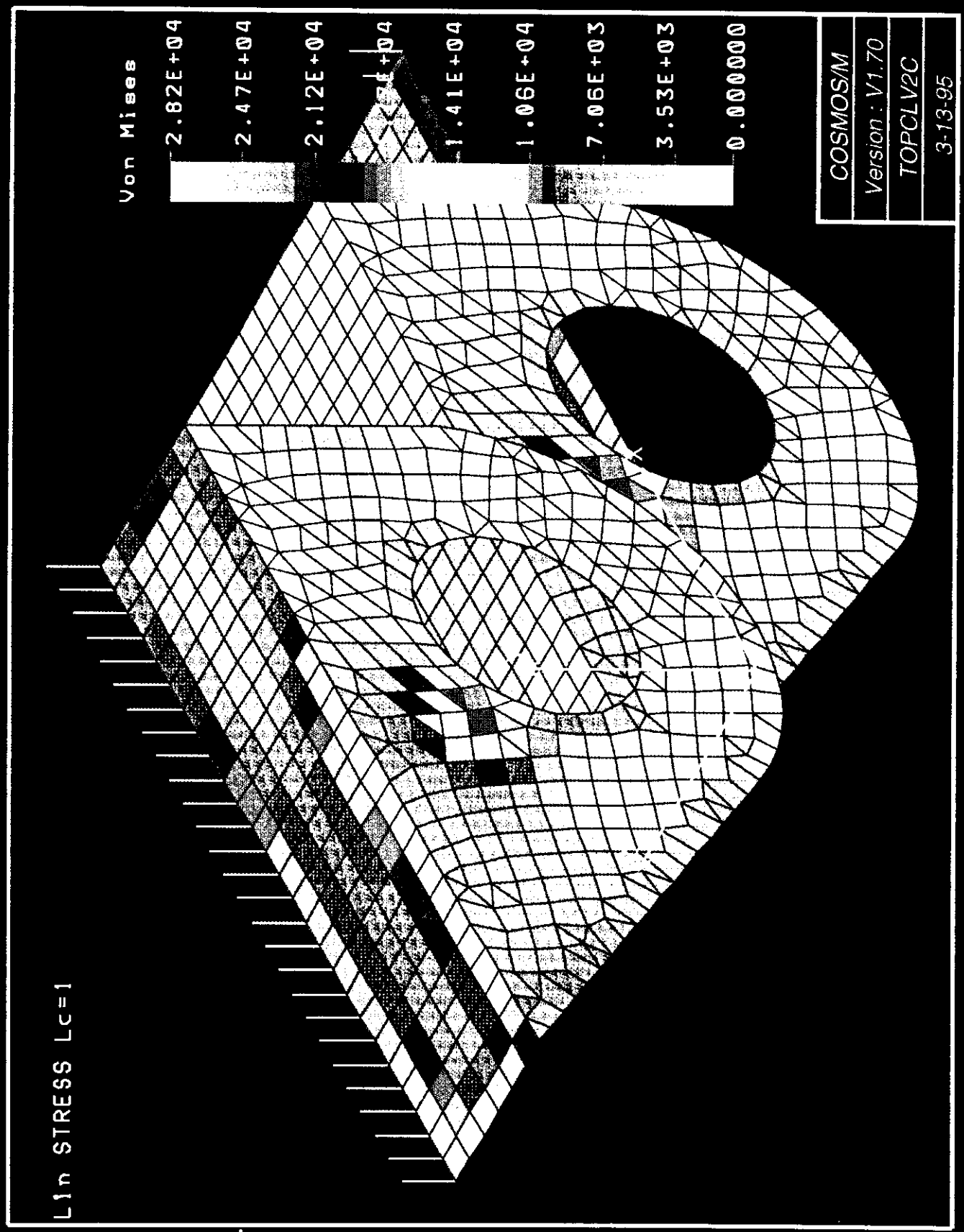
L1n STRESS Lc=1
Von Mises
2.82E+04
2.47E+04
2.12E+04
1.41E+04
1.06E+04
7.06E+03
3.53E+03
0.000000
COSMOS/M
Version : V1.70
TOPCLV2C
3-13-95

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APPENDIX D

Lower Hydraulic Clevis Analysis

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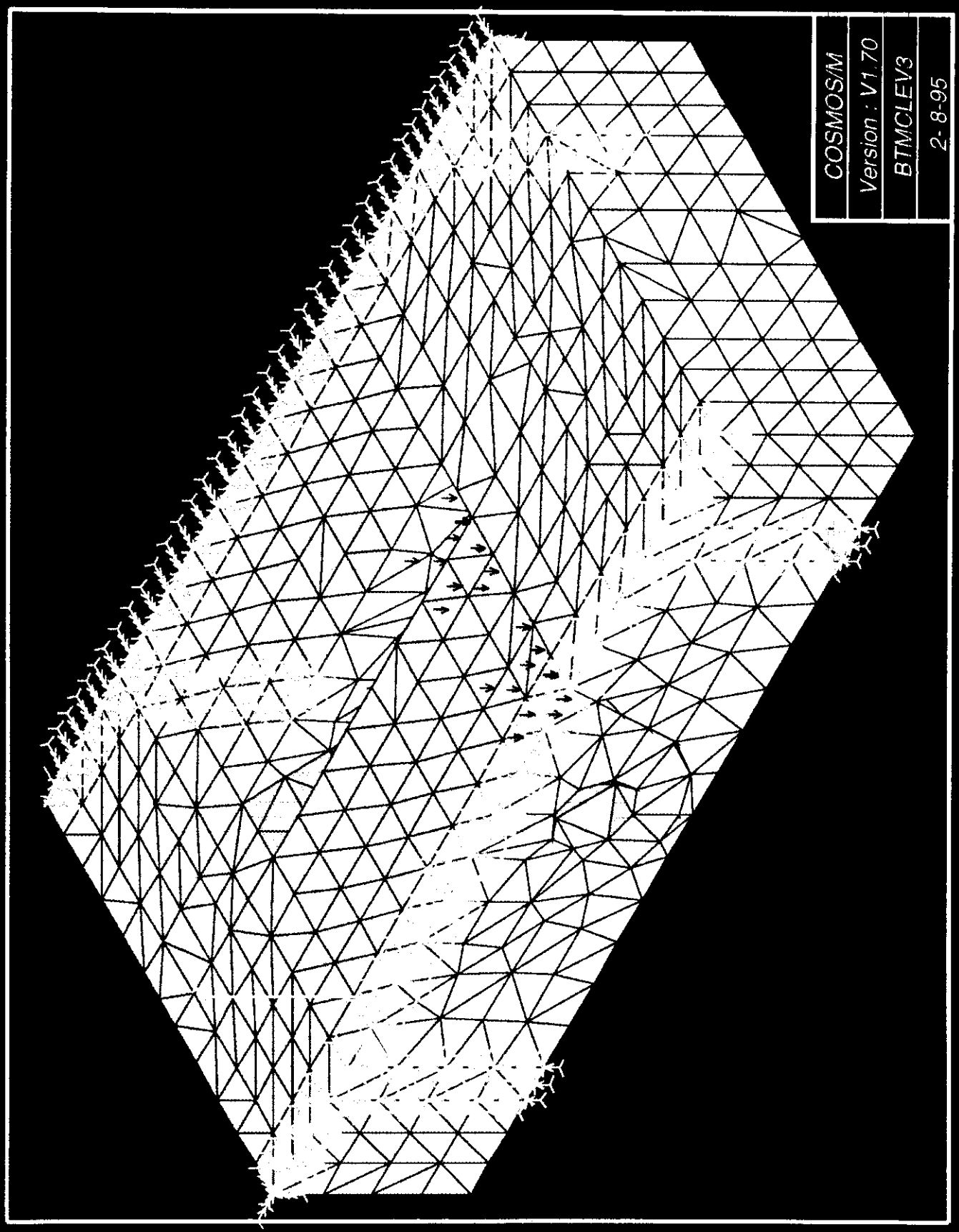

Figure 5. Plot Of Elements and Boundary Condition For Hydraulic Trailer Lower Clevis.

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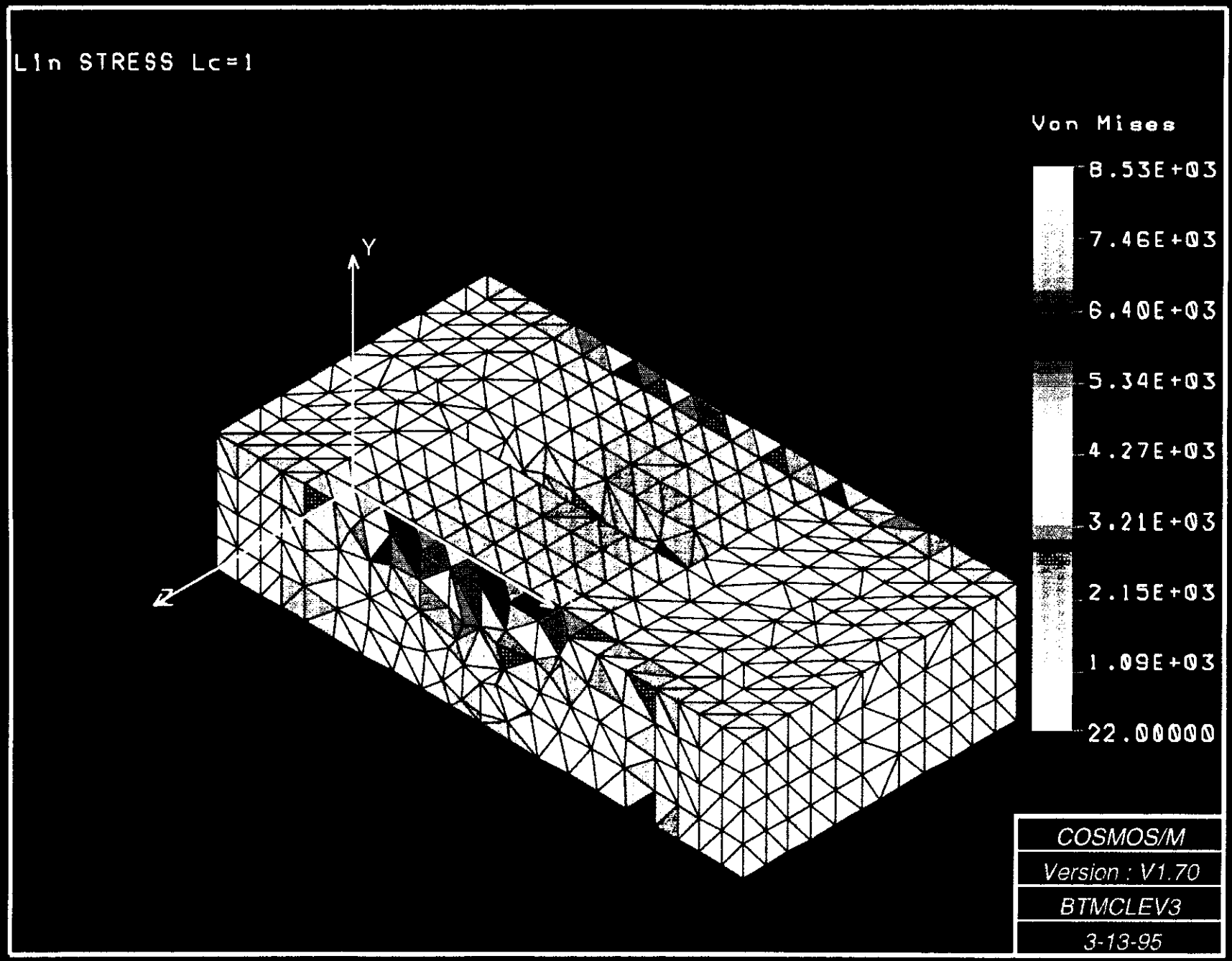

Figure 6. Von Mises Hydraulic Stress Plot Of Trailer Lower Clevis.

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APPENDIX E

KAMP Engineering Calculations

I. 1st SUBMITAL OF CALCULATIONS FROM KAMP INC.

STRESS AND DEFLECTION ANALYSIS

OF

101-SY HYDRAULIC TRAILER

Drawing Number KS15000694

Prepared for

KAMP SYSTEMS, INCORPORATED.
2028 East Cedar,
Ontario, California 91761

by

Graham S. S. Barr, P. E.
23467 Schoolcraft Street
West Hills, California 91307

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 1 of
		ORIG BY: G.S.S.B.	DATE: 11/12/94.
		CHK'D BY: [illegible]	DATE: 1-26-95
SUBJECT: KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM: HANFORD SY-1-1 MITIGATION/SAFETY.	

101-SY HYDRAULIC TRAILER Drawing Number KS15000694
STRESS AND DEFLECTION ANALYSIS

SCOPE

The 101-SY Hydraulic Trailer, Drawing Number KS15000694, manufactured by Kamp Systems, Incorporated, was examined to determine its stress levels and deflections under the action of its own weight and the weight of various payload configurations. The load cases were in accordance with Westinghouse/Hanford Document No. WHA-S-0280, Rev. D.

The evaluation of the stress and deflections used the formulas of Reference 1. Some of these formulas were implemented in the computer program of reference 2.

Details of all significant calculations are incorporated into this report. Some simplifying assumptions have been made where noted.

CONCLUSIONS.

The results of the analysis showed that the 101-SY Hydraulic Trailer was adequately designed with acceptable stress levels. Beam deflections were high in one load case if the container stiffness is ignored. Maximum bending stress in the beams was less than 27,123 psi and the maximum shear stress was 1,751 psi.

The analysis was performed in conjunction with the design. If the as-built condition varies significantly from the intent of the drawing package, some changes may be required in the calculations.

The worst case load for the outriggers was used throughout the calculations. This determined to be the load on the forward outriggers with the payload horizontal. The wind loads were calculated for the payload in the upright position and were small in comparison to the jack loads. As the load transitions from one position to the other, the wind load will add up to 6% to the jack load when the container reaches the vertical position.

Graham S. S. Barr 1-26-95.

Graham S. S. Barr, P. E. Date:

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 3 of 42.
		ORIG BY: G.S.S.B.	DATE 9/04/94.
		CHK'D BY:	DATE:

SUBJECT: KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.

PROGRAM: HANFORD SY-1-1 MITIGATION/SAFETY.

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Contents....3.

Hydraulic Trailer Description....4.

Trailer Main Beam Bending Stresses....5.

Tongue and Wheel Loads....9.

Wind Load Calculations....9.

Outrigger Loads and Stresses....10.

Outrigger Deflections and Natural Frequency Estimates....15.

Lifting Load Stresses, Cylinder and Hinge Clevises....19.

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101-SY HYDRAULIC TRAILER ANALYSIS.

PROGRAM: HANFORD SY-1-1
MITIGATION/SAFETY.

HYDRAULIC TRAILER DESCRIPTION.

The Hydraulic Trailer described in Drawing Number KS15000694, is a rugged assembly fabricated from A36 steel plate and rolled WF I-beam sections. The overall width is 11 feet and it is 85 feet long.

The trailer carries a 53 foot long, 6 foot diameter, cylindrical container, mounted on a strong-back assembly, both supplied by Westinghouse/Hanford. This is hinged to the trailer to permit the container and strong-back to be erected to the vertical by means of a four stage hydraulic cylinder. To steady the trailer during this operation, four levelling jacks are fitted to outrigger beams telescoping out from the trailer sides.

Due to the critical nature of the payload to be carried in the container, the trailer structure and components have to operate safely and reliably under a variety of environmental conditions. To ensure this safe operation, the required margins were specified at a 3:1 Factor of Safety for the loads occurring during the jacking and lifting operations.

When operating on the road with the full 200,000 lb load, the safety factor on the main beam bending stresses varies as load is transferred from the end supports to the center support. Load case 1 gives a safety factor of 1.63 using the ceertified yield stress while load case 2 has a corresponding safety factor of 2.21. The actual factor of safety will depend on the degree of load transfer that is achieved, either by jacking at the center support or by tensioning the tie-downs.

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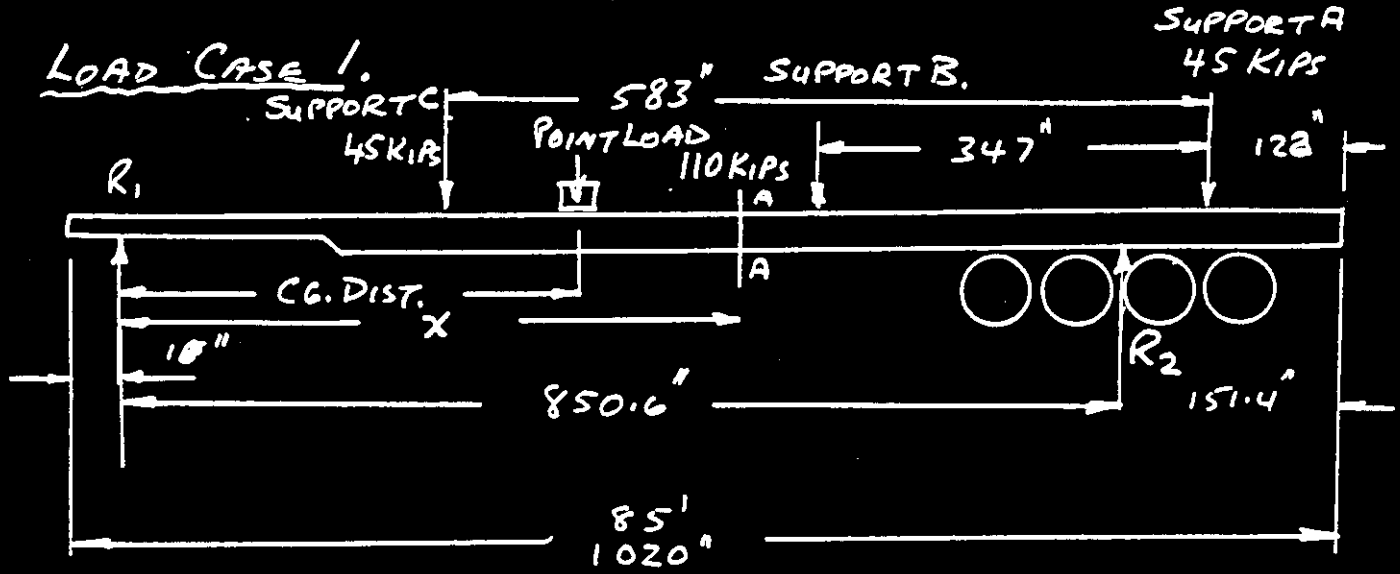
TRAILER MAIN BEAM BENDING STRESSES.

THE TRAILER COMPONENT WEIGHTS AND C.G. LOCATIONS WERE TABULATED USING A SPREAD SHEET COMPUTER PROGRAM. DATA FROM THIS WAS USED TO CALCULATE THE TONGUE AND RUNNING GEAR REACTION LOADS.

LOAD CASE 1.



TAKING MOMENTS ABOUT R_1

$$R_2 = \frac{\Sigma \text{ MOMENTS}}{850.6}$$

$$= 191,233 \text{ lb.}$$

$$R_2 = \Sigma \text{ WEIGHTS} - R_1 \quad R_2$$

$$R_1 = 297,998 - 191,233$$

$$= 106,765 \text{ lb.}$$

FROM LOAD CASE 1 ABOVE: (SUPPLIED BY WHC) -

SUPPORT A - 45,000 lb
" B - 45,000
" C - 110,000

TRAILER WT. W/O RUNNING GEAR - 97,988 lb

297,998 lb

Randy Summers 6/30/95

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THE BENDING MOMENT AT SECTION A-A WAS CALCULATED FROM THE SPREAD SHEET DATA AS FOLLOWS:

$$\text{BENDING MOMENT } M_{A-A} = R_1 X - \Sigma[\text{POINT LOAD}(X - \text{CG DIST.}) - \Sigma \text{CONTINUOUS LOAD}\left(\frac{X^2}{24}\right)$$

FOR $X = 515''$

BENDING MOMENT $M_{A-A} = 106{,}765 \times 515 - 17{,}267{,}224 - 5{,}276{,}872$

$= 32{,}439{,}879$ IN. LB.

$S = 2 \times 598 = 1{,}198 \text{ IN}^3$

[FOR 2 EACH 30 WF 191 BEAMS]

BENDING STRESS = 27,123 psi.

THIS CALCULATION WAS REPEATED FOR OTHER VALUES OF X. THE RESULTS WERE AS FOLLOWS:

X INCHES BEHIND TONGUE	BENDING STRESS (PSI)
465	26,198
490	26,685
515	27,123
540	26,716

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THE LOWEST YIELD STRENGTH FROM THE CERTIFIED MILL REPORT ACCOMPANYING THE WIDE FLANGE BEAMS, WAS LISTED AS 44,300 psi.

$$\text{THE RESULTING SAFETY FACTOR} = \frac{44,300}{27,123}$$

$$= 1.633.$$

IT MUST BE NOTED HERE THAT THIS LOAD CASE IS A VERY ARTIFICIAL ONE AS IT NEGLECTS THE CONSIDERABLE STIFFNESS OF THE CYLINDRICAL CONTAINER.

LOAD CASE 2.

THE CALCULATIONS WERE REPEATED FOR LOAD CASE 2 WITH 100,000 LB AT SUPPORTS A & C, AND NO LOAD AT SUPPORT B.

TAKING MOMENTS ABOUT R_1

$$R_2 = \frac{\Sigma \text{ MOMENTS}}{850.6} = \frac{16\,6\,22,988}{850.6}$$

$$= 195,889 \text{ lb.}$$

$$R_1 = \Sigma \text{ WEIGHT} - 195,889$$

$$= 297,988 - 195,889$$

$$= 102,099 \text{ lb.}$$

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THE WORST CASE BENDING FOR LOAD CASE 2 IS AT SUPPORT C, $X = 258$ INCHES.

BENDING MOMENT $M = 102,099 \times 258 - 1,083,906 - 1,324,346$

$= 23,933,290$ IN LB.

$S = 2 \times 598 = 1,196$ IN^3.

BENDING STRESS $= \frac{M}{S}$

$= 20,011$ psi.

FACTOR OF SAFETY $= \frac{44,300}{20,011}$

$= \underline{2.21}$

THESE CALCULATIONS SHOW THAT THE LOAD TRANFER FROM SUPPORTS A & C TO SUPPORT B EFFECTED BY JACKING UP SUPPORT C AND/OR BY THE TIE-DOWNS, CAUSES VERY LITTLE CHANGE IN THE TONGUE LOADS OR RUNNING GEAR LOADS.

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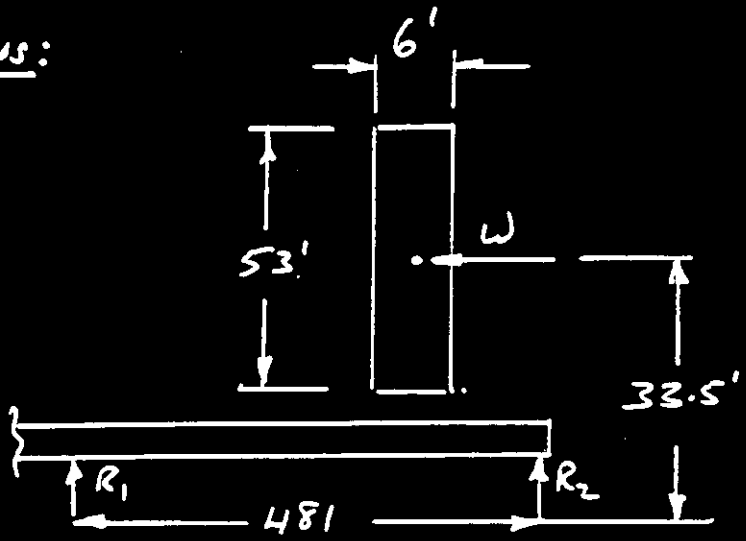
THE TONGUE AND WHEEL LOADS ARE SUMMARIZED AS FOLLOW:

LOAD CASE #	TONGUE LOAD (LB)	RUNNING GEAR LOAD (LB)
1	106,765	191,233
2	102,099	195,889

WIND LOAD CALCULATIONS:



FORE & AFT WIND.

WIND LOAD, $W = 6 \times 10 \times 53$

$= 3,180$ LB

MOMENTS ABOUT R_2

$$R_1 = \frac{3,180 \times 33.5 \times 12}{481}$$

$= 2,658$ LB LOAD / JACK = 1,313 lb

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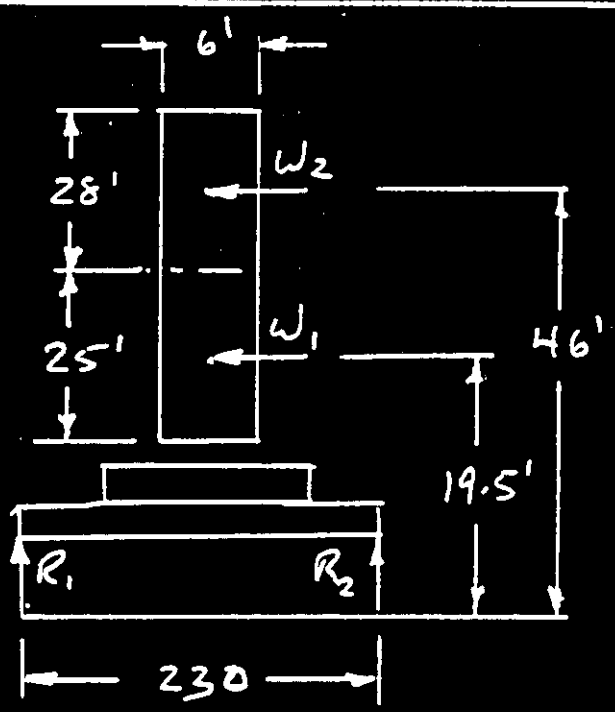
LATERAL WIND.

WIND LOADS,

$W_1 = 6 \times 12 \times 25 = 1{,}800$ LB

$W_2 = 6 \times 10 \times 28 = 1{,}680$ LB



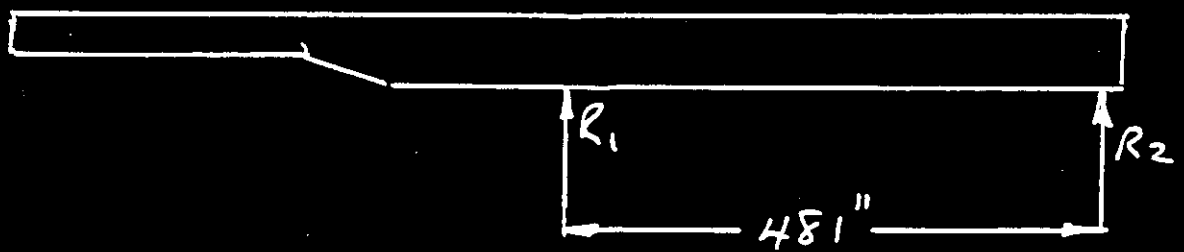
TAKING MOMENTS ABOUT R_2.

$$R_1 = \frac{1800 \times 19.5 \times 12 + 1680 \times 46 \times 12}{230}$$

$= 5{,}862$ LB

LOAD PER JACK $= 2{,}931$ LB.

OUTRIGGER LOADS AND STRESSES.



THE WEIGHTS OF LOAD CASES 1 AND 2 WERE MODIFIED, THE WEIGHT OF THE LEAD SHOT WAS REMOVED & THE RUNNING GEAR WEIGHTS WERE ADDED. THE SPREAD SHEET WAS ALSO MODIFIED TO GIVE MOMENTS ABOUT THE FORWARD JACK LOCATION, R_1.

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THE RESULTS WERE AS FOLLOWS:

CONTAINER & STRONGBACK HORIZONTAL.

Σ MOMENTS = 18,333,804 IN LB

REAR JACK REACTION, $R_2 = \frac{\Sigma M}{481} = 38{,}116$ LB

LOAD PER REAR JACK = 19058 LB.

FRONT JACK REACTION, $R_1 = \Sigma$ WEIGHTS $- R_2$

$= 229{,}598 - 38{,}116$

$= 191{,}482$ LB.

LOAD PER FRONT JACK = 95,741 LB.

CONTAINER & STRONGBACK VERTICAL.

Σ MOMENTS = 55,996,404 IN LB

REAR JACK REACTION, $R_2 = \frac{\Sigma M}{481} = 116{,}417$ LB.

LOAD PER REAR JACK = 58,208 LB

FRONT JACK REACTION, $R_1 = \Sigma$ WEIGHTS $- R_2$

$= 229{,}598 - 116{,}417$

$= 113{,}181$ LB

LOAD PER FRONT JACK = 56,590 LB

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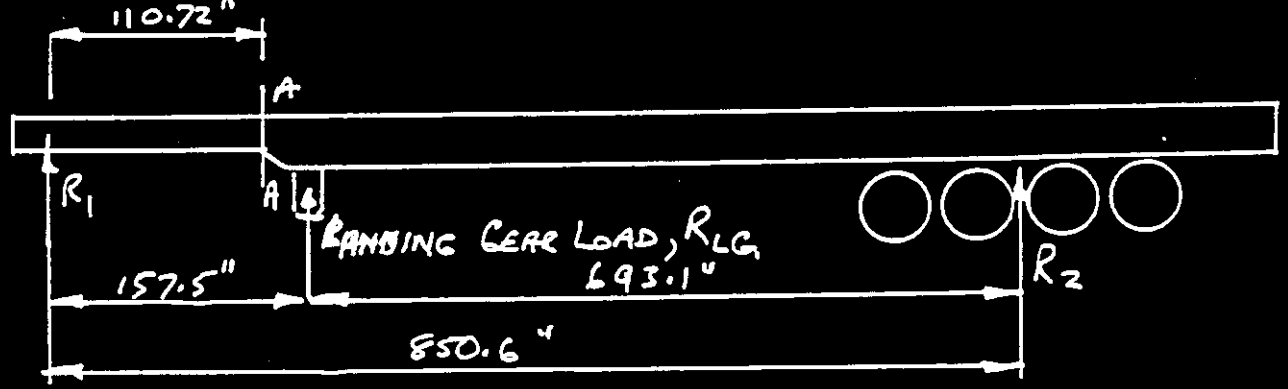
FROM THESE CALCULATIONS THE WORST CASE JACK LOAD ARISES WITH THE CONTAINER HORIZONTAL AND CORRESPONDS TO 95,740 lb. [NEGLECTING WIND LOAD IN HORIZONTAL POSITION]

THE WORST CASE COMBINATION OF WIND LOAD WITH THE CONTAINER VERTICAL JACK LOAD WOULD BE AT THE REAR JACK AND CORRESPONDS TO 58,208 + 2,931 lb = 61,139 LB.

LANDING GEAR LOADS & GOOSE NECK BENDING.



WORST CASE TONGUE LOAD FROM LOAD CASE 1

R_1 = 106,765 lb

LANDING GEAR LOAD, $R_{LG} = \frac{106,765 \times 850.6}{693.1} = 131,026$ LB.

LOAD PER LANDING GEAR JACK = 65,513 LB.

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WORST CASE GOOSE NECK BENDING MOMENT [SECTION A-A]

$= 106{,}765 \times 110.72'' = 11{,}821{,}021$ IN. LB.

$S = \frac{I}{C} = \frac{2750 \times 2}{9} = 609\ IN^3$

BENDING STRESS $= \frac{11{,}821{,}021}{609} = \underline{19{,}410}$ psi

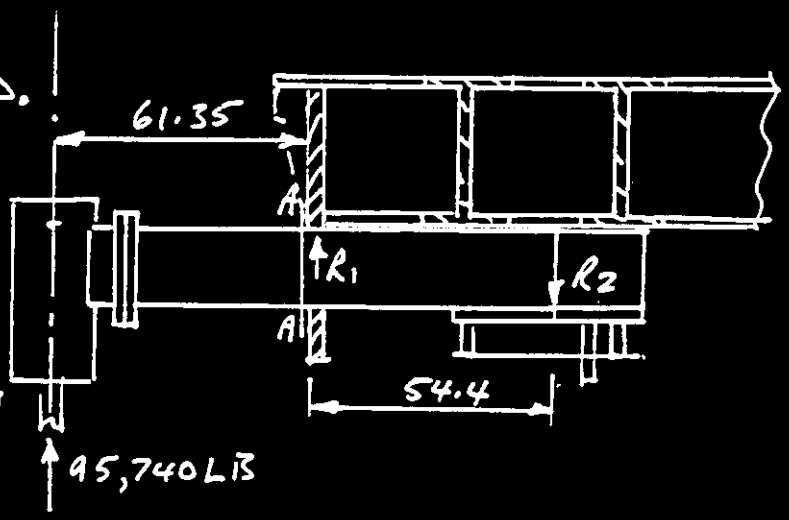
YIELD STRESS $= 44{,}300$ psi

FACTOR OF SAFETY $= \frac{44{,}300}{19{,}410} = \underline{2.28}$

OUTRIGGER BEAMS FOR JACKS:

USING WORST CASE LOAD.

MOMENTS ABT R_2.



REACTION, R_1

$= \frac{95{,}740[61.35+54.4]}{54.4}$

$= \underline{203{,}711}$ LB.

REACTION, $R_2 = R_1 - 95{,}740 = \underline{107{,}971}$ LB.

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OUTRIGGER BEAM SECTION PROPERTIES:

BOX BEAM FABBED FROM $1\frac{1}{2}$" PLATE

OUTSIDE DIMENSIONS 7" WIDE BY 16" DEEP.

ASSUME PLATE THICKNESS = $1\frac{5}{16}$" AFTER MACHINING ALLOWANCE.

MOMENT OF INERTIA, $I = \frac{7(16)^3 - 4.375(13.375)^3}{12}$

$= 1,517 \text{ in.}^4$

SECTION MODULUS, $S = I/c = 1,517/8$

$= 190 \text{ in.}^3$

WORST CASE BENDING MOMENT

$= 95,740 \ (61.35)$

$= 5,873,649 \text{ in lb.}$

BENDING STRESS $= \frac{5,873,649}{190}$

$= 30,913 \text{ psi}$

MATERIEL SELECTED FOR THIS COMPONENT IS 4140 STEEL WITH 4130 WELDING ROD. THIS HAS BEEN HEAT TREATED TO GIVE AN ULTIMATE STRESS OF 135,500psi AND A YIELD STRESS OF 129,000psi

SAFETY FACTOR IN BENDING $= \frac{129,000}{30,913} = \underline{4.17.}$

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BEAM DEFLECTION:

USE JACK LOAD WITH CONTAINER VERTICAL.
ASSUME DEFLECTION OF BEAM DUE TO R_2 RESULTS IN ROTATION OF SECTION A-A.
THIS WILL ROUGHLY DOUBLE THE DEFLECTION CALCULATED FOR AN END LOADED CANTILEVER BEAM.

FROM ROARK 5th EDITION, TABLE 3, CASE 1,

$$\text{DEFLECTION} = \frac{WL^3}{3EI} = \frac{95{,}740\,(61.35)^3}{3(29\times10^6)(1{,}517)}$$

$$= 0.1675'' \quad [\text{CONTAINER HORIZONTAL}]$$

WORST CASE DEFLECTION TRAILER WITH CONTAINER VERTICAL

$$= \frac{61{,}139\,(61.35)^3}{3(29\times10^6)(1{,}517)}$$

$$= 0.107''$$

ASSUMING ACTUAL DEFLECTION = 0.214"

$$\text{NATURAL FREQUENCY} = \frac{3.13}{\sqrt{0.214}} = \underline{\underline{6.8\ \text{Hz.}}}$$

NOTE: A SIMILAR CALCULATION FOR THE TRAILER OVERHANG FORWARD OF THE FORWARD JACK LOCATION SHOWS NATURAL FREQUENCY

$$= \frac{3.88}{\sqrt{\frac{WL^3}{8EI}}} \qquad W = 40400\ \text{LB},\quad L = 513'',\quad I = 18{,}340\ \text{in}^3$$

[CANTILEVER WITH DISTRIBUTED LOAD.]

$$= 3.4\ \text{Hz.}$$

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STRESSES IN BEAM CONNECTION TO TRAILER

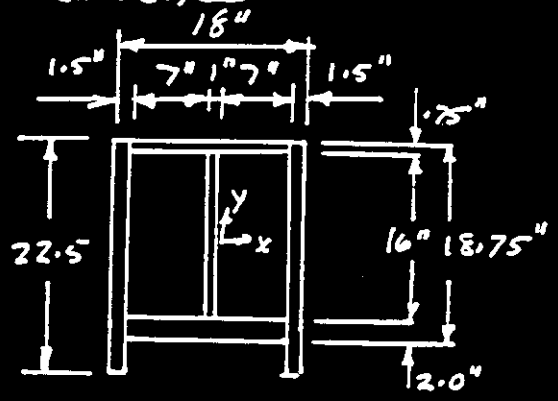
BEARING STRESS AT R_1

$R_1 = 203,711$

BEARING AREA $= (6.25)(1.5)$

BEARING STRESS $= 21,729$ psi.

AT REACTION R_2, LOAD IS DOUBLED DUE TO JACK SUPPORT FOR OTHER SIDE. LOAD CARRIED BY BEAM 35" LONG, SECTION AS SKETCHED



THE SECTION PROPERTIES WERE CALCULATED USING A COMPUTER DRAFTING PROGRAM

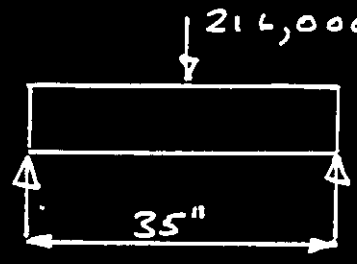
$I_{xx} = 5,888 \text{ in}^4$

$C = 11$ in [TENSION SIDE]

$= 11.5$ in [COMP. SIDE]

BENDING MOMENT $= \frac{WL}{4}$

$= 1,890,000$ in lb



TENSILE STRESS $= \frac{(1,890,000)(11)}{5,888}$

$= 3,530$ psi

COMPRESSIVE STRESS $= \frac{(1,890,000)(11.5)}{5,888} = 3,691$ psi.

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THESE STRESSES SHOW THE BEAM SECTION TO BE CONSERVATIVELY DESIGNED. IT SHOULD BE NOTED, HOWEVER, THAT A SHORT DEEP BEAM DOES NOT FOLLOW THE SIMPLE THEORY OF FLEXURE. ROARK, 4th EDITION, ARTICLE 35 IN CHAPTER 8 SHOWS THAT A BEAM WITH A SPAN TO DEPTH RATIO OF 1.5 WILL HAVE MAXIMUM STRESSES 1.038 TIMES THE CALCULATED FOR THE TENSION SIDE AND 3.583 TIMES CALCULATED FOR COMPRESSION. THE SHEAR STRESS WILL ALSO BE INCREASED TO 1.92 TIMES THE CALCULATED VALUE.

FOR COMPRESSION SIDE

WORST CASE STRESS = $(3,585)(3,691)$

= 13,233 psi

X 3:1 SAFETY FACTOR = 39,701 psi > 44,300 psi

$$\text{SHEAR STRESS} = \frac{VAz}{Ib}$$

$$= \frac{\left(\frac{216000}{2}\right)(68.8)(5.6)}{(5,888)(4)}$$

= 1,751

X CONC. FACTOR = (1,751)(1.92) = 3,362 psi

X 3:1 SAFETY FACTOR = 10,088 psi.

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OUTRIGGER BOX BEAM HANGS BELOW TRAILER ON 4 EACH, 1" PLATES, 12" WIDE.

$$\text{TENSION STRESS} = \frac{21{,}600}{(4)(1)(12)} = 4{,}500 \text{ psi}.$$

THIS NEGLECTS ADDITIONAL SUPPORT FROM 1" PLATE AT CENTER OF BOX WHICH ALSO CONNECTS TO TRAILER.

TWIST IN OUTRIGGER BEAM:

ASSUME LONGITUDINAL WIND LOAD = 4,000 LB.
LOAD/JACK = 1,000 LB DISTANCE FROM NEUTRAL AXIS TO GROUND = 38.5 INCHES.

SECTION OF SUPPORT BEAM 16 x 7 INCHES PLATE 1.31" THICK

$$K = \frac{2(1.31)^2(16-1.31)^2(7-1.31)^2}{(16)(1.31)+(7)(1.31)-(2)(1.31)^2} = 898 \text{ IN}^4$$

$$\text{TWIST}, \theta = \frac{TL}{KG} = \frac{(1000)(38.5)(54.4)}{(898)(11.5E^6)}$$

$$= 0.0002 \text{ RADIANS} = 0.012^\circ.$$

$$\text{STRESS}, S_s = \frac{Tz}{J} = \frac{(38{,}500)(8.73)}{1{,}881}$$

$$= 178 \text{ psi} \quad \text{(LOW)}$$

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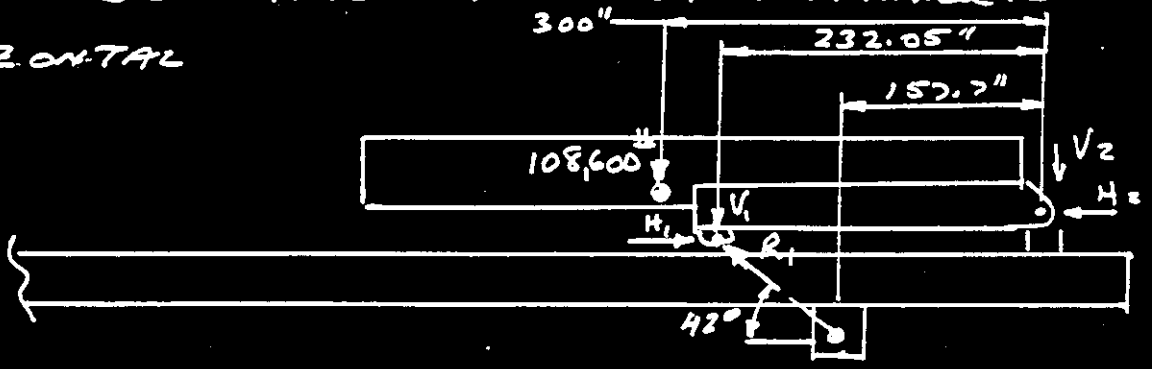
LIFTING LOAD STRESSES:

WORST CASE LIFTING LOADS WHEN CONTAINER IS HORIZONTAL



V_1, VERTICAL LIFTING LOAD COMPONENT.

$$= \frac{108600 \times 300}{232.05} = 140,401 \text{ LB}$$

H_1, HORIZONTAL COMPONENT.

$$= \frac{V_1}{\tan 42^\circ} = 155,931 \text{ LB.}$$

R_1, CYLINDER LOAD.

$$= \frac{V_1}{\sin 42^\circ} = 209,826 \text{ LB.}$$

LOWER CYLINDER MOUNTING POINT.

$$\text{PIN BEARING.} = \frac{209,826}{(3.25) \times 5 \times 2} = 6,456 \text{ psi}$$

$$\text{PIN SHEAR} = \frac{209,826}{\frac{\pi (3.25)^2}{4} (2)} = 12,646 \text{ psi.}$$

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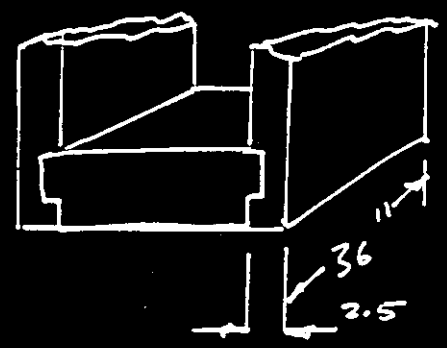
THE OTHER COMPONENTS OF THE LOWER PIVOT SUPPORT WERE DELIBERATELY DESIGNED TO BE AT LOW STRESS LEVELS TO ENSURE DEFLECTIONS WOULD BE LOW.



TENSILE STRESS DUE TO V_1

$$= \frac{140,401}{(2)(36)(2.5)}$$

$$= 780 \text{ psi.}$$

SHEAR STRESS DUE TO H_1 $= \frac{155\ 931}{(2)(36)(2.5)} = 866 \text{ psi.}$

BENDING MOMENT DUE TO H_1 $= (155\ 931)(29) = 4,522,000$ IN LB

SECTION MODULUS $= \frac{(8)(36)^2}{6} = 1,728 \text{ IN}^3$

BENDING STRESS $= 2,617 \text{ psi}$

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AFT PIVOT SUPPORT:

THE AFT PIVOT PIN IS LOADED VERTICALLY BY A LOAD = $V_1 - 1{,}08{,}600 = 31{,}801$ LB.
IT HAS A HORIZONTAL LOAD = $H_1 = 155{,}931$ LB.

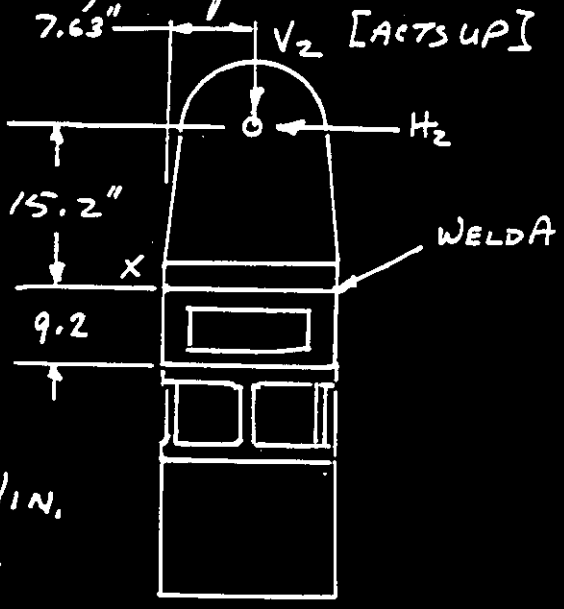
RESULTANT LOAD = $\sqrt{V_2^2 + H_2^2} = 159{,}140$ LB.

PIN DIAMETER = 3.00"

PIN BEARING = $\frac{159{,}140}{2(3 \times 3)} = \frac{17682}{2}$ psi.

$= \underline{8{,}841}$ psi

PIN SHEAR = $\frac{159140}{2\left(\frac{\pi(3)^2}{4}\right)} = 11{,}256$ psi.



TAKING MOMENTS ABOUT X

LOAD AT WELD A

$= \frac{H_2(15.2) + V_2(7.63)}{2(7.63)}$

$= \frac{171{,}218}{\cancel{39{,}411}}$ LB.

LENGTH OF WELD AT A = 2×33.12

LOAD/INCH OF WELD = $\underline{2{,}584}$ LB/IN.

ALLOWABLE STRESS FOR 3:1 S.F. = 4,533

EFFECTIVE THROAT FOR GROOVE WELD = $\frac{2584}{4533} = 0.57$" MINIMUM

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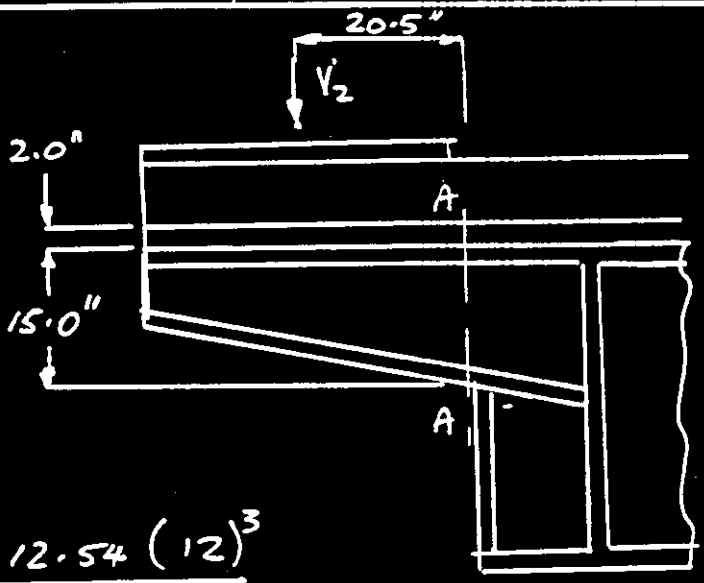
AFT PIVOT SUPPORT BEAM



V_2 WITH CONTAINER VERTICAL

$= \frac{108.6}{2} + 6_{(WIND)}$ KIPS

$= 60{,}300$ LB.

SECTION MODULUS AT A-A

$$S_{xx} = \frac{15.25\,(17)^3 - 12.54\,(12)^3}{(12)(8.5)}$$

$= 522\ IN.^3$

BENDING MOMENT $= (60{,}300)(20.5) = 1{,}236{,}150$ IN LB.

BENDING STRESS $= M/I_c = \underline{2{,}367}$ psi.

HORIZONTAL BENDING & TORSION DUE TO H_2.

$$\text{SECTION MODULUS, } S_{yy} = \frac{17\,(15.25)^3 - 13\,(13.25)^3}{12\,(7.625)}$$

$= 328\ IN.^3$

BENDING MOMENT $= \frac{155{,}391}{2} \times 20.5 = 1{,}592{,}757$ INLB

BENDING STRESS $= M/I_c = \underline{4{,}849}$ psi.

TORSION AT A-A $= \frac{155{,}391}{2} \times 30.9 = 2{,}400{,}791$ IN LB.

$$\text{SHEAR STRESS} = \frac{T}{2t(a-t)(b-t_1)} = \frac{2{,}400{,}791}{2(1)(14)(14.25)}$$

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SHEAR STRESS DUE TO TORSION = 6,017 psi

COMBINED STRESS INTERACTION

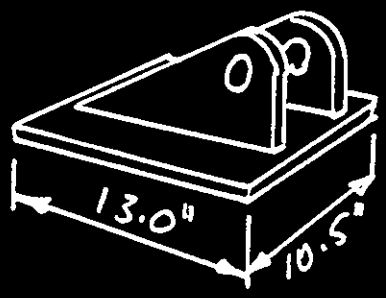
$$\left(\frac{f_s}{\text{SHEAR ALLOW.}}\right)^2 + \left(\frac{f_{t(\text{BEND})}}{\text{TENSILE ALLOW}}\right)^2 \leq 1.0$$

$$\left(\frac{6017}{7,200}\right)^2 + \left(\frac{4,849}{12,000}\right)^2 = 0.861 \text{ . OK.}$$

FORWARD CLEVIS:

WORST CASE LOAD DUE TO SHEAR FROM H_1, USE R THE RESULTANT

SHEAR LOAD = 159,140 LB



$$\text{WELD SHEAR STRESS} = \frac{159,140}{2(13+10.5)} = 3,385 \text{ LB/IN.}$$

$$\text{ALLOWABLE SHEAR STRESS} = \frac{13,600}{3} = 4,533 \text{ psi.}$$

[3:1 FACTOR OF SAFETY]

EFFECTIVE THROAT REQUIRED FOR GROOVE WELD

$$= \frac{3,385}{4,533} = 0.75 \text{ INCHES}$$

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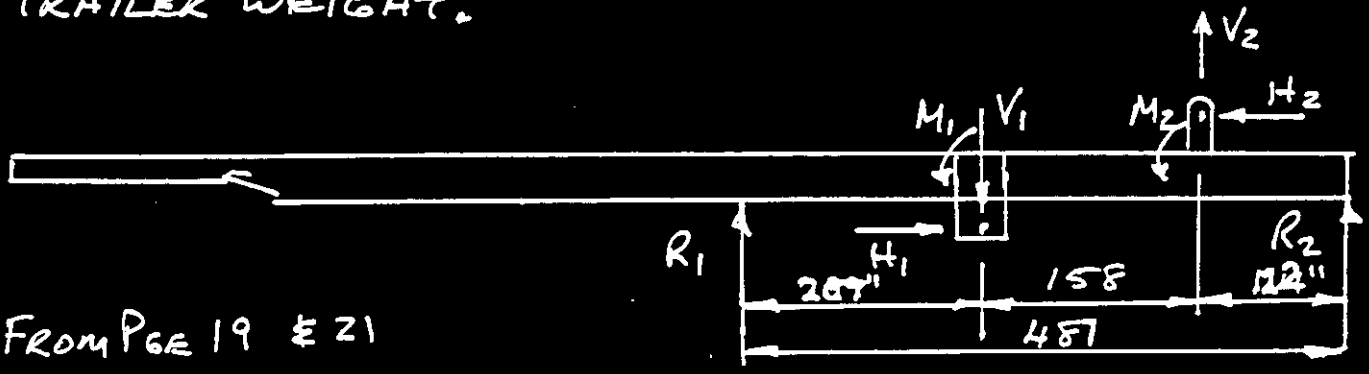
MAIN BEAM STRESSES DUE TO LIFTING LOADS.

TO DETERMINE THE BENDING MOMENTS IN THE MAIN BEAM WHEN THE CONTAINER IS BEING ERECTED, THREE SEPARATE LOAD CASES MUST BE SUMMED. THE WORST CASE CONDITION OCCURS JUST AS THE CYLINDER JACK LIFTS THE CYLINDER & STRONGBACK OFF SUPPORTS B AND C. THE MAXIMUM BENDING OCCURS JUST FORWARD OF THE CYLINDER PIVOT. IT IS THE SUM OF THE REACTIONS AT THE FORWARD JACK, MULTIPLIED BY THE LENGTH OF BEAM MINUS THE BENDING PRODUCED BY THE TRAILER WEIGHT.



FROM PGE 19 & 21

H_1 = 155,931 LB V_1 = 140,401 LB

H_2 = 155,931 LB V_2 = 31,801 LB ACTING UP

MOMENT DUE TO $H_1 = M_1 = 7.4 \times 10^6$ IN LB

MOMENT DUE TO $H_2 = M_2 = 6.23 \times 10^6$ IN LB.

REACTIONS AT R_1 & R_2 DUE TO $M_1 \pm M_2 = \frac{M_1 + M_2}{487}$

= 28,000 LB UP AT R_1 & DOWN AT R_2.

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FOR REACTION AT R_1 DUE TO V_1 & V_2 TAKE MOMENTS ABOUT R_2.

$$R_1 \text{ COMPONENT} = \frac{(140{,}401)(280) - (31{,}801)(122)}{487}$$

$$= 72{,}756 \text{ LB.}$$

$$R_2 \text{ COMPONENT} = V_1 - (R_1 + V_2) = 35{,}843 \text{ LB.}$$

REACTIONS AT R_1 & R_2 DUE TO TRAILER WEIGHT AND BENDING MOMENT DUE TO TRAILER WEIGHT AT THE CYLINDER PIVOT WERE CALCULATED WITH THE SPREADSHEET.

TRAILER WT. R_1 COMPONENT = 97,813 LB.
TRAILER WT. R_2 COMPONENT = 23,184 LB.

$$\Sigma R_1 = 97{,}813 + 72{,}756 + 28{,}000 = 198{,}569 \text{ LB.}$$

$$\Sigma R_2 = 23{,}184 + 35{,}843 - 28{,}000 = 31{,}027 \text{ LB.}$$

MOMENT AT CYL. PIVOT DUE TO TRAILER WTS. M_{TW}
$= 19{,}200{,}973$ IN LB.

BENDING MOMENT AT CYL PIVOT $= (\Sigma R_1)(207) - M_{TW}$
$= (198{,}569)(207) - 19{,}200{,}973$
$= 21{,}902{,}810$ IN LB.

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PLEASE NOTE THAT THE BEAM SECTION AT THE CYLINDER PIVOT IS STIFFENED BY THE PIVOT ASSEMBLY. THE CRITICAL POINT IS LOCATED JUST FORWARD OF THE PIVOT ASSEMBLY. TO ENSURE THE 3:1 FACTOR OF SAFETY, 12.5" × 0.5" × 108" STRIPS OF A36 STEEL WERE WELDED TO THE TOP AND BOTTOM FLANGES OF EACH BEAM.

THE COMPOSITE SECTION HAS A MOMENT OF INERTIA

$= I_{BEAM} + 2qr^2$ $\quad q$ = AREA OF PLATE, r = DISTANCE FROM CENTROID OF BEAM TO CENTROID OF PLATE.

$= 9170 + 2(12.5)(.5)(15.59)^2$

$= 12,208\ IN^4$

$c = 15.34 + 0.5 = 15.84\ IN.$

SECTION MODULUS, $S = I/c = 770\ IN^3$

TRAILER SECTION MODULUS $= 1,540\ IN^3$ [2 BEAMS]

BENDING MOMENT AT FRONT EDGE OF CYLINDER PIVOT ASSEMBLY $= \Sigma R_i (207-18) - M_{TW}$

$= (198;569)(191) - 18,500,000$

$= 19,426,679\ IN\,LB.$

BENDING STRESS $= \frac{19,426,679}{1,540} = 12,614\ psi$

ALLOWABLE $= \frac{44,300}{3} = 14,766\ psi$ MARGIN $= \frac{14,766}{12,614} - 1 = 0.17$

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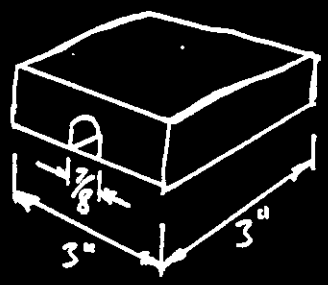
THE BENDING MOMENTS ELSEWHERE ON THE MAIN BEAMS SHOWED AMPLE MARGINS DURING THE JACKING AND CYLINDERS ERECTION OPERATIONS.

TIE-DOWN STRESSES:

D-RING MOUNTING BLOCK, SKETCHED, IS WELDED TO TRAILER.



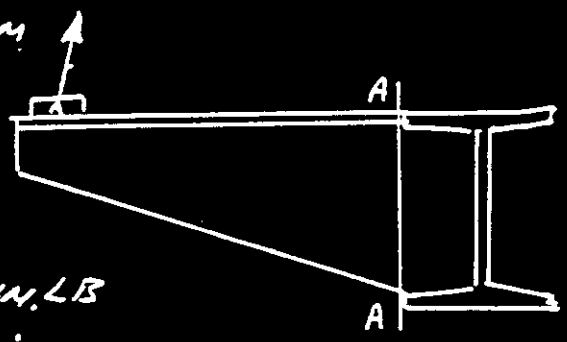
LENGTH OF WELD = 12 − 1 3/4
= 10.25 INCHES

LOAD = 33,000 # LOAD/INCH = 3,220.
X 3:1 SF = 9,660 LB/IN.

ALLOWABLE STRESS = 13,600 psi.

EFFECTIVE THROAT = $\frac{9,660}{13,600}$ = 0.71 INCHES MINIMUM.

TIE-DOWN LOAD CARRIED ON T-BEAM CANTILEVERED FROM TRAILER FRAME



SECTION A-A I = 1841.6 IN.⁴

C = 18.4 S = 100 IN.³

BENDING MOMENT = 1,185 000 IN.LB

BENDING STRESS = 11,850 psi

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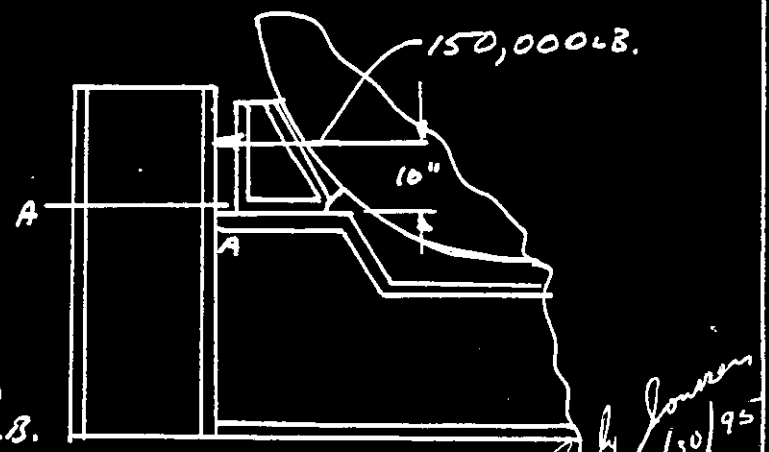
FRONT SUPPORT:

THE FRONT SUPPORT MUST RESTRAIN THE CYLINDER DURING TRANSIT AND A 150,000 LB SIDE LOAD IS POSSIBLE.



SECTION A-A

$I = 829\ IN^4$

$C = 7.5\ IN$

$S = 110\ IN^3$

BENDING MOMENT = 1,500,000 INLB.

Randy Jones 6/30/95

TRAILER.

BENDING STRESS = 13,636 psi.

ALLOWABLE WITH 3:1 S.F = (14,766) → CERTIFIED MILL REPORT (p. E-44) - $F_{Y\ MINIMUM}$ = 44,300 psi ÷ 3 = 14,766

MARGIN = $\frac{14,766}{13,636} - 1 = 0.082.$

RUNNING GEAR MOUNTING:

THE CRITICAL AREA IN THIS CONNECTION IS THE WELD BETWEEN THE MOUNTING BLOCKS ON THE AXLE ASSEMBLY AND THE TRAILER. THE WELD HERE SEES A COMPLEX LOAD CONDITION CAUSED BY A 60,000 LB VERTICAL LOAD, A 45000 LB ~~LITERAL~~ LONGITUDINAL LOAD AND 180,000 IN LB OF BENDING.

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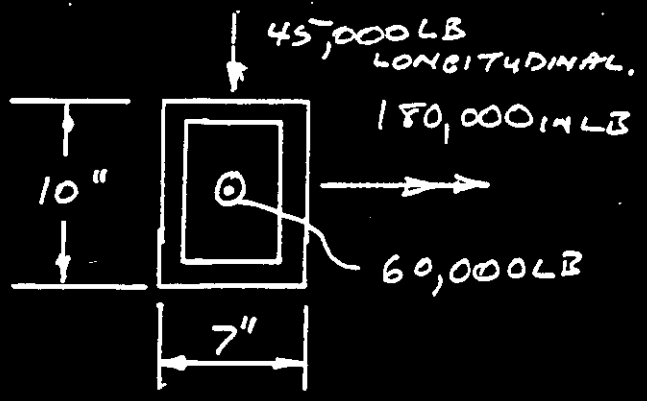
$$S_W = \frac{d^2}{3} = \frac{10^2}{3} = 33.3 \text{ IN}^2$$

$$A_W = 2(10) = 20 \text{ IN.}$$



$$f_{LONG} = \frac{45K}{20} = 2,250 \text{ LB/IN}$$

$$f_{BEND.} = \frac{M}{S_W} = \frac{180K}{33.3} = 5,400 \text{ LB/IN.}$$

$$f_{VERT} = \frac{60K}{20} = 3,000 \text{ LB/IN}$$

$$f_{RESULTANT} = \sqrt{f_{LONG}^2 + f_{BEND}^2 + f_{VERT}^2} = 6,600 \text{ LB/IN.}$$

MINIMUM THROAT REQD = $\frac{\text{ACTUAL}}{\text{ALLOWABLE}}$

$$= \frac{6,600}{14,850} = \underline{0.444 \text{ IN.}}$$

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REFERENCES

1. FORMULAS FOR STRESS AND STRAIN, 5TH EDITION, Roark and Young, McGraw-Hill 1975.

2. MSC/CASE Version 2.0, Computer Aided Solutions for Engineers, The MacNeal/Schwendler Company

3. MIL-HDBK-5F, METALLIC MATERIALS AND ELEMENTS FOR AEROSPACE VEHICLE STRUCTURES, 1 NOVEMBER, 1990.

4. HANDBOOK OF DESIGN STRESSES FOR ALUMINUM, Aluminum Company of America, 1966.

5. DESIGN OF WELDED STRUCTURES, Omer W. Blodgett, James F Lincoln Arc Welding Foundation.

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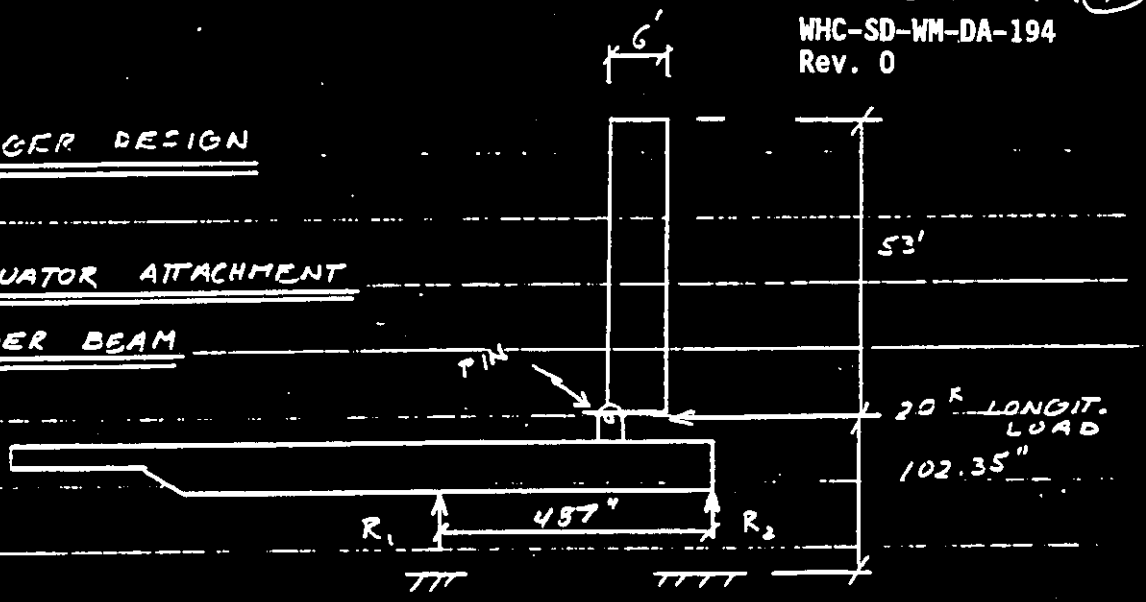
APPENDIX.

OUTRIGGER DESIGN

SUPPORT ACTUATOR ATTACHMENT TO OUTRIGGER BEAM



REAR OUTRIGGER LOAD

$R_1 = 93^K$ (G. BARR CALCS - DL + LL + LATERAL WIND)

ADD LONGITUDINAL LOAD = 10% OF VERT. LOAD

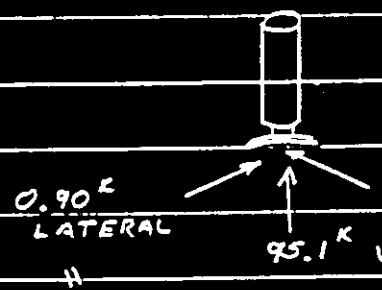
0.10×200^K CAPACITY = 20^K @ PIN

$\Sigma M_{R_2} = -20^K (103.35") + R_1 (48.7) \therefore R_1 = \frac{4.20^K}{2} = 2.10^K$

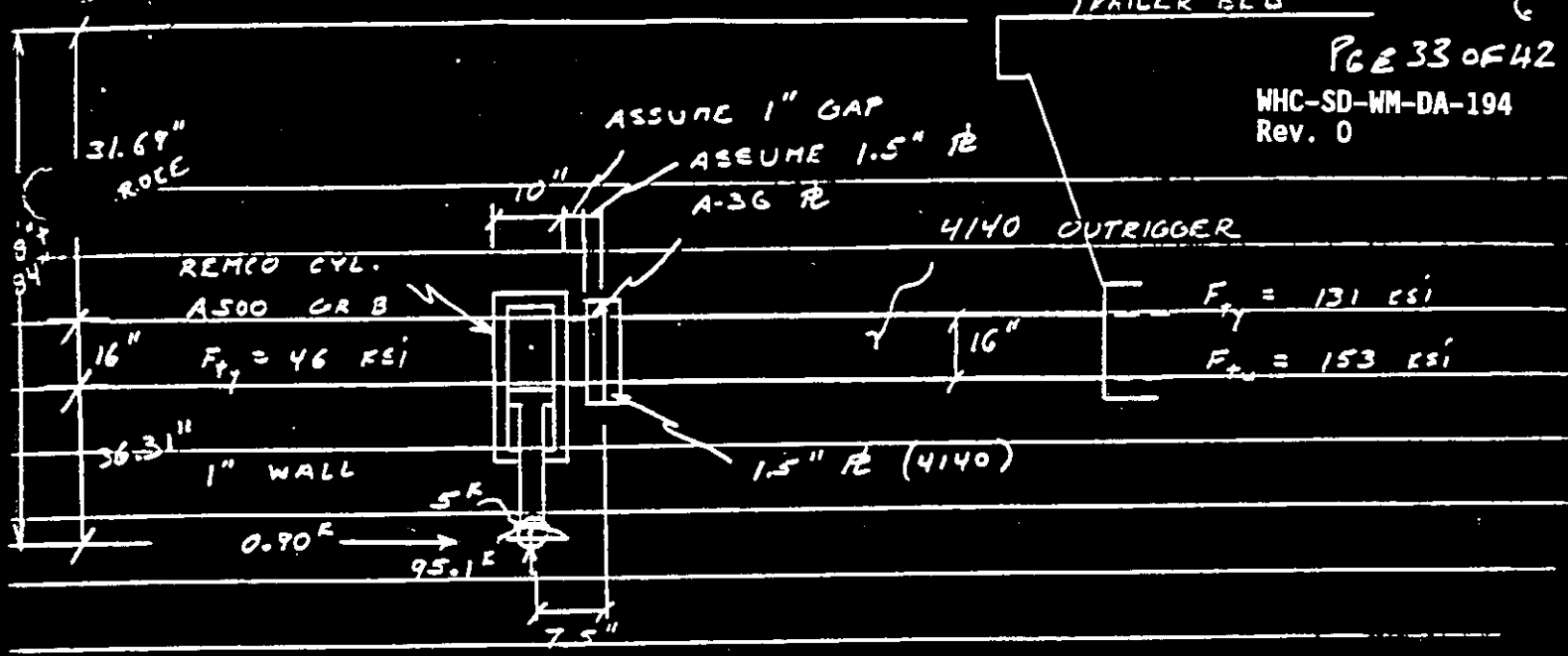
R_1 TOTAL = 93 + 2.10 = 95.1^K

ACTUATOR SHEAR = $\frac{20}{4} = 5^K$

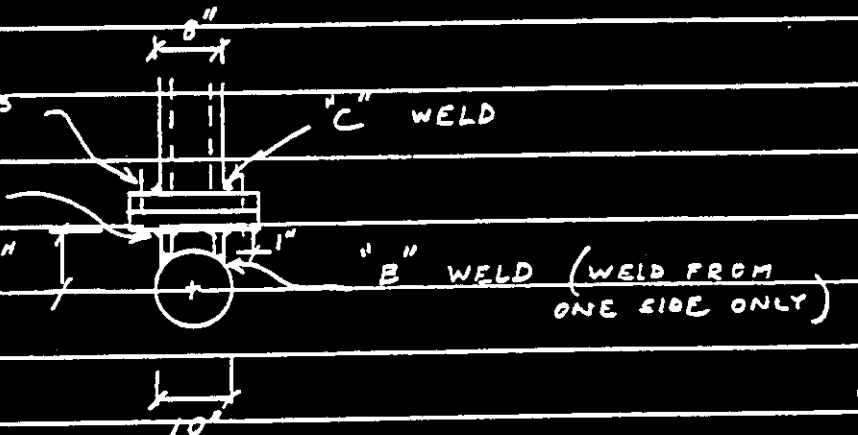
R_1 MAX



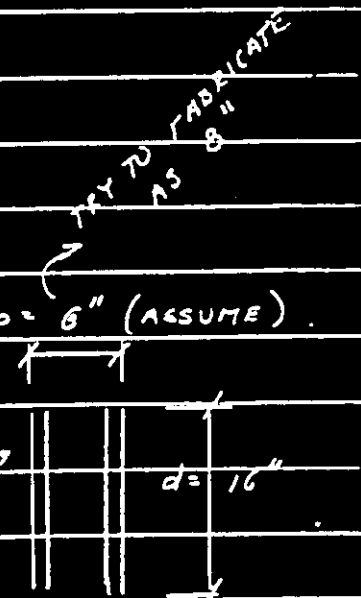
LAT. WIND = $\frac{1.8 + 1.68}{4 \text{ SUPPORTS}} = 0.87 \sim 0.90^K$ (G. BARR CALCS)



PROBLEM - PROVIDE BOLTED CONNECTION - CYLINDER TO OUTRIGGER
(CANNOT WELD - DISSIMILAR MATL'S)



TRY TO FABRICATE AS



"A" WELDS - FILLETS ON BOTH SIDES - EACH Ø

VERT. LOAD = 95.1K

$$J_w = \frac{d\left(3b^2 + d^2\right)}{6}$$

CONSIDER OUTER WELDS ONLY

$$= \frac{16\left(3(6^2) + 16^2\right)}{6} = 970.7 \text{ in}^3$$

BLODGET

$$S_w = (2)\frac{d^2}{3} = (2)\frac{16^2}{3} = 170.7$$

$$A_w = 4(16) = 64$$

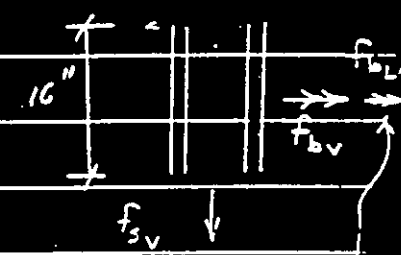
"A" WELDS -

$V = 95.1^k$

VERT = 95.1^k $\qquad M = 6''(95.1^k) = 571$ in-k

✓ $f_{b_V} = \frac{M}{S_w} = \frac{571}{170.7} = 3.35$ k/in

✓ $f_{s_V} = \frac{V}{A_w} = \frac{95.1}{64} = 1.49$ k/in



LATERAL = 0.90^k

✓ $f_{b_{LAT}}$: $M_w = 0.90^k\left(36.31'' + \frac{16''}{2}\right) = 39.9$ in-k

✓ $f_{b_{LAT}} = \frac{M_w}{S_w} = \frac{39.9}{170.7} = 0.23$ k/in

✓ $f_{s_{LAT}} = \frac{V_{LAT}}{A_w} = \frac{0.90}{64} =$ IGNORE

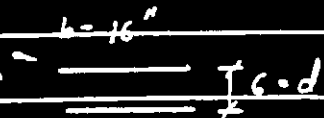
LONGITUDINAL = 5^k

$f_{T_{LON.}}$: TORSION = $5^k\left(36.31 + \frac{16}{2}\right) = 221.6$ in-k

✓ $f_{T_{LON}} = \frac{TOR}{S_w} = \frac{221.6}{970.7} = 0.23$ k/in

✓ $f_{V_{LONG}} = \frac{5^k}{64} = 0.08$ k/in

✓ $f_{b_{LON}} = \frac{M_w}{S_w} = 5^k(6'') = \frac{30}{96} = 0.31$ k/in



$S_w = bd = 6(16)$
$= 96$

$$f = \sqrt{(3.35 + 0.23 + .31)^2 + (0.23 + .08)^2 + 1.49^2} = 4.18 \text{ k/in}$$

$$\omega = \frac{4.18}{7.20} = 0.58'' = \frac{5}{8}'' \text{ FILLET}$$

↳ LEG

"B" WELD

$V = 95.1$

VERT. = 95.1

$M = 4.5''(95.1) = 428$ in-k

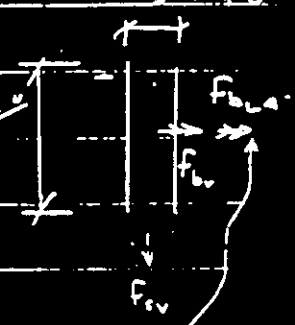
ESTIMATED

$b = \cancel{7}\ 6$

$f_{b_v} = \frac{428}{\cancel{85.33}\ 108} = \cancel{5.02}\ 3.96$

$f_{s_v} = \frac{95.1}{\cancel{32}\ 36} = \cancel{2.97}\ 2.64$

$d = \cancel{16''}\ 18$



$J_w = \frac{d(3b^2 + d^2)}{6} = \frac{16(3(\cancel{7}\ 6)^2 + \cancel{16}\ 18^2)}{6} = \cancel{1074.7}\ 1152.0$

$S_w = \frac{d^2}{3} = \frac{\cancel{16}\ 18^2}{3} = \cancel{85.33}\ 108.0$

$A_w = 2(\cancel{16}\ 18) = \cancel{32}''\ 36$

LATERAL

$f_{b_{LAT}}$: $M_w = 0.90^k(44.31'') = 39.9$ in.k

$f_{b_{LAT}} = \frac{39.9}{\cancel{85.33}\ 108} = \cancel{0.47}\ .37''$

$f_{s_{LAT}} = \frac{0.90}{\cancel{32}\ 36} = 0.03$

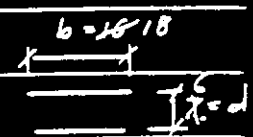
LONGITUDINAL = 5^k

$f_{T_{LON.}}$: TORSION = $5^k(44.31'') = 221.6$ in-k

$f_{T_{LON}} = \frac{TOR}{J_w} = \frac{221.6}{\cancel{1074.7}\ 1152} = \cancel{0.21}\ .19$

$f_{v_{LONG.}} = \frac{5}{\cancel{32}\ 36} = \cancel{0.16}\ .14$

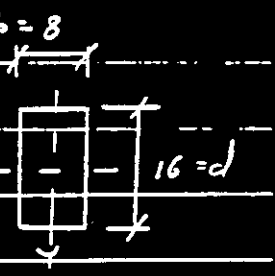
$f_{b_{LON}} = \frac{M_w}{S_w} = \frac{5^k(4.5'')}{\cancel{112}\ 108} = \cancel{0.20}\ .21$



$S_w = bd = \cancel{18}\ 18(\cancel{7}\ 6) = \cancel{112}\ 108$

$f = \sqrt{(\cancel{5.02}\ 3.96 + \cancel{.47}\ .37 + .03 + \cancel{.20}\ .21)^2 + \cancel{2.97}\ 2.64^2 + (\cancel{.21}\ .19 + \cancel{.16}\ .14)^2} = \cancel{6.46}\ 5.29\ ^k/in$

$w = \frac{\cancel{6.46}\ 5.29}{7.20} = \cancel{0.90}\ .73'' = \frac{3}{4}''$ EFFEC. THROAT



"C" WELD

$S_{wx} = bd + \frac{d^2}{3} = 8(16) + \frac{16^2}{3} = 213.3$

$S_{wy} = 16(8) + \frac{8^2}{3} = 149.3$

$A_w = 48$

$J_w = \frac{(b+d)^3}{6} = \frac{(8+16)^3}{6} = 2304$

VERT. = 95.1^K — $V = 95.1$, $M = 9"(95.1) = 856$ in-K

$f_{bv} = \frac{856}{213.3} = 4.01$

$f_{sv} = \frac{95.1}{48} = 1.98$

LATERAL = 0.90^K = previous PJ.

$f_{b_{LAT}} = \frac{39.9 \text{ in-k}}{213.3} = 0.19$

$f_{s_{LAT}} = \frac{0.90}{48} = .02$ - IGNORE

LONGITUDINAL = 5^k

$f_{T_{LON}} = \frac{TOR}{J_w} = \frac{5^k(44.31")}{2304} = \frac{221.6 \text{ in-k}}{2304} = 0.10$

$f_{v_{LON}} = \frac{5}{48} = .10$

$f_{b_{LON}} = \frac{M_w}{S_{wy}} = \frac{5^k(9")}{149.3} = \frac{45}{149.3} = 0.30$

$f = \sqrt{(4.01 + 0.19 + 0.30)^2 + 1.98^2 + (.10 + .10)^2} = 4.92$ K/in

$w = \frac{4.92}{1.2} = 0.68$ — 3/4" FILLET

BOLTS

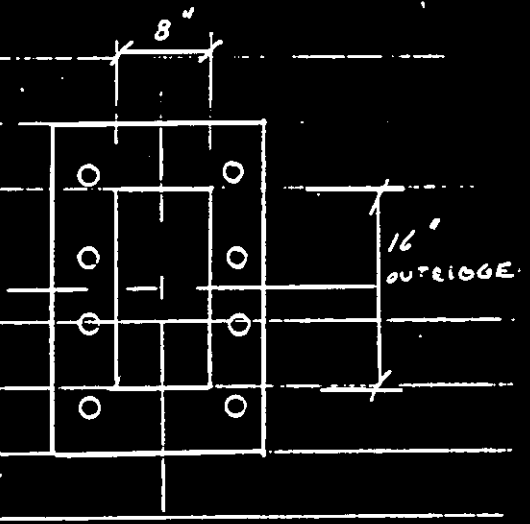
REF: SALMON + JOHNSON - 2ND ED - "STEEL STRUCTURES" P. 164

CONSIDER VERT. LOADS FOR DESIGN - LATERAL + LONGIT. LOADS ARE SECONDARY

$V = 95.1^{K}$

$M = 7.5'\left(95.1\right) = 713.25\ in\text{-}K$

BEARING CONNECTION



TRY 1" BOLTS

- A325 - THDS. EXCLUDED - STD. HOLE
- 6" PITCH

SHEAR ONLY - $R_{ss} = F_v \times AREA = \frac{30^{K}}{2}\left(.7854\right) = 11.78^{K}/BOLT$

WHC SF

TENS. ONLY - $R_t = F_t \times AREA = \frac{44^{KSI}}{2}\left(.7854\right) = 17.28^{K}/BOLT$

EST. NO. BOLTS = $n = \sqrt{\frac{6M}{R_t p}}$

M = MOM. PER LINE OF BOLTS

R = LOAD IN TENS./BOLT

p = PITCH

$n = \sqrt{\frac{6\left(\frac{713.25}{2}\right)}{17.28\left(6\right)}} = 4.54$ BOLTS FOR M

$n = \frac{95.1/2}{11.78} = 4.04$ BOLTS FOR SHEAR

$n = \sqrt{n^2_{BEND.} + n^2_{SHEAR}} = \sqrt{4.54^2 + 4.04^2} = 6.1$ PER LINE

∴ TOO MANY

TRY $1\frac{1}{4}$" BOLTS - 7" PITCH

SHEAR ONLY - $R_{ss} = \frac{30}{2}\left(1.227\ in^2\right) = 18.41$

TENS. ONLY - $R_T = \frac{44}{2}\left(1.227\right) = 27.0$

BOLT NO. EST.

$$n = \sqrt{\frac{6\left(\frac{713.25}{2}\right)}{27.0\ (7)}} = 3.36 \text{ BOLTS - M}$$

$$n = \frac{\frac{95.1}{2}}{18.41} = 2.58 \text{ BOLTS}$$

$$n = \sqrt{3.36^2 + 2.58^2} = 4.2 \text{ BOLTS} - \text{TRY } 4/\text{LINE}$$

$$\Sigma A_y^2 = 4\left(1.227\ in^2\right)\left(10.5^2 + 3.5^2\right) = 601.23\ in^4$$

$$f_t = \frac{My}{\Sigma A_y^2} = \frac{713.25\ (10.5)}{601.23} = 12.46\ ksi < F_t = \frac{44\ ksi}{2} = 22\ ksi \quad O.K.$$

$$f_v = \frac{V}{\Sigma A} = \frac{95.1}{8\left(1.227\right)} = 9.69\ ksi < \frac{30}{2}\ ksi \quad O.K$$

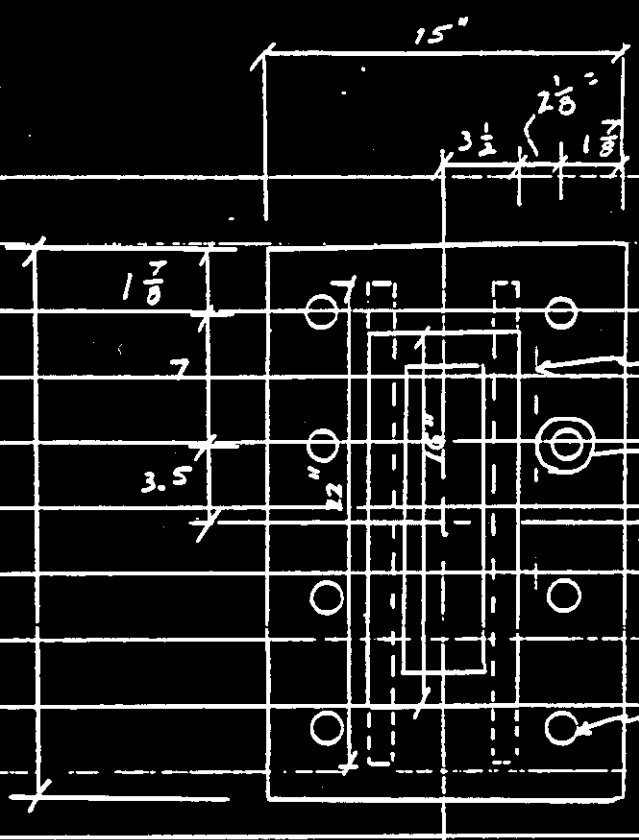
INTERACTION - TENS./SHEAR

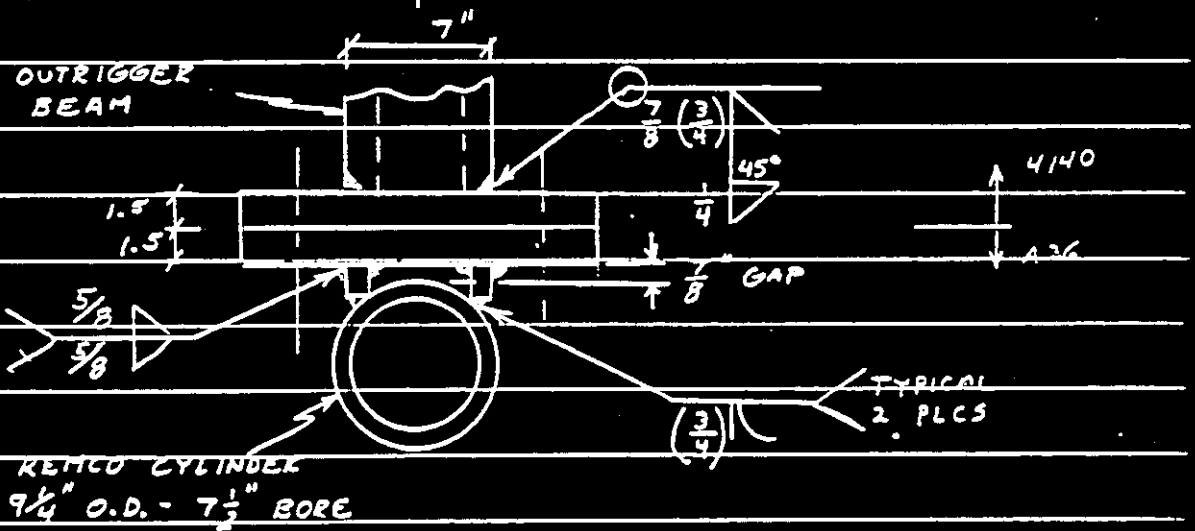
$$F_T = \sqrt{\left(\frac{22^2}{44^2}\right) - 2.15\, f_v^2} = \sqrt{\frac{22^2}{44^2} - 2.15\left(9.69\right)^2} = 16.8\ ksi > f_t = 12.46$$

WHC ALLOWABLES = $\frac{F_t}{2}$ ~~- use 22~~ - OK.

USE 8 - $1\frac{1}{4}$" ϕ A325 BOLTS - 4/ROW

7" PITCH THDS. EXCLUDED



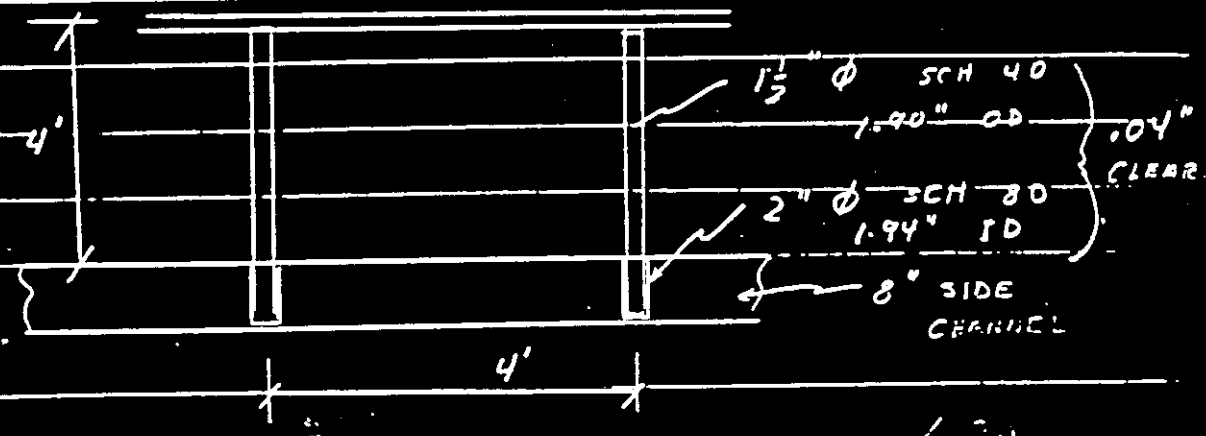


1 1/4" BOLT - STD. HOLE ← 1.5 x bolt dia. - ALONG LINE OF TRANSMITTED FORCE → 1 5/8" AT GAS CUT EDGE

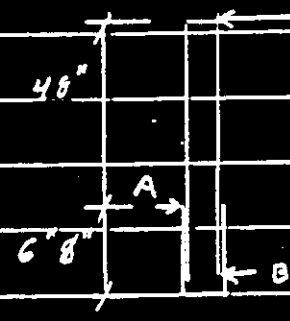
EDGE DISTANCE = 1 7/8" (AISCS TABLE J3.5)

WRENCH CLEARANCE: SOCKET - 1 11/16" = 1/3 DIA. - O.F.

HAND-RAILS



LOAD - 200# PT. LOAD @ TOP OF RAIL



$\Sigma M_A = -200(48) + R_B(6")$

$R_B = 1600$ lb.

$R_A = 1800$ lb.

$M_{max} = 200(48") = 9600$ in-lbs

$S = .326$

$f_b = \frac{9600}{.326} = 29,448$ psi

PIPE MAT'L - A53 Grade B

$F_y = 35$ KSI

REQ'D S.F. = 1:1 YIELD (TOM MACKEY) ∴ O.K.

WELD -

$S_w = \frac{d^2}{3} = \frac{6^2}{3} = 12$

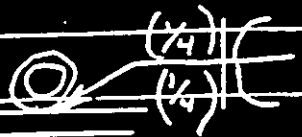
$A_w = 12$

$M = 200(57") = 10,400$ in-lb

$f_b = \frac{10,400}{12} = .87$ KSI

$f_v = \frac{200}{12} = .02$ KSI

$w = \frac{.89}{7.2} = .12$



Trailer Weights & Moments, Load Case 1, 540".
9/04/94

Item #	Description	LBPFT	Length	CGdist	Weight	Moment	BM	CBM
1	Landing Gear	800.00	1.00	152.0	800	121600	310400	
2	Cross Beam #1	191.00	11.00	152.0	2101	319352	815188	
3	Hyd. Power Syste	6000.00	1.00	152.0	6000	912000	2328000	
4	Hydraulic Fluid	2700.00	1.00	206.0	2700	556200	901800	
5	Front Support	2000.00	1.00	258.0	2000	516000	564000	
6	Cross Beam #2	191.00	11.00	258.0	2101	542058	592482	
7	Support C	45000.00	1.00	258.0	45000	11610000	12690000	
8	Cross Beam #3	99.00	11.00	290.0	1089	315810	272250	
9	Cross Beam #4	99.00	11.00	357.0	1089	388773	199287	
10	Cross Beam #5	99.00	11.00	416.0	1089	453024	135036	
11	Cross Beam #6	99.00	11.00	479.0	1089	521631	66429	
12	Deck & Support	72.50	85.00	492.0	6163	3031950	0	
13	Main Beam	191.00	85.00	492.0	16235	7987620	0	
14	Main Beam	191.00	85.00	492.0	16235	7987620	0	
15	Side Channel (L)	11.50	83.00	507.0	955	483932	0	
16	Side Channel (R)	11.50	83.00	507.0	955	483932	0	
17	Cross Beam #7	191.00	11.00	513.0	2101	1077813	56727	
18	Forward Jack Ass	7300.00	1.00	513.0	7300	3744900	197100	
19	Support B	110000.00	1.00	533.0	110000	58630000	770000	
20	Cross Beam #8	99.00	11.00	542.0	1089	590238	0	
21	Cross Beam #9	191.00	1.67	612.0	319	195210	0	
22	Cylinder	4000.00	1.00	672.0	4000	2688000	0	
23	Cylinder Pivot	6250.00	1.00	712.0	6250	4450000	0	
24	Cross Beam #10	191.00	1.67	849.0	319	270806	0	
25	Cross Beam #11	191.00	11.00	880.0	2101	1848880	0	
26	Rear Pivot Assy	4200.00	1.00	880.0	4200	3696000	0	
27	Support A	45000.00	1.00	880.0	45000	39600000	0	
28	Cross Beam #12	191.00	1.67	925.0	319	295047	0	
29	Cross Beam #13	191.00	11.00	994.0	2101	2088394	0	
30	Rear Jack Assy.	7300.00	1.00	994.0	7300	7256200	0	
					297998	162662988	19898699	

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NUCOR-YAMATO STEEL CO.

P.O. BOX 1228
BLYTHEVILLE, AR 72316

CERTIFIED MILL REPORT

QUALITY STEEL — MADE IN THE USA

** ALL STEEL PRODUCED BY NUCOR-YAMATO STEEL COMPANY WAS MELTED AND MANUFACTURED IN THE UNITED STATES OF AMERICA.

MAIN LONGITUDINAL BM. - WIDE FLANGE

• F_y MINIMUM = 44,300 PSI

GRADES: ASTM A36-91 ASME SA-36
GRADES: ASTM A709-91A GR36

3/94	CUSTOMER NO. 1101	INVOICE NO. 130814	BILL OF LADING 138810									
		MECHANICAL PROPERTIES			CHEMICAL PROPERTIES							
	HEAT NUMBER	YIELD PT psi	TENS psi	%	C	Mn	P	S	Si	Cu		
2 -040.0	43756	45500	62800	27	.07	.49	.020	.04	.16	.30		
		48600	64400	28								
-094.0	40770	47500	63300	30	.05	.73	.014	.02	.21	.24		
		45300	63600	31								
4.0	44145	53900	64600	26	.06	.54	.022	.02	.13	.30		
		55200	66000	26								
30 -099.0	44072	50000	62300	30	.07	.56	.017	.02	.10	.30		
		50700	63700	30								
30 -191.0	41609	46600	63400	31	.08	.63	.018	.02	.21	.32		
		47600	63700	30								
30 -191.0	44046	44300	61400	32	.07	.60	.014	.02	.12	.32		
		44800	62100	33								
036 -150.0	43982	51100	64100	30	.09	.65	.019	.01	.11	.30		
		51900	66700	29								

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ELONGATION BASED ON 8.00 INCH GAGE LENGTH

I HEREBY certify, that the contents of this report are accurate and correct. All test results and operations performed by this material manufacturer are in compliance with the requirements of the material specification, and when designated by the purchaser, meet the applicable specification.

STATE OF ARKANSAS
COUNTY OF MISSISSIPPI
SWORN TO AND SUBSCRIBED BEFORE ME THIS

GARY OXFORD
PLANT METALLURGIST - QUALITY ASS

II. WHC REVIEW WITH COMMENTS

Comments - 101-SY Hydraulic Trailer Analysis

Graham Barr Calculations

General Comment

This structure has extensive weldments and the workers at KAMP probably spent 6-8 weeks doing nothing but welding. However, the analysis addresses only 3 welds. There should be weld calculations on every piece of hardware. Although many of the welds are full penetration or at least very large, the lack of weld analysis concerns me. Also, there is a general lack of analysis for all stiffeners/gusset plates.

Specific Comments

The following are specific items that need to be provided:

1. pg 18 - what is clearance between sliding outrigger beams and support? If substantial twist can occur due to trailer longitudinal loads, the shear stresses can increase dramatically (i.e., because the outrigger is only 7" wide, small eccentricities in load application point can result in high stresses). Also the lateral support bracket at outer edge of trailer.

2. pg 21 - detailed analysis of aft pivot support beam is required - no analysis has been performed (area under strong-back base clevis).

3. pg 23 - detailed analysis of the actuator pin attachment lug to the strongback (including welds) is required - no analysis has been performed and lugs are not shown on drawings.

4. Calculations for main trailer beam splice, splice plates, and welds. Also, the CMTR's and coupon test results are not available for main beams (not shown on dwgs.)

5. Provide calculations for web crimpling on outrigger beams and web crimpling on main trailer beams.

6. pg 17 - stress risers on outrigger beams (due to deep-beam considerations) do not meet 3 to 1 SF. Justify acceptance of outrigger/trailer interface beam (what is 13,233 psi, 39,701 psi, and 44,300 psi).

7. pg 21 - include material type to justify analysis on aft pivot support. There is high shear stress on pin - what material is pin? (SF 3 to 1?)

8. pg 28 - what is basis for allowable bending stress of 14,766 psi on front support beam? Provide calculations for the attachment of container support to trailer frame. Also, SF of 3 to 1 is not required for transport loads.

9. pg 20 - analysis for actuator pin mounting block is inadequate for the complex structure involved; suggest adding Coverdell's FEM analysis of the block as an appendix to Barr's calculations (this may require some additional work on Coverdell's part).

10. Provide calculations for the stainless steel deck and deck welding to the trailer frame.

11. Additional items that must be addressed as no analysis has been performed:

    - landing gear
    - wheel attachment brackets that form interface between rear wheel assemblies and bottom of trailer
    - "snubber" that prevents container from traveling beyond vertical (not shown on dwg.)
    - center adjustable support located at front of strongback. (not shown on dwg.)
    - king pin bracketry
    - brackets that attach actuator pin mounting block (see pg 20 of Barr's calculations) to trailer - "bucket area".
    - outrigger attachment at aft end of trailer
    - change TBD in "CONCLUSION" section of report to actual values.

III. FINAL SUBMITAL OF CALCULATIONS FROM KAMP INC.

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 1 of
		ORIG BY: G.S.S.B.	DATE: 11/12/94.
		CHK'D BY: KB.	DATE:
SUBJECT: KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM: HANFORD SY-1-1 MITIGATION/SAFETY.	

RESPONSES TO COMMENTS ON ANALYSIS:

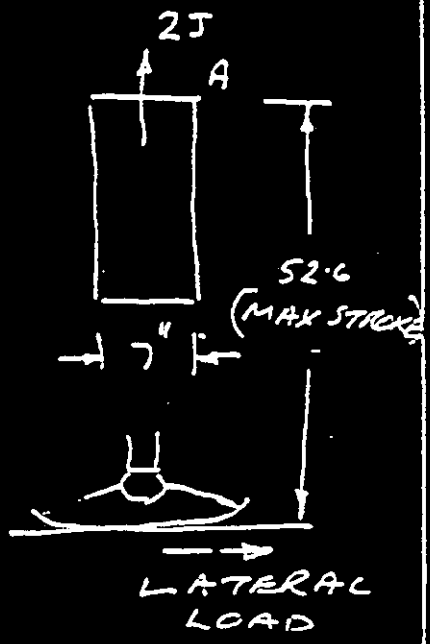
1) OUTRIGGER BEAM CLEARANCE:

FROM THE DRAWING DIMENSIONS THE CLEARANCE BETWEEN THE BEAM AND THE OUTBOARD BEAM SUPPORT IS NOMINALLY 0.10". THEORETICALLY THIS WOULD ALLOW A ROTATION IN THE ORDER OF 0.2°. IN OPERATION, THE BEAM IS LOADED AGAINST THE OUTBOARD SUPPORT WITH A FORCE TWICE THE JACK LOAD.

TAKING MOMENTS ABOUT A
THE LATERAL LOAD REQUIRED
TO CAUSE THE BEAM TO ROTATE

$$= \frac{2J(3.5)}{52.6}$$

$$= 0.13 \text{ JACK LOAD.}$$



2) AFT PIVOT SUPPORT BEAM:

THIS COMPONENT WAS EXAMINED IN DETAIL WITH RANDY JORENSON. THE BENDING & TORSION CALCULATIONS AND THE WELD CALCULATION WERE DEEMED SIGNIFICANT FOR THE REPORT.

THE AFT PIVOT CLEVISES HAVE 2" THICK BASE PLATES. THESE MOUNT DIRECTLY TO ANOTHER 2" THICK PLATE. THIS, IN TURN, SITS ON A GRID OF 2" THICK PLATES SET ON EDGE. THE WORST CASE LOAD WOULD OCCUR WITH THE PAYLOAD CONTAINER VERTICAL. THE LOAD PER CLEVIS WOULD BE 54,300 LB. ASSUMING THIS IS TRANSFERRED TO THE BASE UNIFORMLY DISTRIBUTED ACROSS THE WIDTH, THE WORST CASE BENDING MOMENT IN THE BASE IS 8,000 IN LB. [USING CASE ON P.C.]

$$I/c = \frac{15.25(4)^2}{6} = 40.7 \text{ in}^3$$

BENDING STRESS = 196 psi.

3. UPPER CLEVIS LOADS.

CYLINDER LOAD = 209,826 lb (AT LIFT-OFF)

HORIZONTAL COMPONENT = 155,931 lb.
VERTICAL COMPONENT = 140,401 lb.

PIN BEARING AREA = (2.875)(3.25) (IN CYLINDER)
= 9.340 □"

PIN SHEAR AREA = $2\left[\pi \frac{(3.25)^2}{4}\right]$ (DOUBLE SHEAR)

= 16.6 □"

BEARING STRESS = $\frac{209,826}{9.34}$

= 22,456 psi

SHEAR STRESS = $\frac{209,826}{16.6}$

= 12,646 psi

PIN MATERIAL IS 8620 STEEL HEAT TREATED TO 94,761 psi ULTIMATE AND 67,154 psi YIELD TENSILE STRENGTH PER TEST DATA
THE PIN STRESSES ARE SATISFACTORY, WITH A 3:1 FACTOR THEY BECOME 67,386 FOR BEARING & 37,938 psi FOR SHEAR.—
NOTE: THE TEST SAMPLE WAS TAKEN FROM THE CENTER OF A 4.0" DIAMETER ROUND. SAFETY FACTOR = $\frac{67,154}{2 \times 12646} = 2.655$

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3.0 UPPER CLEVIS LOADS (CONTD.)

THE BEARING AREA IN THE CLEVIS

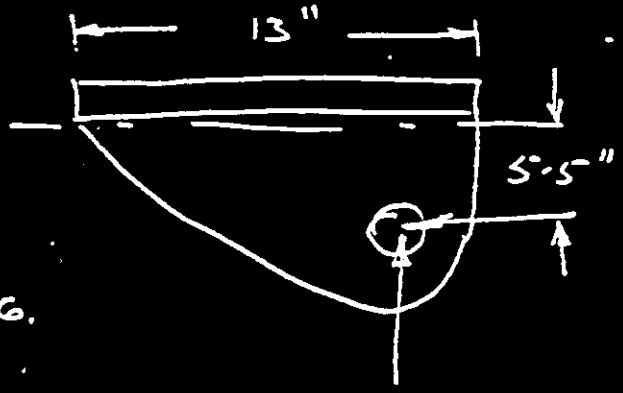
$= 2 \times 2 \times 3.25$

$= 13 \square''$

BEARING STRESS $= \frac{209,826}{13} = 16,140$ psi

$\times 3$ (SAFETY FACTOR) $= 48,421$ psi

THIS SHOULD BE ACCEPTABLE WITH A-36 STEEL PLATE.



WELD SIZING:

TWO WELDS 13" LONG ARE CONSIDERED LOAD BEARING.

SHEAR LOAD / INCH $= \frac{156\,000}{26}$

$= 6,000$ LB/IN.

BENDING MOMENT $= 156,000 \times 5.5$

$= 858,000$ IN. LB.

$S = \frac{13^2}{3} = 56.33$

BENDING ~~STRESS~~ LOAD $= \frac{858\,000}{56.33} = 15,230$ LB/IN.

3. UPPER CLEVIS LOADS (CONT'D)

$$\text{COMBINED LOAD} = \sqrt{6{,}000^2 + 15{,}230^2}$$

$$= 16{,}369 \text{ lb/in.}$$

$$\text{REQUIRED } \omega = \frac{16\,369}{7{,}200} = \underline{2.25''}$$

THE CLEVIS FINITE ELEMENT ANALYSIS DATA PROVIDED BY WESTINGHOUSE/HANFORD WAS REVIEWED. THE STRESS CONCENTRATION INDICATED WAS ON THE COMPRESSION SIDE AND SEEMS TO BE MAGNIFIED BY THE MODEL USED IN THE ANALYSIS. THE STRONGBACK INTERFACE WAS NOT FULLY MODELLED. AND IN THE TRAILER WILL PROVIDE THE SUPPORT REQUIRED TO MINIMISE THE EFFECT OF THE COMPRESSIVE STRESS.

→ IN WHC-SD-WM-DA-194

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4. MAIN TRAILER BEAM SPLICE.

THE WORST CASE LOAD CONDITION FOR A BEAM SPLICE IS THE SPLICE LOCATED JUST FORWARD OF THE LOWER CYLINDER PIVOT ASSEMBLY. HERE THE SPLICE IS SUPPORTED BY $12\frac{1}{2} \times \frac{5}{8}$ PLATES WELDED ON THE FLANGES

PGE 26 OF THE REPORT GIVES THE EXTREME FIBER STRESS AT THIS LOCATION = 12,614 psi

THE EXTREME FIBER STRESS IN THE SPLICE WELD $= 12{,}614 \times \frac{30.68}{30.68 + 1.25}$

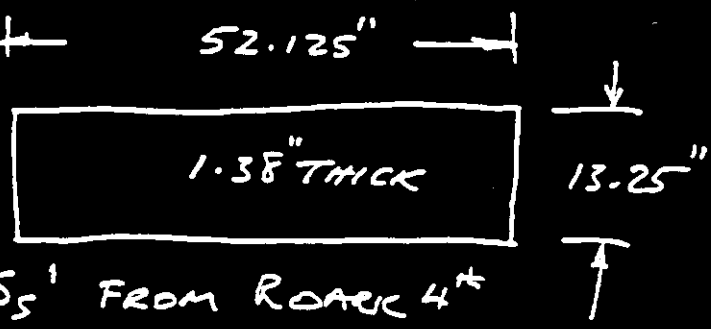
$= 12{,}120$ psi [ALLOWABLE = 13,000 psi]

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 7 of
		ORIG BY: G.S.S.B.	DATE: 11/12/94
		CHK'D BY: [illegible]	DATE:
SUBJECT: KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM: HANFORD SY-1-1 MITIGATION/SAFETY.	

5. WEB CRIPPLING

OUTRIGGER BEAMS.

BEAM WEB PER SKETCH, EDGES CLAMPED.



CRITICAL SHEAR STRESS, S_s' FROM ROARK 4th EDITION =

$$= K \frac{E}{1-\nu^2} \left(\frac{t}{b}\right)^2$$

$$= 7.38 \frac{29\,E6}{1-(.3)^2} \left(\frac{1.38}{13.25}\right)^2$$

$$= 2,555,169.9 \text{ psi.} \quad \text{— ADEQUATE.}$$

MAIN BEAMS.

CRITICAL SHEAR

$$= 7.38 \frac{29E6}{1-(.3)^2} \left(\frac{0.71}{26.75}\right)^2$$

$$= 165,684 \text{ psi.} \quad \text{ADEQUATE.}$$

6. OUTRIGGER BEAM SUPPORT BOX

THIS COMPONENT WAS ANALYSED AS A STAND-ALONE UNIT NEGLECTING THE ADDITIONAL STIFFENING OF THE WF 30X191 BEAM IT IS WELDED TO. THE COMPRESSIVE STRESS OF 13,233 psi MULTIPLIED BY THE SAFETY FACTOR OF 3 GIVES 39,701psi. THIS IS LESS THAN THE YIELD STRESS VALUES IN THE CERTIFICATIONS EVEN WITH THIS 3X WORST CASE ASSUMPTION.

7. AFT PIVOT SUPPORT

THE AFT PIVOT SUPPORT IS FABRICATED FROM A 36 STEEL WHILE THE PINS ARE 8620 ALLOY STEEL HEAT TREATED TO 129,000psi ULTIMATE & 99,000psi YIELD TENSILE STRENGTH. THE SHEAR STRENGTH SHOULD BE ROUGHLY 0.5 TIMES THE TENSILE STRENGTH.

. CALCULATED SHEAR STRESS [PGE. 21]

= 11,256 psi

x3 S.F. = 33,768 psi THIS IS LESS THAN $\frac{99,000}{2}$ WHICH IS IN THE SUPPLIERS LITERATURE. THE TEST DATA, OBTAINED FROM A 0.4"DIA SAMPLE MACHINED FROM A 4.0"DIA ROUND, DIFFERS FROM THIS. THE MEASURED ULTIMATE STRESS WAS 94,761 psi WHILE THE YIELD STRESS WAS 67,154psi.

ACTUAL S.F. = $\frac{67,154}{2 \times 11,256}$ = 2.983 — O.K.

8a) FRONT SUPPORT BEAM

THE ALLOWABLE STRESS OF 14,766 psi EQUALS $\frac{44,300}{3}$. 44,300 psi IS THE CERTIFIED YIELD STRENGTH FOR THE WF 30x191 BEAMS USED FOR THE FRONT SUPPORT.

THE CONNECTION TO THE TRAILER USES A 1" ~~RELIEF~~ FILLET WELD, 7,200 lb/in ALLOW.

WORST CASE LOAD = 150,000 lb SIDE LOAD.

REQUIRED WELD = $\frac{150,000}{7,200}$

= 21 INCHES.

ACTUAL WELD > 100 INCHES.

8 b) FRONT SUPPORT :— WEDGE FASTENING.

TWO WEDGE SHAPED PIECES ARE PROVIDED IN THE FRONT SUPPORT TO PERMIT THE ADJUSTMENT TO THE CONTAINER POSITION.

8b) FRONT SUPPORT:- WEDGE FASTENING. (CONTD)

AT PRESENT, THE DRAWING SHOWS 2 EA 1.00-8 A-325 bolts ~~ONE JACK SCREWS~~ BEHIND THE WEDGE AND 2 EA. BOLTS HOLDING IT IN PLACE AFTER POSITIONING. THIS WILL ~~NOT~~ BE ADEQUATE FOR A 150,000 lb LOAD. IF THE TIE-DOWN SYSTEM IS NOT CONSIDERED ADEQUATE TO RESTRAIN THE CONTAINER DURING THE LIMITED MOVEMENT AT FULL LOAD, THE WEDGES SHOULD BE WELDED IN PLACE. IN ADDITION, A SHIM SHOULD BE WELDED IN THE SPACE WHERE THE JACK SCREWS ARE TAKING THE LOAD.

→ 4, A-325, 1" ϕ bolts O.K.

Randy Lawson 2/10/95

9.) ACTUATOR LOWER PIVOT MOUNTING BLOCK

ANALYSIS CONTAINED IN WHC-SD-WM-DA-194

THIS UNIT WAS ANALYSED, USING A FINITE-ELEMENT COMPUTER PROGRAM, BY WESTINGHOUSE/HANFORD PERSONNEL. SOME COMPRESSIVE STRESS CONCENTRATIONS WERE NOTED BUT IT WAS NOT CLEAR IF THEY WERE NOT ARTIFACTS FROM THE MODELLING TECHNIQUE USED. THE SUPPORT PROVIDED BY THE HEAVY 2.5" PLATES ON EACH SIDE DID NOT APPEAR TO HAVE BEEN FULLY INCORPORATED IN THE MODEL.

IN MY OPINION, THE DESIGN OF THIS COMPONENT IS MORE THAN ADEQUATE.

VORTEX INDUCED OSCILLATIONS OF THE TRAILER ELEMENTS.

CONCERN ABOUT THE NEED TO OPERATE UNDER ADVERSE WEATHER CONDITIONS, IN PARTICULAR WINDS OF 15 KNOT STRENGTH, HAS CAUSED A GREAT DEAL OF ANALYSIS. THE PERIODIC EXCITING FORCES MAY BE DUE TO KARMAN VORTEX SHEDDING. THE EXCITING FREQUENCY OF THIS EXCITATION IS GIVEN BY THE FORMULA

$$\frac{n\,d}{V} = C$$

n = FREQUENCY IN CPS
d = DIAMETER OF CYLINDER
V = VELOCITY OF WIND
C = 0.207 FOR CYLINDER

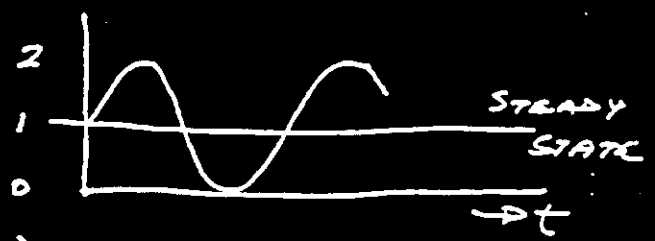
$$\therefore \text{FREQUENCY, } n = (.207)\frac{22}{5.5}$$

$$= 0.828 \text{ cps}$$ FOR 15 mph WIND AND 5.5' DIAMETER.

WHAT IS NOT AVAILABLE IN THE LITERATURE IS A MEASURE OF THE INTENSITY OF THE EXCITING FORCE. WE KNOW THAT A STEADY STATE WIND OF 15 MILES PER HOUR PRODUCES A WIND LOAD OF 0.56 lb/FT^2 ON THE PROJECTED AREA. FOR THE 53' CYLINDER THIS GIVES A STEADY STATE LOAD OF 164 lb.

VORTEX INDUCED OSCILLATIONS, (CONTD)

A REASONABLE ASSUMPTION OF THE DYNAMIC LOAD IN ABSOLUTE WORST CASE CONDITIONS IS AS SHOWN IN THE GRAPH. WITH THE EXCITATION AS SHOWN AT 15 mph, WE WOULD HAVE A FORCE OF ± 164 lb ACTING ON THE CYLINDER.



WE ALSO KNOW THAT A DYNAMIC SYSTEM WITH A NATURAL FREQUENCY OF .828 cps WOULD HAVE A 1g DEFLECTION IN ACCORDANCE WITH THE FORMULA:

$$\text{NATURAL FREQUENCY} = \frac{3.13}{\sqrt{1g \text{ DEFLECTION}}}$$

$$\text{IE THE 1g DEFLECTION} = \left(\frac{3.13}{0.828}\right)^2 = 14.28''$$

SINCE THE CONTAINER PLUS THE STRONG BACK WEIGHS A TOTAL OF 84,000 lb OUR WORST CASE WIND LOAD OF 164 lb WILL MOVE THE CENTER OF GRAVITY $14.28 \times \frac{164}{84,000} = 0.027$ INCHES

THIS ASSUMES THE NATURAL FREQUENCY COINCIDES WITH THE EXCITATION FREQUENCY.

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6104	SHEET 16 of
		ORIG BY: G.S.S.B.	DATE: 11/12/94.
		CHK'D BY: KB	DATE: 2-9-95
SUBJECT: KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM: HANFORD SY-1-1 MITIGATION/SAFETY.	

VORTEX INDUCED OSCILLATIONS. (CONTD.)

IN AN ATTEMPT TO FURTHER RATIONALIZE THIS PROBLEM, FINITE ELEMENT ANALYSIS WAS USED TO DETERMINE THE NATURAL FREQUENCY OF THE CONTAINER/TRAILER ASSEMBLY WHEN THE CONTAINER IS ERECTED TO THE VERTICAL POSITION. THE MAJORITY OF THIS WORK WAS PERFORMED AT HANFORD USING COSMOS-M, VERSION 1.7. A CHECK MODEL WAS ALSO RUN USING IMAGES-3D.

REVIEWING THE COSMOS-M MODEL SHOWS THE LOWEST NATURAL FREQUENCY IN THE TRANSVERSE DIRECTION (WORST CASE) TO BE 1.04 HZ. THE MASS & CG LOCATION FROM THIS MODEL WERE REPORTED AS 230,000 lb @ -268, 109, 17.5.

THIS SHOULD PROVIDE A SUITABLE MARGIN ABOVE THE EXPECTED EXCITATION FREQUENCIES, ESPECIALLY CONSIDERING THE EXTREMELY LOW RATIO OF EXCITING FORCE TO THE MASS OF THE TRAILER/CONTAINER COMBINATION.

10) STAINLESS STEEL DECK

DECKING IS SUPPORTED ON THE TRAILER FRAME. SUPPORTS INCLUDE WIDE FLANGE BEAMS, CHANNEL SECTIONS AND ANGLE SECTIONS. THE ANGLE SECTIONS ARE 48" LONG 2×2×¼. A 200 lb LOAD ON THE CENTER WILL HAVE A BENDING MOMENT = 1200 IN LB.

SECTION MODULUS, $S = 0.247\ in^3$.

BENDING STRESS = 4,858 psi. OK.

DEFLECTION FROM COMPUTER = 0.0115".

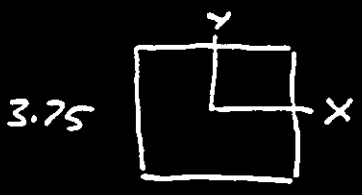
LARGEST UNSUPPORTED DECK PANEL IS 30×38". THIS WAS MODELLED USING MSC/CASE WITH FIXED EDGES AND A 200# LOAD AT THE CENTER. THE DEFLECTION AT THE CENTER WAS GIVEN AS 0.44 INCHES. (SEE ATTACHED PRINTOUT)

MAXIMUM BENDING MOMENTS WERE:

$M_X = 58.5$ IN LB

$M_Y = 64.4$ IN LB

ELEMENT.



WORST CASE BENDING STRESS

$$= \frac{M}{S} = \frac{58.5}{\left[\frac{3.75(.102)^2}{6}\right]}$$

$$= 8,996 \text{ psi} \quad \text{— LOW.}$$

MAXIMUM BOUNDARY REACTION = 26.58 lb

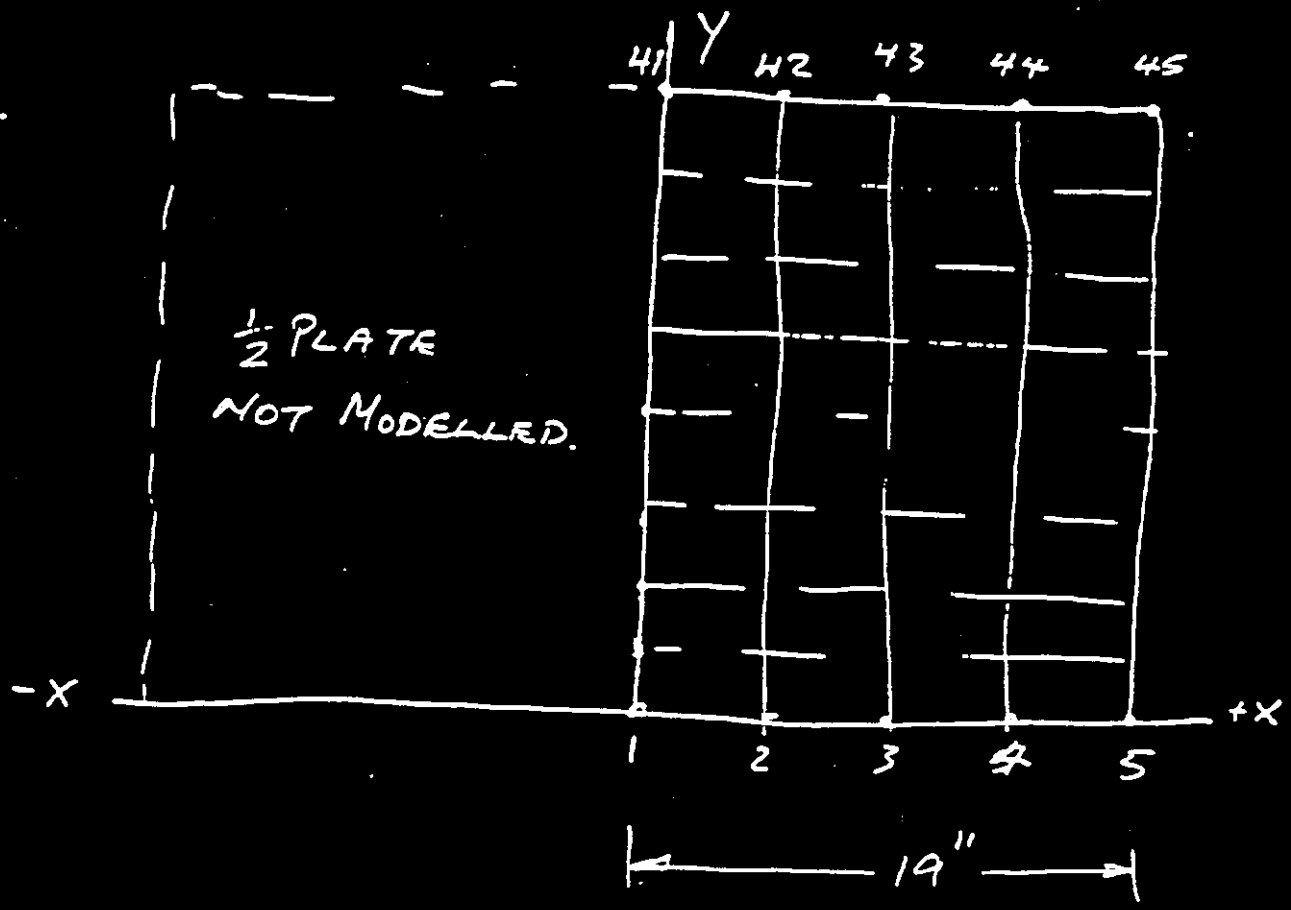
SHEAR AREA = 4.75×0.102

$= 0.485\ in^2$

SHEAR STRESS = $\frac{26.58}{0.485}$

$= 54.8\ psi.$ — LOW.

NOTE: MSC CASE MODELS PLATE HALF ONLY AS SKETCHED BELOW.



LOADING CONDITION : TYPE 1 - SINGLE POINT LOAD
BOUNDARY CONDITIONS:
SIDE :FIXED SUPPORT
TOP :FIXED SUPPORT
BOTTOM:FIXED SUPPORT

INPUT VARIABLES:
PLATE LENGTH.2L = 38 WIDTH.W = 30 THICKNESS.t = .102
ELAS MOD.E = 2.9E+07 POISSON = .3
LOAD.P = 200
b = 4(W/8)

Node	X	Y	DEFLECT.	ROT-X	ROT-Y
1	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2	4.750E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3	9.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4	1.425E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5	1.900E+01	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6	0.000E+00	3.750E+00	6.235E-02	2.952E-02	0.000E+00
7	4.750E+00	3.750E+00	5.195E-02	2.462E-02	-4.109E-03
8	9.500E+00	3.750E+00	2.865E-02	1.377E-02	-5.215E-03
9	1.425E+01	3.750E+00	7.581E-03	3.997E-03	-3.284E-03
10	1.900E+01	3.750E+00	0.000E+00	0.000E+00	0.000E+00
11	0.000E+00	7.500E+00	1.988E-01	4.089E-02	0.000E+00
12	4.750E+00	7.500E+00	1.645E-01	3.292E-02	-1.314E-02
13	9.500E+00	7.500E+00	9.131E-02	1.794E-02	-1.579E-02
14	1.425E+01	7.500E+00	2.674E-02	5.611E-03	-1.045E-02
15	1.900E+01	7.500E+00	0.000E+00	0.000E+00	0.000E+00
	0.000E+00	1.125E+01	3.503E-01	3.761E-02	0.000E+00
	4.750E+00	1.125E+01	2.790E-01	2.493E-02	-2.505E-02
18	9.500E+00	1.125E+01	1.507E-01	1.220E-02	-2.620E-02
19	1.425E+01	1.125E+01	4.525E-02	3.809E-03	-1.721E-02
20	1.900E+01	1.125E+01	0.000E+00	0.000E+00	0.000E+00
21	0.000E+00	1.500E+01	4.402E-01	6.706E-08	0.000E+00
22	4.750E+00	1.500E+01	3.294E-01	3.865E-08	-3.363E-02
23	9.500E+00	1.500E+01	1.746E-01	2.631E-08	-3.050E-02
24	1.425E+01	1.500E+01	5.270E-02	1.001E-08	-1.990E-02
25	1.900E+01	1.500E+01	0.000E+00	0.000E+00	0.000E+00
26	0.000E+00	1.875E+01	3.503E-01	-3.761E-02	0.000E+00
27	4.750E+00	1.875E+01	2.790E-01	-2.493E-02	-2.505E-02
28	9.500E+00	1.875E+01	1.507E-01	-1.220E-02	-2.620E-02
29	1.425E+01	1.875E+01	4.525E-02	-3.809E-03	-1.721E-02
30	1.900E+01	1.875E+01	0.000E+00	0.000E+00	0.000E+00
31	0.000E+00	2.250E+01	1.988E-01	-4.089E-02	0.000E+00
32	4.750E+00	2.250E+01	1.645E-01	-3.292E-02	-1.314E-02
33	9.500E+00	2.250E+01	9.131E-02	-1.794E-02	-1.579E-02
34	1.425E+01	2.250E+01	2.674E-02	-5.611E-03	-1.045E-02
35	1.900E+01	2.250E+01	0.000E+00	0.000E+00	0.000E+00
36	0.000E+00	2.625E+01	6.235E-02	-2.952E-02	0.000E+00
37	4.750E+00	2.625E+01	5.195E-02	-2.462E-02	-4.109E-03
38	9.500E+00	2.625E+01	2.865E-02	-1.377E-02	-5.215E-03
39	1.425E+01	2.625E+01	7.581E-03	-3.997E-03	-3.284E-03
40	1.900E+01	2.625E+01	0.000E+00	0.000E+00	0.000E+00
	0.000E+00	3.000E+01	0.000E+00	0.000E+00	0.000E+00
	4.750E+00	3.000E+01	0.000E+00	0.000E+00	0.000E+00
43	9.500E+00	3.000E+01	0.000E+00	0.000E+00	0.000E+00
44	1.425E+01	3.000E+01	0.000E+00	0.000E+00	0.000E+00
45	1.900E+01	3.000E+01	0.000E+00	0.000E+00	0.000E+00

MAX VALUES: DEFLECTION = 4.402E-01 ROT-X =-4.089E-02 ROT-Y = 3.363E-02

Node	X	Y	Mx	My	Mxy
1	0.000E+00	0.000E+00	-9.179E+00	-3.060E+01	1.152E+00
2	4.750E+00	0.000E+00	-7.639E+00	-2.546E+01	-2.958E-01
3	9.500E+00	0.000E+00	-4.126E+00	-1.375E+01	-2.865E-01
4	1.425E+01	0.000E+00	-9.323E-01	-3.108E+00	-1.412E-01
5	1.900E+01	0.000E+00	0.000E+00	0.000E+00	8.396E-01
6	0.000E+00	3.750E+00	-1.231E+00	-1.295E+01	-1.345E-01
7	4.750E+00	3.750E+00	-1.764E+00	-1.115E+01	-3.751E+00
8	9.500E+00	3.750E+00	-2.433E+00	-7.067E+00	-4.622E+00
9	1.425E+01	3.750E+00	-2.784E+00	-3.332E+00	-3.080E+00
10	1.900E+01	3.750E+00	-1.784E+00	-5.353E-01	-1.794E-01
11	0.000E+00	7.500E+00	9.256E+00	7.729E-02	6.248E-02
12	4.750E+00	7.500E+00	4.874E+00	5.657E-01	-5.681E+00
13	9.500E+00	7.500E+00	-1.385E+00	2.854E-01	-5.946E+00
14	1.425E+01	7.500E+00	-4.731E+00	-1.193E+00	-4.007E+00
15	1.900E+01	7.500E+00	-7.641E+00	-2.292E+00	-2.444E-01
16	0.000E+00	1.125E+01	2.563E+01	1.346E+01	-1.039E+00
17	4.750E+00	1.125E+01	9.939E+00	1.553E+01	-6.290E+00
18	9.500E+00	1.125E+01	-1.534E+00	6.710E+00	-4.406E+00
19	1.425E+01	1.125E+01	-6.288E+00	3.294E-01	-2.713E+00
20	1.900E+01	1.125E+01	-1.350E+01	-4.049E+00	-1.446E-01
21	0.000E+00	1.500E+01	5.852E+01	6.442E+01	-4.292E-06
22	4.750E+00	1.500E+01	5.402E+00	2.273E+01	-1.371E-05
23	9.500E+00	1.500E+01	-1.090E+00	9.122E+00	-6.229E-06
24	1.425E+01	1.500E+01	-6.865E+00	8.790E-01	-4.292E-06
25	1.900E+01	1.500E+01	-1.588E+01	-4.764E+00	-8.941E-07
26	0.000E+00	1.875E+01	2.563E+01	1.346E+01	1.039E+00
27	4.750E+00	1.875E+01	9.939E+00	1.553E+01	6.290E+00
28	9.500E+00	1.875E+01	-1.534E+00	6.710E+00	4.406E+00
29	1.425E+01	1.875E+01	-6.288E+00	3.294E-01	2.713E+00
30	1.900E+01	1.875E+01	-1.350E+01	-4.049E+00	1.446E-01
31	0.000E+00	2.250E+01	9.256E+00	7.744E-02	-6.247E-02
32	4.750E+00	2.250E+01	4.874E+00	5.658E-01	5.681E+00
33	9.500E+00	2.250E+01	-1.385E+00	2.855E-01	5.946E+00
34	1.425E+01	2.250E+01	-4.731E+00	-1.193E+00	4.007E+00
35	1.900E+01	2.250E+01	-7.641E+00	-2.292E+00	2.444E-01
36	0.000E+00	2.625E+01	-1.231E+00	-1.295E+01	1.345E-01
37	4.750E+00	2.625E+01	-1.764E+00	-1.115E+01	3.751E+00
38	9.500E+00	2.625E+01	-2.433E+00	-7.067E+00	4.622E+00
39	1.425E+01	2.625E+01	-2.784E+00	-3.332E+00	3.080E+00
40	1.900E+01	2.625E+01	-1.784E+00	-5.353E-01	1.794E-01
41	0.000E+00	3.000E+01	-9.179E+00	-3.060E+01	-1.152E+00
42	4.750E+00	3.000E+01	-7.639E+00	-2.546E+01	2.958E-01
43	9.500E+00	3.000E+01	-4.126E+00	-1.375E+01	2.866E-01
44	1.425E+01	3.000E+01	-9.323E-01	-3.108E+00	1.412E-01
45	1.900E+01	3.000E+01	0.000E+00	0.000E+00	-8.396E-01

MAX VALUES: Mx = 5.852E+01 My = 6.442E+01 Mxy = 6.290E+00

[illegible]	[illegible]	[illegible]
4.750E+00	0.000E+00	-2.083E+01
9.500E+00	0.000E+00	-8.063E+00
1.425E+01	0.000E+00	2.605E+00
1.900E+01	0.000E+00	2.393E+00
1.900E+01	3.750E+00	3.072E+00
[illegible]00E+01	7.500E+00	-2.393E+00
[illegible]00E+01	1.125E+01	-8.222E+00
1.900E+01	1.500E+01	-1.054E+01
1.900E+01	1.875E+01	-8.222E+00
1.900E+01	2.250E+01	-2.394E+00
1.900E+01	2.625E+01	3.072E+00
1.900E+01	3.000E+01	2.393E+00
1.425E+01	3.000E+01	2.605E+00
9.500E+00	3.000E+01	-8.063E+00
4.750E+00	3.000E+01	-2.083E+01
0.000E+00	3.000E+01	-2.658E+01

MAXIMUM BOUNDARY REACTION = 2.658E+01

11) LANDING GEAR:

THE LANDING GEAR CYLINDERS BOLT TO A PLATE 15" WIDE BY 1.5" THICK. THIS PLATE WELDS TO THE END OF A WIDE FLANGE CROSS MEMBER AND IS GUSSETTED BY ANOTHER 1.5" THICK PLATE.

TYPICALLY THE LANDING GEAR LOAD FROM LOAD CASE 1. IS 130,649 lb.
LOAD PER JACK = 65,324 lb

OFF SET OF JACK LOAD = 6 INCHES
BENDING MOMENT = 392,277 IN LB.
SECTION MODULUS OF 15 x 1.5 PLATE IS

$$\frac{bd^2}{6} = \frac{15 \times 1.5^2}{6} = 5.625$$

ADDING 20" LEG FROM GUSSET, HOWEVER, GIVES $I = 1,929\ in^4$ & $C = 13.7"$

$$\text{SECTION MODULUS} = \frac{1,929}{13.7} = 140.8\ in^3.$$

BENDING STRESS = 2,786 psi SMALL.

OTHER STRESS WERE SIMILARLY SMALL.
AGAIN DESIGN IS MORE THAN ADEQUATE

11. King Pin Bracketry.

The King Pin welds into a 0.5" plate, which is supported on the wide flange longitudinal beams & 2 cross beams. The worst case tongue weight is 106,000 lb [load case 1] and there is a 1.5 worst case factor for the side load. The offset is estimated to be 1.5 inches.
This results in a bending moment of 238,500 inch lb on the pin and its supporting plate.

APPENDIX F

Container-Pump Transport Tractor/Trailer Combinations

Container-Pump Transport

Tractor/Trailer Combinations

When the 241SY101 tank mixer pump is removed and placed in a container, the container will be transported to the Central Waste Complex (CWC) via a tractor/trailer. Various tractor/trailer combinations are available to transport the container. A study was initiated to investigate potential combinations; the results and calculations are contained in this appendix.

The results of this study are important for several reasons. First, if the highest-capacity WHC tractor available on the Hanford site (DOE owned tractor) could not pull the trailer, a jeep would be necessary or a commercial tractor with a higher capacity would have to be procured. Note: after the study was completed, it was determined that using a jeep with the WHC tractor was not an option because it is necessary to back the trailer into position at the CWC, which is extremely difficult with a jeep attached. Second, the various tractor/trailer combinations each have different turn in radii, which is important for determining the amount of roadway modifications necessary to transport the container from the 241SY Tank Farm to the CWC. Third, if it is necessary to off-load the container onto another trailer, cranes would have to be properly positioned and it is important to know how to position the container on the trailer, i.e., which end of the container faces forward.

The study considered many parameters, such as using both WHC and commercial tractors, the various trailers available on-site, both lead and steel shielding shot, shielding the container at various locations, and considering the top end of the container facing both forward and rearward. For each of the combinations, the load at the trailer support points (the king pin and rear tires) was calculated. The support loads were compared to the allowable capacities of the tractors and trailers and the determination made if the particular combination was an option. A summary of results table is shown on pages A-3 through A-5, with the remainder of this appendix containing calculations and references. In the summary table, note that R_1 is the kingpin load and R_2 is the load at the center of the rear tires.

ANALYTICAL CALCULATIONS

Subject SY-101 TRAILER STUDY SUMMARY

Originator M.A. NELSON Date 3/3/95

Checker Randy Johnson Date 3/16/95

CASE #	DESCRIPTION	TRAILER	TRACTOR	RXN FORCES	OPTION
CASE 1	CONTAINER, PUMP, & LEAD SHOT TO COL. # 14 WITH CONT. CAPS FACING REAR OF TRAILER	60 TON	WHC NO JEEP	$R_1 = -9300$ # $R_2 = 139,300$ #	NO
CASE 2	C., P., & L.S. TO COL. # 14 WITH C. CAPS FACE FORWARD	60 TON	WHC NO JEEP	$R_1 = 7,800$ # $R_2 = 122,200$ #	NO
CASE 3	C., P., & L.S. TO COL. # 25, WITH THE CAPS FACING REAR OF THE TRAILER	60 TON	WHC NO JEEP	$R_1 = -25,000$ # $R_2 = 190,000$ #	NO
CASE 4 & CASE 5	CASE 4 IS CASE 2 WITH STEEL SHOT CASE 5 IS CASE 3 WITH STEEL SHOT (NO CALCS)	60 TON	WHC NO JEEP	$R_1 = 6000$ # $R_2 = 114,450$ #	NO
CASE 6	C., P., & LEAD SHOT TO COL. # 14 WITH CAPS FACING FRONT	150 TON	WHC NO JEEP	$R_1 = 46,900$ # $R_2 = 127,000$ #	YES
CASE 7	C., P., & L.S. TO COL. # 14 WITH CAPS FACING REAR	150 TON	WHC NO JEEP	$R_1 = 36,700$ # $R_2 = 137,300$ #	NO
CASE 8	C., P., & L.S. TO COL. # 25 WITH CAPS FACING REAR ONLY (OTHER DIR. WON'T WORK) EITHER, CALL DONE	150 TON	WHC NO JEEP	$R_1 = 36,100$ # $R_2 = 172,900$ #	NO

ANALYTICAL CALCULATIONS

Subject SY-101 TRAILER STUDY SUMMARY

Originator W.A. NEWSOM Date 3/3/95

Checker [signature] Date 3/16/95

CASE #	DESCRIPTION	TRAILER	TRACTOR	RXN FORCES	OPTION
CASE 9 & CASE 10	CASE 9 IS CASE 7 WITH STEEL SHOT COL #14 CASE 10 IS CASE 8 WITH STEEL SHOT COL #25	150 TON	WHC NO JEEP	BY INSPECTION B/C LESS WT. OF STEEL SHOT	YES
CASE 11	STRONG BACK ONLY	KAMP 100 TON	WHC NO JEEP	R_1 = 42,800# R_2 = 82,900#	YES
CASE 12	EMPTY CONTAINER & STRONG-BACK	KAMP 100 TON	WHC NO JEEP	R_1 = 63,400# R_2 = 119,300#	YES
CASE 13	CONTAINER, PUMP & LEAD SHOT TO COL. # 14	KAMP 100 TON	LAMPSON ONLY; NO JEEP	R_1 = 86,000# R_2 = 149,700#	YES
CASE 14	C., P., & L.S. TO COL # 25	KAMP 100 TON	LAMPSON ONLY; NO JEEP	R_1 = 104,340 R_2 = 166,400	YES
CASE 15	C., P., & STEEL SHOT TO COL. # 14	KAMP 100 TON	LAMPSON ONLY; NO JEEP	R_1 = 76,000# R_2 = 150,100#	YES
CASE 16	C., P., & STEEL SHOT TO COL. #25	KAMP 100 TON	LAMPSON ONLY; NO JEEP	THIS CASE WILL EXCEED WHC TRACTOR CAP. B/C CASE 15 DID	YES
CASE 17	CONTAINER, PUMP + STRGBK. (NO SHIELDING)	KAMP 100 TON	LAMPSON OR WHC WITH JEEP	R_1 = 71,340 R_2 = 130,400	YES

↳ 11% OVERLOAD ON WHC TRACTOR W/O JEEP.

ANALYTICAL CALCULATIONS

Subject SY-101 TRAILER STUDY SUMMARY

Originator W.A. NELSON Date 3/16/95

Checker [signature] Date 3/16/95

NOTES:

(1) R_1 = KINGPIN RXN FORCE

R_2 = CENTER OF REAR AXLES RXN FORCE

(2) VEHICLE CAPACITIES = GVWR LESS VEHICLE WT.

- 60 TON TRAILER = 60,000# FOR R_2
- 150 TON TRAILER = 135,000# FOR R_2
- ★ KAMP TRAILER = 240,000# FOR R_2
- WHC TRACTOR = 64,385# KINGPIN LOAD
- LAMPSON TRACTOR > 80,000# G.V.W.
- JEEP = 70,000# > 400,000# TOTAL LOAD

(3) IN "DESCRIPTION" SECTION CONTAINER MUST BE ORIENTATED AS DESCRIBED.

(4) FOR CALCULATIONS, CONTAINER WAS POSITIONED ON TRAILER AS FAR FORWARD (i.e., CLOSEST TO KINGPIN) AS POSSIBLE. WHEN CONTAINER IS TO BE POSITIONED ON TRAILER, REFER TO THIS CALCULATION PACKAGE FOR LOCATING CONTAINER ON TRAILER.

- POINT OF CONTAINER IS POSITIONED AT POINT ON TRAILER BED WHERE FLAT PART OF BED BEGINS TO SLOPE UPWARD (FOR 60 & 150 TON TRAILERS)

(5) 60 & 150 TON TRAILERS AVAILABLE THRU WHC,

★ "KAMP TRAILER" IS THE WHC 100-TON TRAILER (MANUFACTURED BY KAMP SYSTEMS, INC.)

DESIGN CALCULATION

(1) Drawing _____ (2) Doc. No. _____ (3) Page 4 of 16
(4) Building _____ (5) Rev. _____ (6) Job No. _____
(7) Subject SY-101 TRAILER STUDY
(8) Originator W.T. NEWSOM Date 2/8/95
(9) Checker Randy Jonier Date 3/16/95

(10)

SY101 TRAILER WEIGHTS:

1) TRAILER WT. = 120,962 # (TRAILER 97,988# & RUNNING GEAR 22,974#) (REF. GRAHAM BARR CALCS, Pg.)

2) WT. OF CONTAINER: (SHIELDED TO COL #14) & REF

- EMPTY = 57,000 # (INCLUDES 2 CAPS & 2 PLATES)
- SHIELDED = 88,000 #
- SHIELDED W/ PUMP INSTALLED = 110,000 #
  C.G. = 29.59' (355")
- CAPS = 1703# & 1709#
- PLATES = 2281# & 1764# (OUTSIDE) (INSIDE)

(ALL THREE ARE REF. FROM WHC-SD-TP-SEP-026 Pg. B6-B14)

3) WT. OF STRONG BACK:

- TOTAL = 28,340 # (REF. J.V. EGGER, SPREADSHEET.)

4) WT. OF PUMP:

- TOTAL = 22,000 # (REF. WHC-SD-TP-SEP-026, Pg. B6-8)

5) WT OF LEAD SHIELDING: TO COL #14

- TOTAL = 31,000 # (REF. WHC-SD-TP-SEP-026, Pg. B6-8)

DEN. LEAD = .409 lbs/in³
DEN STEEL = .283 lbs/in³
} (REF. MANUAL OF STEEL CONSTRUCTION, 9th ED., pg 6-8) (MISC.)

6) WT. OF STEEL SHOT: (SHIELDED TO COL. #14)

- TOTAL = $31{,}000 \left(\frac{.283}{.409}\right) = 21{,}450$ #

ANALYTICAL CALCULATIONS

Subject SY-101 TRAILER STUDY
Originator W.A. NEWSOM Date 3/15/95
Checker Randy Jonsen Date 3/16/95

7) WT. SHIELDED TO COL. #25 (FULLY SHIELDED)

- EMPTY CONTAINER = 57,000#
- CONTAINER & SHIELDING = 130,000#
- CONTAINER, SHIELDING, & PUMP = 145,000# → C.G. = 31.83' (382")
- WT. OF LEAD SHIELDING = 73,000#
- WT. OF STEEL SHIELDING = $(73{,}000\#)\left(\frac{.283}{.409}\right) = 50{,}500\#$

(REF: WHC-SD-TP-SEP-026)

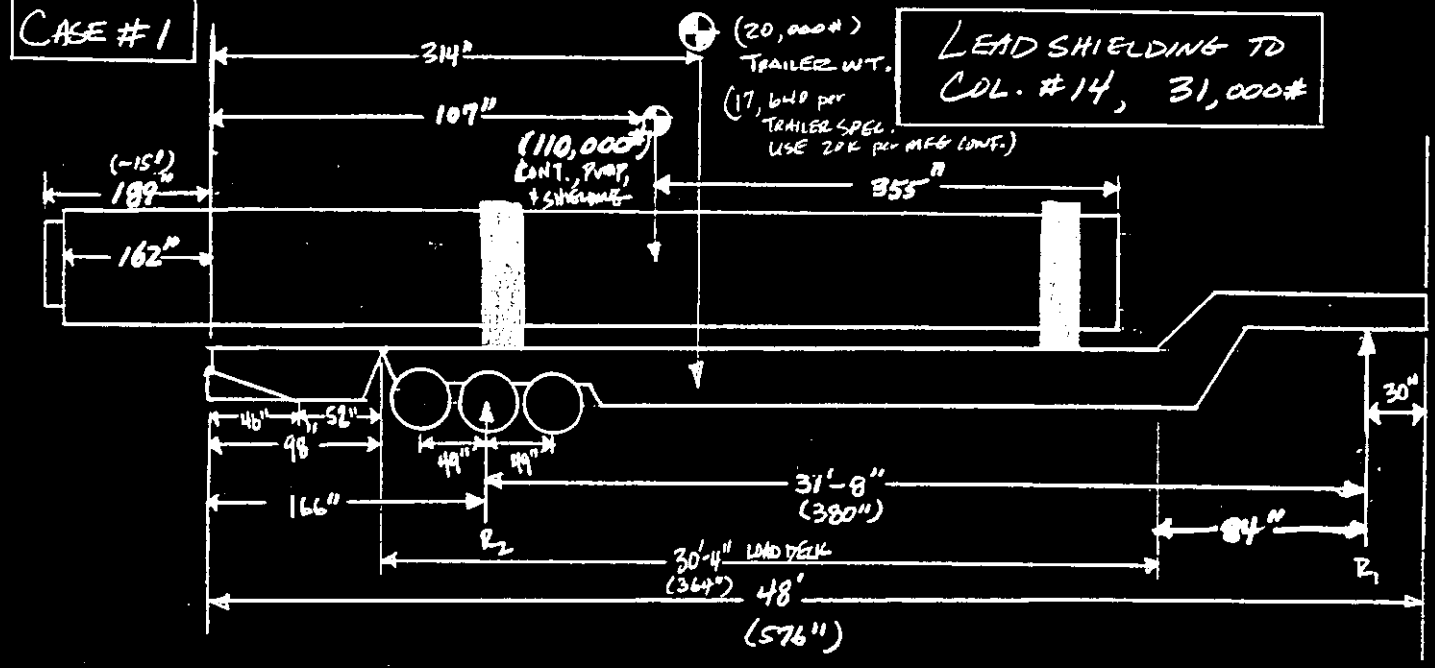
ANALYTICAL CALCULATIONS

Subject SJ 101 CONTAINER, PUMP & SHIELDING LOADED ON 60 TON TRAILER

Originator WA NEWSOM Date 2/8/95

Checker Randy Jonison Date 3/16/95

CASE #1



LEAD SHIELDING TO COL. #14, 31,000#

60 TON LOWBOY
TRAILER WIDTH = 10'
CONTAINER LENGTH = 53' (636")
" " WITH CAPS = 54'¼' = 651"

* TRAILER CG DIST. APPROX AFTER DISCUSSION WITH TRAILER MFG.

CONTAINER CAPS FACING REAR OF TRAILER

$\Sigma M_{R_2} = 0$; $R_1(380") = 110{,}000(-59") + 20{,}000(148")$

(651 − 355 − 189 − 166 = −59"
∴ CG. OF PUMP, CONT., & SHIELDING IS TO THE LEFT OF R_2, THIS SKETCH ABOVE DOES NOT CORRECTLY SHOW THIS)

$R_1 = -9300\#$

THIS WILL NOT WORK.
TRAILER WILL TEND TO LIFT TRACTOR OFF THE GROUND WITH 9300# FORCE

$R_2 = 110{,}000 + 20{,}000 - (-9300) = 139{,}300\# > 60{,}000\#$
THUS OVER TRAILER LIMIT.

ANALYTICAL CALCULATIONS

Subject Sy 101 CONT. PUMP & SHIELDING ON 60 TON LOWBOY

Originator W A Newsom Date 2/8/95

Checker Randy Johnson Date 3/16/95

CASE # 2 (REF. DWG. ON PREV. PAGE)

LEAD SHIELDING TO COL. # 14 31,000 #

CONTAINER CAPS FACE FRONT

$\Sigma M_{R_2} = 0$; $R_1(380") = (110,000)(.0") + (20,000)(148")$

(355 - 189 - 166 = 0)

$R_1 = \frac{2.96\ E6}{380} = 7,800\ \#$ < 64,000# OKAY TO USE

$\Sigma F_y = 0$; $110,000 + 20,000 - 7,800 = R_2$

$R_2 = 122,200\ \# > 60,000\ \#$ NOT OK TO USE

CASE #3 (REF. DWG ON PREV. PAGE) (CAPS FACE REAR)

LEAD SHIELDING TO COL # 25 WT. OF 73,000 #

$\Sigma M_{R_2} = 0$; $R_1(380") = (145,000)(-86") + (20,000)(148")$

(661 - 382 - 189 - 166 = -86")

$R_1 = \frac{-9.57\ E6}{380} = -25,000\ \#$ < 64,000# CAN NOT USE (UPLIFT ON KINGPIN)

$\Sigma F_y = 0$; $145,000 + 20,000 - (-25,000) = R_2$

$R_2 = 190,000\ \# > 60,000\ \#$ CAN NOT USE

ANALYTICAL CALCULATIONS

Subject 60 TON TRAILER LOADED W/ SY101 CONTAINER – STEEL SHOT

Originator W.A. NEWSOM Date 3/9/95

Checker [signature] Date 3/16/95

CASE #4

(SEE SKETCH FOR 60 TON TRAILER)

(CAPS FACE REAR)

F.R: 651 − 303 − 189 − 166 = −7

F.F: 303 − 189 − 166 = −52

R_1 = −6000 #

SHIELDED TO COL # 14 W/ STEEL SHOT NT. OF 21,450 #

CONTAINER WT. & C.G REF. CALCS. IN APPENDIX

NT = 100,450 #

CG = 303 in

$\Sigma M_{R_2} = 0$; $R_1(380) = (100,450)(-7) + (20,000)(148)$

$R_1 = \frac{2.25E6}{380}$

$R_1 = 6,000$ # < 64,400 # ∴ O/K TO USE W/ TRACTOR

$\Sigma F_y = 0$, $R_2 = 20,000 + 100,450 - 6,000$

$R_2 = 114,450$ # > 60,000 # ∴ EXCEED TRAILER AXLE CAPACITY

* NOTE CAPS FACE FRONT WILL NOT WORK EITHER

$R_1 = -6000$ #

CASE #5

SHIELDED TO COL. #25 W/ STEEL SHOT & PLACED ON 60 TON TRAILER IS NOT A SOLUTION B/C CASE # 4 WOULD NOT WORK & IS LESS WEIGHT THAN CASE 5.

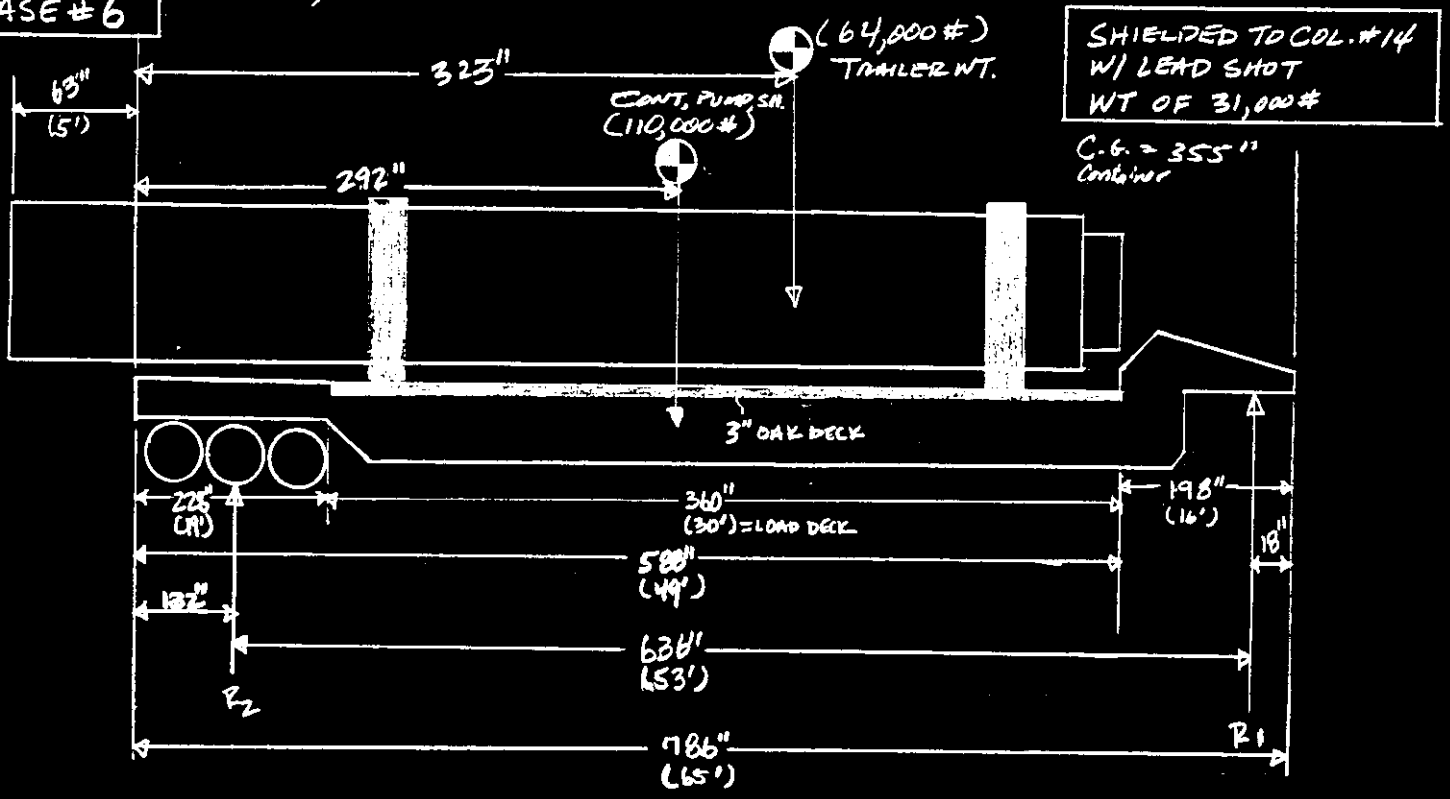
ANALYTICAL CALCULATIONS

Subject SY-101 CONTAINER, PUMP & SHIELDING ON 150 TON TRAILER

Originator WA NEWSOM Date 2/8/95

Checker Randy Jonnen Date 3/16/95

CASE #6



NELSON LOWBOY TRAILER, WIDTH = 13'6"

SOLVE FOR R_1 & R_2:

292 − 132 = 160"

$$\Sigma M_{R_2} = 0; \quad R_1(636) = (64000)(191") + (110{,}000)(160)$$

$$R_1 = \frac{2.98E7}{636} = \underline{46{,}900\ \#} < 64{,}000\ \#$$

∴ CAN USE WHC TRACTOR

$$\Sigma F_y = 0; \quad 110{,}000 + 64{,}000 - 46{,}900 = R_2$$

$$\underline{R_2 = 127{,}000\ \#} < 135{,}000\ \#$$

∴ OKAY TO USE

ANALYTICAL CALCULATIONS

Subject: SY-101 CONT. PUMP & SHIELDING ON 150 TON TRAILER
Originator: WA NEWSOM Date: 2/8/95
Checker: Randy Jarvis Date: 3/16/95

CASE # 7 (SEE SKETCH ON PREV. PAGE)

SHIELDED TO #14 W/ LEAD SHOT WT. OF 31,000#

SAME CONDITIONS EXCEPT ROTATED CONTAINER (CAPS AT REAR OF TRAILER)

651 − 355 − 63 − 132 = 101

SOLVE FOR R_1 & R_2:

$\Sigma M_{R_2} = 0$; $R_1(636) = (64{,}000)(191) + (110{,}000)(101)$

$$R_1 = \frac{2.33E7}{636} = \underline{\underline{36{,}700\#}} < 64{,}000$$

∴ CAN USE WHC TRACTOR

$\Sigma F_y = 0$; $110{,}000 + 64{,}000 - 36{,}700 = R_2$

$$\underline{\underline{R_2 = 137{,}300\#}} > 735{,}000$$

∴ CAN NOT USE TRAILER

~~TOTAL LOAD = 110,000 + 64,000 = 174,000 < 200,000~~

∴ NO JEEP REQ

ANALYTICAL CALCULATIONS

Subject SY-101 CONT., PUMP & SHIELDING ON 150 TON TRAILER

Originator W.A. NEWSOM Date 2/8/95

Checker Randy Johnson Date 3/16/95

CASE #8

(SEE PREVIOUS TRAILER SKETCH)

SHIELDED TO COL #25 W/ LEAD SHOT WT. OF 73,000 #

(CONTAINER CONFIGURED W/ CAPS FACING REAR OF TRAILER) [FACING OTHER DIR. WON'T WORK]

Contain CG = 382" — WHC-SD-TP-SCP-016

SOLVE FOR R_1 & R_2: CG OF CONT. MOMENT ARM = 651" − 382" (UPP END.) = 269" − 63" (OVER HANG) = 206" − 132" = 74

$\Sigma M_{R_2} = 0$; $R_1(636) = (64000)(191) + (145,000)(74)$

$R_1 = \frac{2.30 \text{ E } 7}{636} = 36,100\ \# < 64,000\ \#$

∴ CAN USE WHC TRACTOR

$\Sigma F_y = 0$; $145,000 + 64,000 - 36,160 = R_2$

$R_2 = 172,900\ \# > 135,000\ \#$ ∴ NOT USEABLE

EXCEEDS TRAILER LIMIT

(SEE PREV. 150 TON SKETCH)

(CONTAINER CONFIGURED W/ CAPS FACING FRONT)

SHIELDING TO COL # 25 W/ LEAD SHOT WT. OF 73000 #

302 − 63 − 132" = 151

$\Sigma M_{R_2} = 0$; $R_1(636) = (64000)(191) + (145,000)(151)$

$R_1 = \frac{3.93 \text{ E } 7}{636} = 61,900\ \# < 64,000\ \#$

∴ OK TO USE WHC TRACTOR

$\Sigma F_y = 0$; $145,000 + 64,000 - R_1 = 147,000\ \# > 135,000\ \#$

∴ EXCEEDS TRAILER CAPACITY & CAN'T USE

ANALYTICAL CALCULATIONS

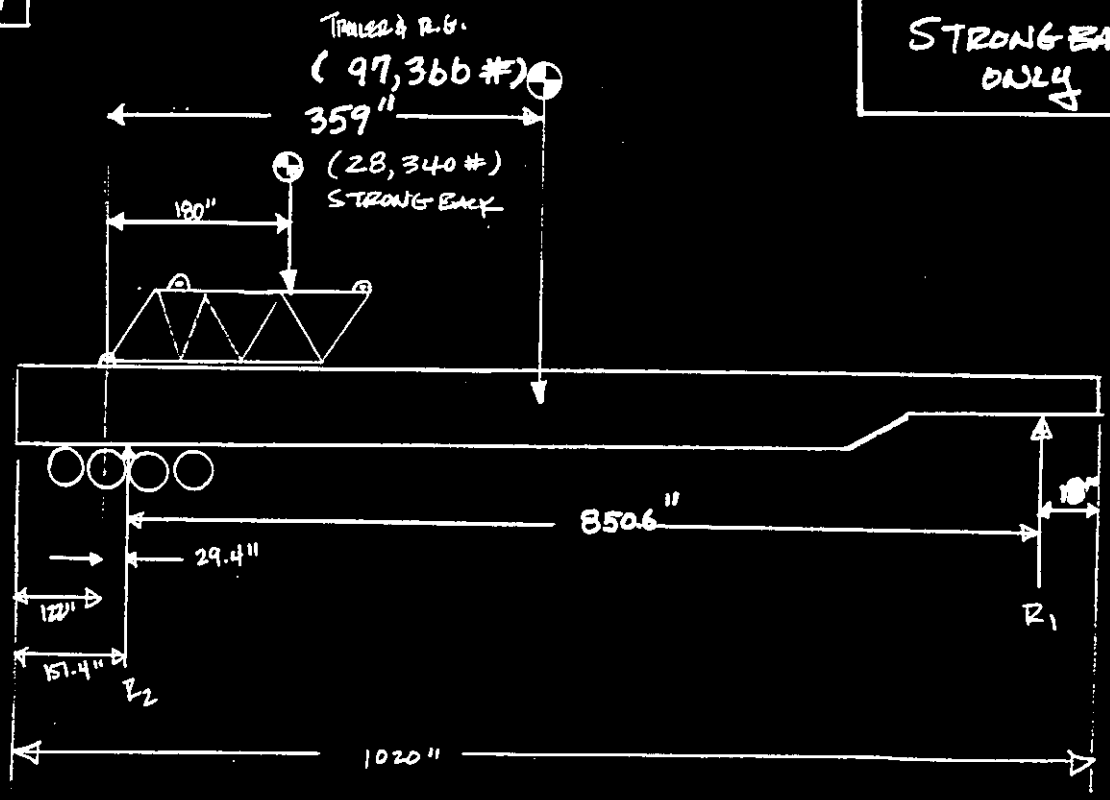
Subject SY-101 TRAILOR & STRONGBACK CG & TONGUE LOAD KAMP TRAILER

Originator W.T. Newsom Date 12/28/94

Checker Randy Johnson Date 3/16/95

CASE #11

STRONGBACK ONLY



SOLVE FOR TONGUE LOAD (RXN FORCE R_1):

$\Sigma M_{R_2} = 0$: $R_1(850.6) = 97{,}366(330) + 28{,}340(150.6)$

$R_1 = \frac{3.64\,E7}{850.6}$

$R_1 = 42{,}800$ #

WITHIN WHC TRACTOR CAPACITY
NO JEEP REQ'D

$\Sigma F_y = 0$; $R_2 = 97{,}366 + 28{,}340 - R_1$

$R_2 = 82{,}906$ # < ∴ OK TO USE

ANALYTICAL CALCULATIONS

Subject SY 101 TONGUE LOAD W/ EMPTY CONTAINER KAMP TRAILER

Originator NA Newsom Date 12/28/94

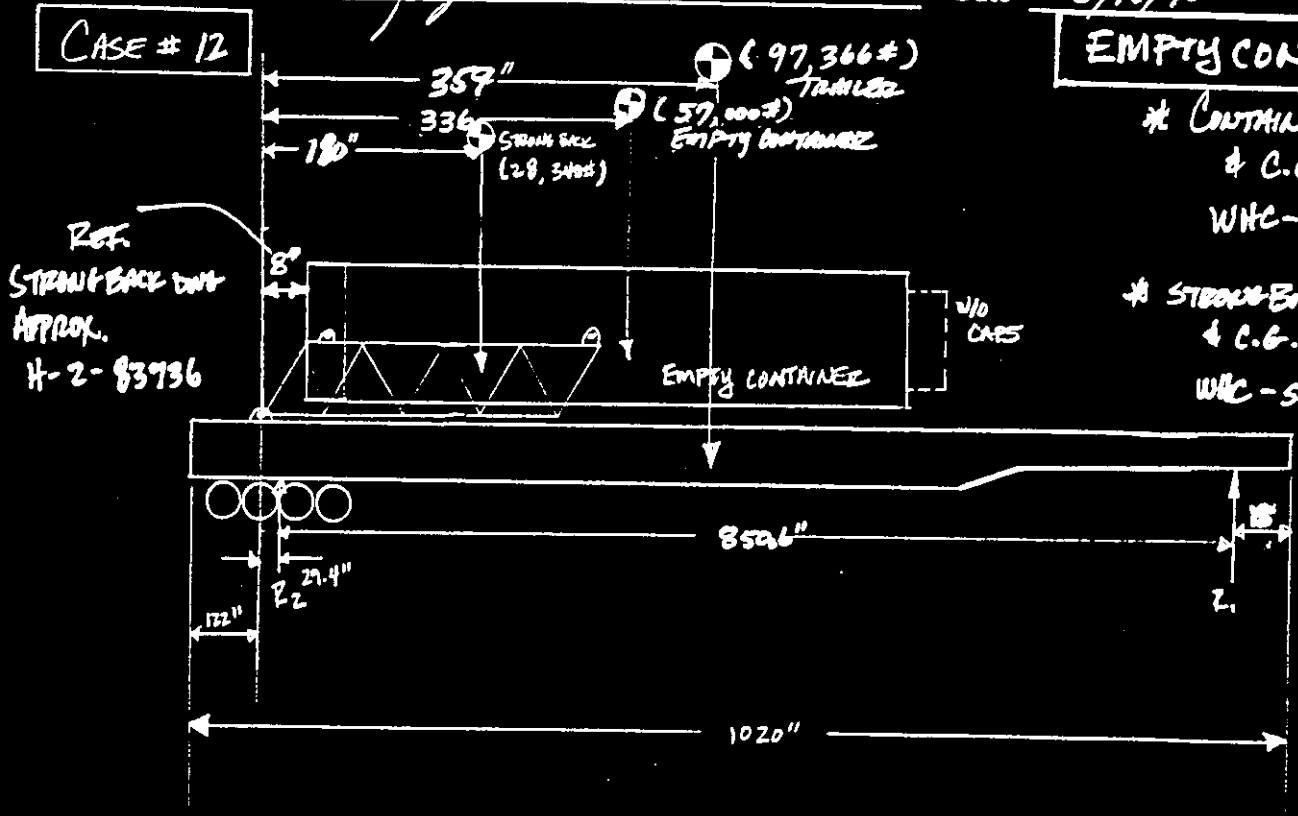
Checker Randy Johnson Date 3/16/95

CASE # 12

EMPTY CONTAINER

CONTAINER WT. & C.G. REF.
WHC-SD-TP-SEP-026
Pg. B6-B

STRONG BACK WT. & C.G. REF.
WHC-SD-WM-DA-165
Pg. 10



SOLVE FOR R/N FORCE R_1 (TONGUE LOAD):

$$\Sigma M_{R_2} = 0 : \quad R_1(850.6) = (97{,}366)(330) + (28{,}340)(151) + (57{,}000)(307)$$

$$R_1 = \frac{5.39E7 \text{ \#-in}}{850.6 \text{ in}}$$

$$R_1 = 63{,}400 \text{ \#}$$

< 64,400# ∴ OKAY TO USE WHC TRACTOR

$$\Sigma F_y = 0; \quad R_2 = 97{,}366 + 28{,}340 + 57{,}000 - R_1$$

$$R_2 = 119{,}300 \text{ \#} < 241{,}000\text{\#}$$

∴ NOT EXCEED TRAILER AXLE CAPACITY, OK TO USE

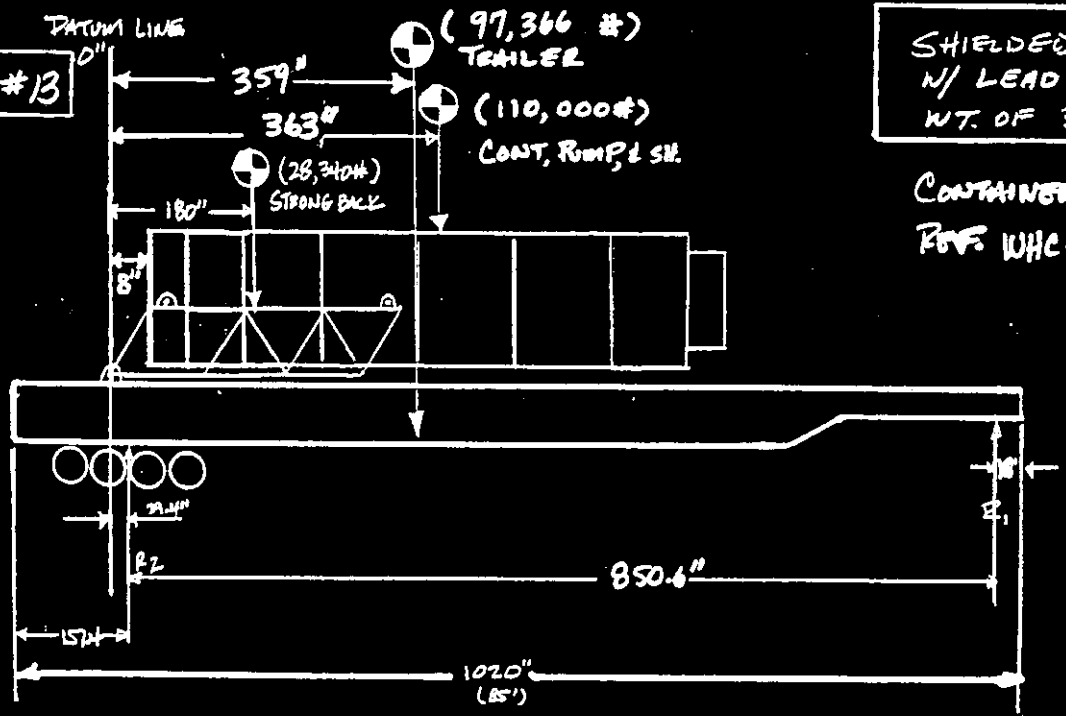
ANALYTICAL CALCULATIONS

Subject SY-101 PUMP CONTAINER, SHIELDING & STRONGBACK ON KAMP TRAILER

Originator W.A. NEWSOM Date 2/27/95

Checker Randy Johnson Date 3/16/95

CASE #13



SHIELDED TO COL. #14
W/ LEAD SHOT
WT. OF 31,000#

CONTAINER C.G. = 355"
REF: WHC-SD-TP-SEP-026

SOLVE FOR R_1:

$\Sigma_1 M_{e_2} = 0$; $R_1(850.6") = 97,366(330") + 28,340(150.6") + 110000(334")$

$$R_1 = \frac{7.31E7}{850.6}$$

$R_1 = 86,000$ #

EXCEEDS WHC TRACTOR CAPACITY OF 64,400 # (W/O JEEP)
∴ MUST USE LAMPSON TRACTOR (W/O JEEP)

$\Sigma_1 F_y = 0$; $R_2 = 97,366 + 110,000 + 28,340 - 86,000$

$R_2 = 149,700$ # < 240,000 # OK

ANALYTICAL CALCULATIONS

Subject SY-101 CONTAINER ON KAMP TRAILER

Originator W.T. NELSON Date 3/9/95

Checker Randy Johnson Date 3/16/95

CASE #14 (SEE SKETCH ON PREV. PAGE)

SHIELDED TO COL #25
W/ LEAD SHOT
WT. OF 73,000

CONTAINER CG = 382"
REF.
WHC-SD-TP-SEP-026
WT = 145,000# PG. B6-9

$\Sigma M_{R_2} = 0$;

$R_1(850.6) = 97,366(330) + 28,340(151) + (145,000)(361)$

$R_1 = \frac{8.88E7}{850.6}$

$R_1 = 104,340\ \#$ > 64,400 # ∴ CANNOT USE WHC TRACTOR

$\Sigma F_y = 0$; $R_2 = 97,366 + 28,340 + 145,000 - R_1$

$R_2 = 166,400\ \#$ < 240,000 ∴ NOT EXCEED TRAILER CAPACITY

ANALYTICAL CALCULATIONS

Subject SY-101 ON KAMP TRAILER CONTINUED

Originator W.A. NELSON Date 2/28/95

Checker Randy Johnson Date 3/16/95

CASE #15 (SEE SKETCH ON PREVIOUS PAGE)

(C.G. OF PUMP, CONT, & SH. HAS CHANGED) (B/C STEEL SHOT)

SHIELDED TO COL #14 W/ STEEL SHOT WT. OF 21,450 #

SOLVE FOR R_1:

Moment Arm For CG = 303 in + 8 in − 29.4 in (Ref. Appendix Calc.)
= 281.6 in

$\Sigma_1 M_{R_2} = 0$; $R_1(850.6) = 97,366(330) + 28,340(150.6) + (100,450)(281.6)$

$R_1 = \frac{6.47E7}{850.6}$

$R_1 = 76,000$ #

> 64,400 # THUS CAN'T USE WHC TRACTOR W/O A JEEP. OR USE LAMPSON TRACTOR

$\Sigma_1 F_y = 0$; $R_2 = 97,366 + 28,340 + 100,450 - R_1$

$R_2 = 150,100$ #

< 240,000 #, THUS WITHIN TRAILER CAPACITY.

CASE 16

STEEL SHOT TO COL # 25 ON KAMP TRAILER. SINCE STEEL SHOT TO COL #14 PRODUCES TO LARGE OF A KINGPIN LOAD FOR THE WHC TRACTOR (CASE #15) THEN CASE #16 WILL OBVIOUSLY EXCEED WHC TRACTOR CAPACITY.

ANALYTICAL CALCULATIONS

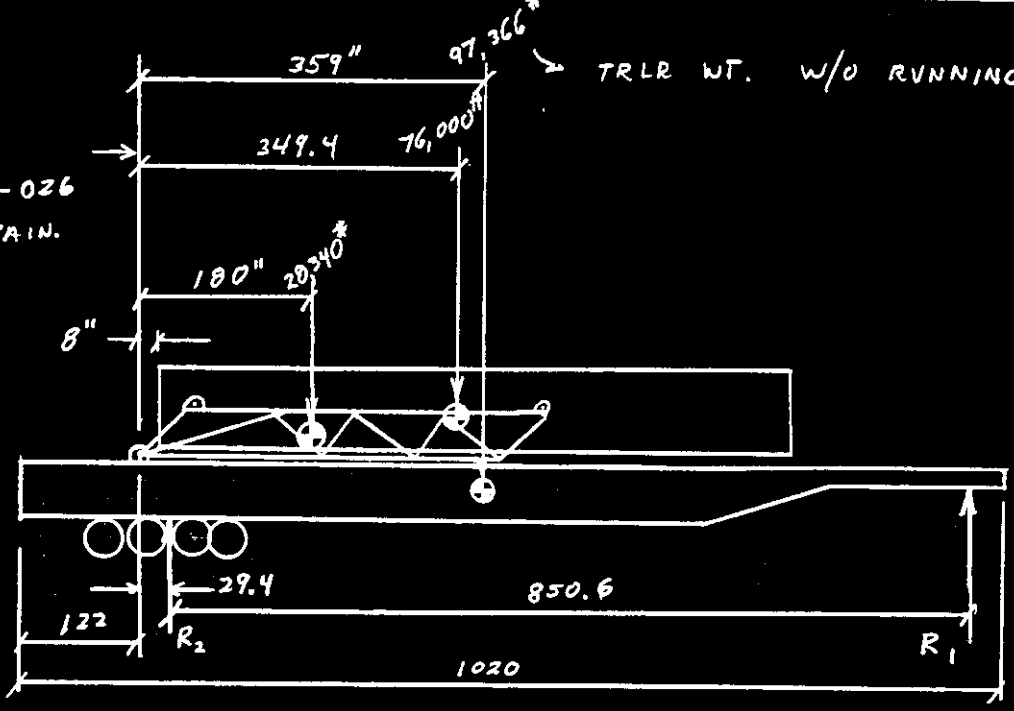
Subject SY-101 TRACTOR TRAILER COMBOS

Originator CALCS FOR INDEPENDENT REVIEW Date 3/28/95

Checker R. L. JORISSEN Date

CASE 17

KAMP TRAILER
WHC TRACTOR (NO JEEP)
STRGBK./CONTAINER/PUMP
• NO SHIELDING



REF:
WHC-SD-TP-SEP-026
LOADED CONTAIN.
WITH NO
SHIELDING
WT = 76^K
CG = 28.45' = 341.4"

$$\Sigma M_{R_2} = 150.6"(28.34^K) + 320"(76^K) + 329.6"(97.366^K) - R_1\,850.6$$

$$R_1 = \frac{60,680}{850.6} = \underline{71,338\#} > 64,385\#$$ WHC TRACTOR CANNOT USE. (11% OVER-LOAD)

USE WHC JEEP

$$\Sigma F_y - R_2 = 28.34 + 76 + 97.366 - 71.34$$

$$\underline{R_2 = 130,400\#} < 240,000 - \text{TRAILER OK}$$

ANALYTICAL CALCULATIONS

Subject SY-101

Originator W.F. Lampson Date 3/6/95

Checker Randy Lampson Date 3/16/95

APPENDIX :

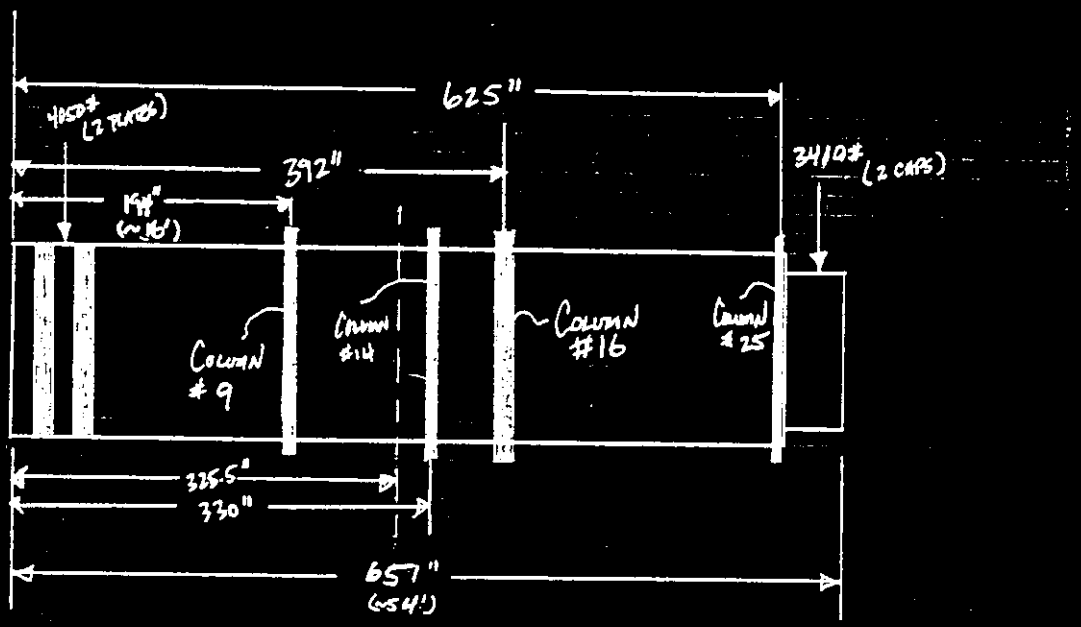
- SKETCH SHOWING LAYOUT DIMENSIONS OF COLUMNS : A-2
  (REF. DWG H-2-83734)
- SKETCH SHOWING EMPTY CONTAINER CG & CHP DIMENSIONS : A-3
  (REF. DWG H-2-83734)
- SCALED WEIGHTS OF KAMP TRAILER & ACTUAL CG CALC. : A-4
  (REF. LAMPSON - SCALES)
- CALC FOR CG OF 150 TON NELSON TRAILER : A-5
  (REF MFG. DWG 896607)
  (REF. DISCUSSION W/ ENGR. AT NELSON MFG)
- WHC TRACTOR ALLOWABLE KINGPIN LOAD : A-6
  (REF. MFG. SPECS ON TRACTOR & DISCUSSION W/ RAY ROBERT)
- CALCS TO FIND CG. & WT. OF STEEL SHOT TO CYL. #14 : A-7 - A-9
- WHC-SD-TP-SEP-026, Pg. ~~B6-8~~ & B6-9 : A-10 & A-11
- LAMPSON TRACTOR CAPACITY : A-12 & A-13
  (REF. DISCUSSIONS W/ R. RUTHERFORD)
  (REF. TRACTOR SPEC SHEET)
- WHC JEEP SPEC SHEET : A-14
- GRAHAM BARR CALC & WA NEWSOM COMPARISON : A-15 & A-16
- 60 TON, 150 TON, & TRACTOR SPEC SHEETS : A-17 - A-19

ANALYTICAL CALCULATIONS

Subject SY-101 CONTAINER, PUMP & SHIELDING CG

Originator W.A. DENSON Date 2/5/95

Checker [signature] Date 3/16/95



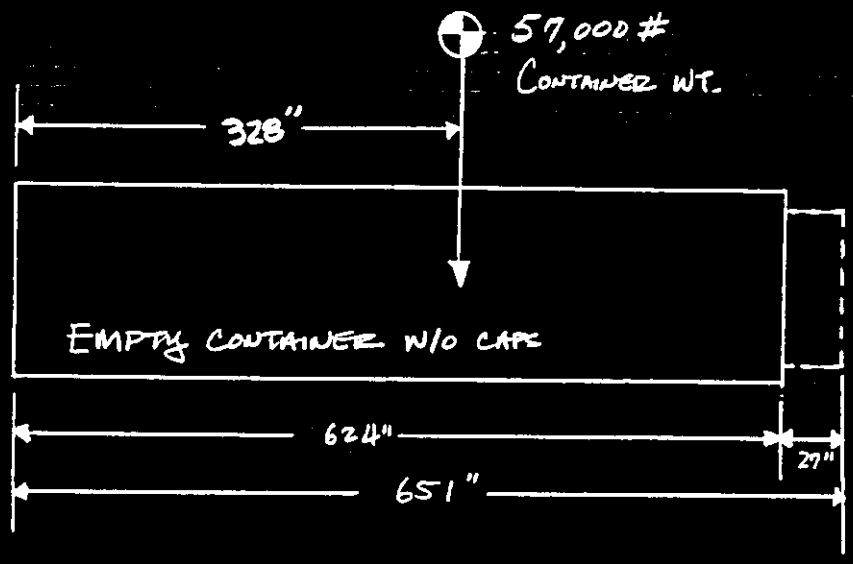
CONTAINER
DWG# H-2-83734

ANALYTICAL CALCULATIONS

Subject SY-101 EMPTY CONTAINER C.G. & WEIGHT

Originator W.A. NEWSOM Date 3/1/95

Checker Randy Jarvis Date 3/16/95



- CONTAINER DIM'S REF. DWG H-2-83734
- CAP DIM'S REF. DWG H-2-83734
- C.G. & WT. OF CONTAINER REF. WHC-SD-TP-SEP-026, PG. B6-8 & B6-9

ANALYTICAL CALCULATIONS

Subject C.G. OF KAMP TRAILER FROM SCALE WEIGHTS

Originator W.A. Newsom Date 2/3/95

Checker Gary Jasinski Date 3/16/95

SCALE WEIGHTS ON KAMP TRAILER: [EMPTY]

KING PIN = 37,740 #
REAR DRIVES = 82,600 #
TOTAL WT. = 120,340 #

RUNNING GEAR WT. = 22,974 # (FROM KAMP INFO)

TRAILER WT. W/O RUNNING GEAR = 97,366 #

$$\Sigma M_{R_2} = 0 ; \quad X_{CG} = \frac{(R_1)(\text{dist. b/w } R_1 \text{ to } R_2)}{\text{TOT. WT. OF TRAILER}} = \frac{(37{,}740\#)(850.6")}{97{,}366.\#} = 329.7"$$

$X_{C.G.}$ (ACTUAL) = 330." (DIST. FROM RXN FORCE R_2, NOT THE REAR OF TRAILER!)

DIST. FROM TRAILER REAR - STRONGBACK BRACKET TO C.G. = 329." + 29.4" = 359."

GRAHAM BARR'S CALC. ⇒ CG = 337"

DIFF. = 337" - 330." = 7"

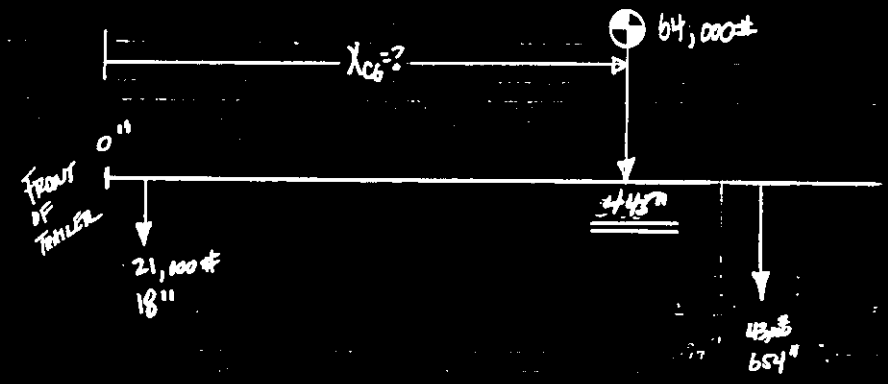
ANALYTICAL CALCULATIONS

Subject C.G. OF 150 TON TRAILER

Originator W.F. NELSON Date

Checker [signature] Date 3/16/95

REFERENCE: NELSON MFG. DWG# 890607
& TONY NIESE @ NELSON



FIND CG:

$$X_{CG} = \frac{\Sigma \text{Moments}}{\text{Wt.}} = \frac{(21\text{K})(18) + (43\text{K})(654)}{64\text{K}}$$

$$= \frac{28500 \text{ in}}{64} = 445$$

$$= \underline{445 \text{ in.}}$$

186 − 18 − 445 = 323" (C.G. FROM REAR OF TRAILER)

ANALYTICAL CALCULATIONS

Subject TRACTOR - WHC ALLOWABLE KINGPIN LOAD

Originator W.A. NEWSOM Date 3/1/95

Checker Randy Jonsen Date 3/16/95

TRACTOR

GVWR = 95,760 #
TRACTOR WT. = 31,375 #
} REF. WHC TRACTOR SPEC. SHEET IN APPENDIX

64,385 #

↑

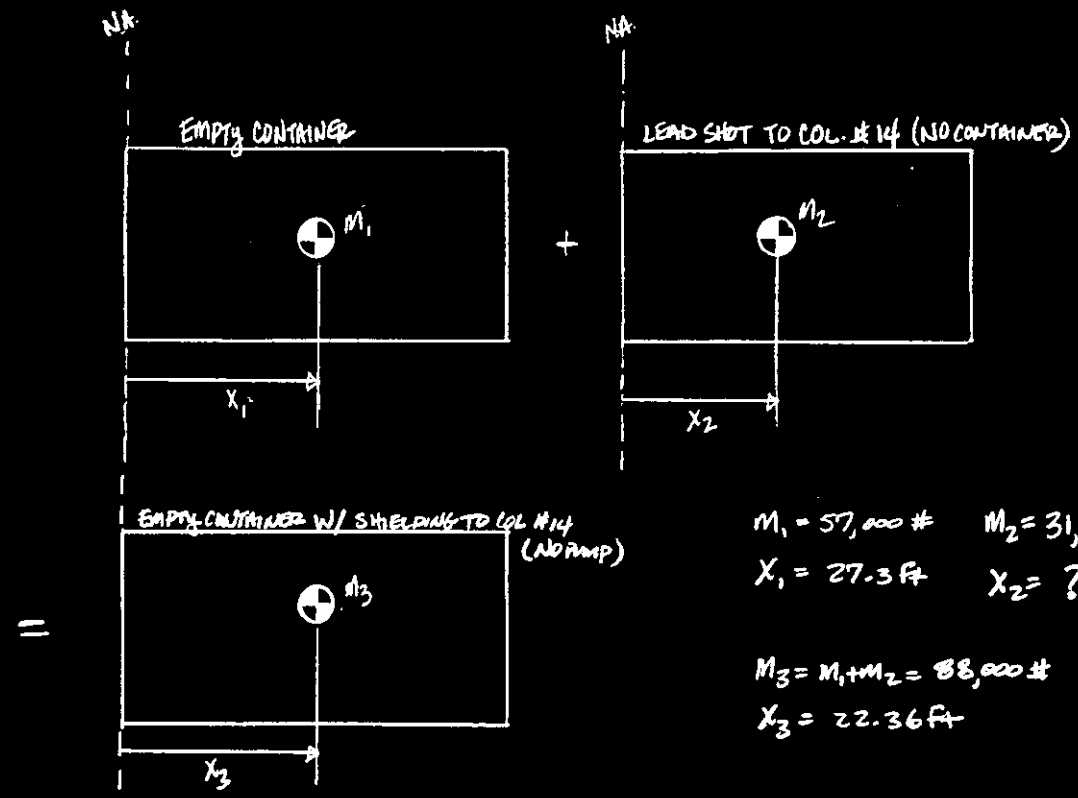
WHC TRACTOR ALLOWABLE LOAD (i.e. Kingpin ALLOWABLE LOAD)

ANALYTICAL CALCULATIONS

Subject DETERMINE C.G. OF LEAD & STEEL SHOT ALONE FOR SY101

Originator W.E. NEWSOM Date 2/28/95

Checker Cindy Jones Date 3/16/95



$M_1 = 57{,}000$ # $M_2 = 31{,}000$ #

$X_1 = 27.3$ ft $X_2 = ?$

$M_3 = M_1 + M_2 = 88{,}000$ #

$X_3 = 22.36$ ft

By Principles of Superposition:

$$M_1X_1 + M_2X_2 = M_3X_3 \quad ; \quad X_2 = \frac{M_3X_3 - M_1X_1}{M_2} = \frac{M_1(X_3 - X_1) + M_2X_3}{M_2}$$

$$X_2 = \frac{(57{,}000)(22.36 - 27.3) + (31{,}000)(22.36)}{(31{,}000)}$$

$$X_2 = 13.28 \text{ ft}$$

ANALYTICAL CALCULATIONS

Subject FIND C.G. OF CONTAINER W/ STEEL SHOT TO COL #14

Originator W.A. Newsom Date 3/2/95

Checker Randy Lawson Date 3/16/95

BY PRINCIPLES OF SUPERPOSITION

$$M_1X_1 + M_2X_2 = M_3X_3$$

$$X_3 = \frac{M_1X_1 + M_2X_2}{M_3} = \frac{M_1X_1 + M_2X_2}{M_1 + M_2}$$

$$X_3 = \frac{(57{,}000)(27.3) + (21{,}450)(13.28)}{78{,}450}$$

$X_3 = 23.47$ ft (282")

$M_1 = 57{,}000$ # : EMPTY CONT.
$X_1 = 27.3$ FT.

$M_2 = 21{,}450$ # : STEEL SHOT TO COL 14 REF PREV. CALC.
$X_2 = 13.28$ ft : CG OF SHOT REF PREV. CALC.

$M_3 = 78{,}450$ # : EMPTY CONT. & STEEL SHOT
$X_3 = ?$: FIND

FIND C.G. OF CONTAINER, STEEL SHOT TO COL 14, & PUMP.

$$M_1X_1 + M_2X_2 = M_3X_3$$

$$X_3 = \frac{M_1X_1 + M_2X_2}{M_3}$$

$$X_3 = \frac{(79{,}000)(28.45') + (21{,}450)(13.28)}{100{,}450}$$

$M_1 = 79{,}000$ # : CONTAINER & PUMP (# IS PLUS 3,000#)
$X_1 = 28.45$ ft : REF WHC-SD-TP-SEP-026 pg B6-9

$M_2 = 21{,}450$ # : STEEL SHOT TO COL. 14, REF PREV. CALC.
$X_2 = 13.28$ ft : REF. PREV. CALC.

$M_3 = 100{,}450$ # :
$X_3 = ?$ FIND

$X_3 = 25.21$ ft (303 in) = LOADED CONT. W/ STEEL SHOT TO COL #14 C.G.

ANALYTICAL CALCULATIONS

Subject WT. OF STEEL SHOT TO COL. # 14

Originator WA NEWSOM Date 3/7/95

Checker Randy Lawson Date 3/16/95

THE STEEL & LEAD SHOT OCCUPY THE SAME VOLUME UP TO COLUMN # 14 OF THE CONTAINER. THUS, BOTH TYPES OF SHOT WILL HAVE THE SAME CENTER OF GRAVITY LOCATION, WHICH IS 13.28 ft FROM THE BOTTOM OF THE CONTAINER, AS FOUND ON THE PREVIOUS PAGE.

$$\text{WT. OF STEEL SHOT TO COL. \#14} = (\text{WT. OF LEAD SHOT TO COL. \#14})\left(\frac{\text{Den. Steel}}{\text{Den. lead}}\right)$$

$$= (31{,}000\#)\left(\frac{.283\ \text{lbs/in}^3}{.409\ \text{lbs/in}^3}\right) = 21{,}450\#$$

$$\text{WT. OF STEEL SHOT TO COL \#14} = \underline{21{,}450\#}$$

ENGINEERING ANALYSIS

A-10

Drawing H-2-83734 Doc. No. 101-SY-WTCG-01 Page 1 of 25
Building Tank 241-SY-101 Rev. 0 Job No.
Subject Weight and Center of Gravity Determination
Originator S. S. Shiraga Date 07/29/94
Checker S. R. Crow Date 08/25/94

I. Objectives:

The objective of this is to determine the weight and center of gravity of the Hydrogen Mitigation Mixer Pump Package.

II. References:

1. Industrial Press, Machinery's Handbook, 20th Edition.

2. AISC, American Institute Of Steel Construction, Manual Steel Construction, Ninth Edition.

3. WHC, Drawing, No. H-2-83734, "Hydrogen Mixer Pump Storage Container".

4. Ingersoll-Rand, Compressed Air and Gas Data, 2nd Edition.

III. Results and Conclusions:

The weight and center of gravity calculated herein, form the basis for other engineering evaluations applicable to this package. The calculated values ar conservative estimates of the actual weight and are the primary input paramet for the drop, lifting, and vibration evaluations. For reasons of conservatism all calculated weights have been rounded upwards. Center of gravity values are all relative to the center of the Bottom End Blind Flange, except for the Top Caps which are relative to the front face of the Top End Flange. The weight and center of gravity of the package for various loading combinations are as follows:

1. Weight of empty package no shielding: W_{empty} = 57,000 lbs

   CG of empty package no shielding: cg_{epack} = 27.3 ft

2. Weight of empty package with shielding to Column 14:

   $W_{sh1pack}$ = 88,000 lbs

   CG of empty package with shielding to Column 14:

   $cg_{sh1pack}$ = 22.36 ft

3. Weight of empty package with full shielding (Column 25):

   $W_{sh2pack}$ = 130,000 lbs

   CG of empty package with full shielding (Column 25):

   $cg_{sh2pack}$ = 26.62 ft

4. Weight of loaded package with no shielding:

ENGINEERING ANALYSIS

A-11

Drawing H-2-83734 Doc. No. 101-SY-WTCG-01 Page 2 of 25
Building Tank 241-SY-101 Rev. 0 Job No.
Subject Weight and Center of Gravity Determination
Originator S. S. Shiraga Date 07/29/94
Checker S. R. Crow Date 08/25/94

W_{pack} = 76,000 lbs

CG of loaded package with no shielding:

cg_{pack} = 28.45 ft

5. Weight of loaded package shielded to Column 14:

$W_{packsh1}$ = 110,000 lbs

CG of loaded package shielded to Column 14:

$cg_{packsh1}$ = 29.59 ft

6. Weight of loaded package fully shielded to Column 25:

$W_{packsh2}$ = 145,000 lbs

CG of loaded package fully shielded to Column 25:

$cg_{packsh2}$ = 31.83 ft

ANALYTICAL CALCULATIONS

Subject LAMPSON TRACTOR CAPACITY

Originator W.A. NEWSOM Date 3/6/95

Checker Randy Johnson Date 3/16/95

PER TELEPHONE CONF. WITH RUSTY RUTHERFORD AT LAMPSON (586-0411 EXT. 272) AND THE ATTACHED FAX:

LAMPSON WILL RENT A TRACTOR ABLE TO PULL THE KAMP TRAILER LOADED TO THE MAXIMUM SCENARIO.

LAMPSON TRACTOR CAPACITY:

KING PIN LOAD > 80,000 lbs.

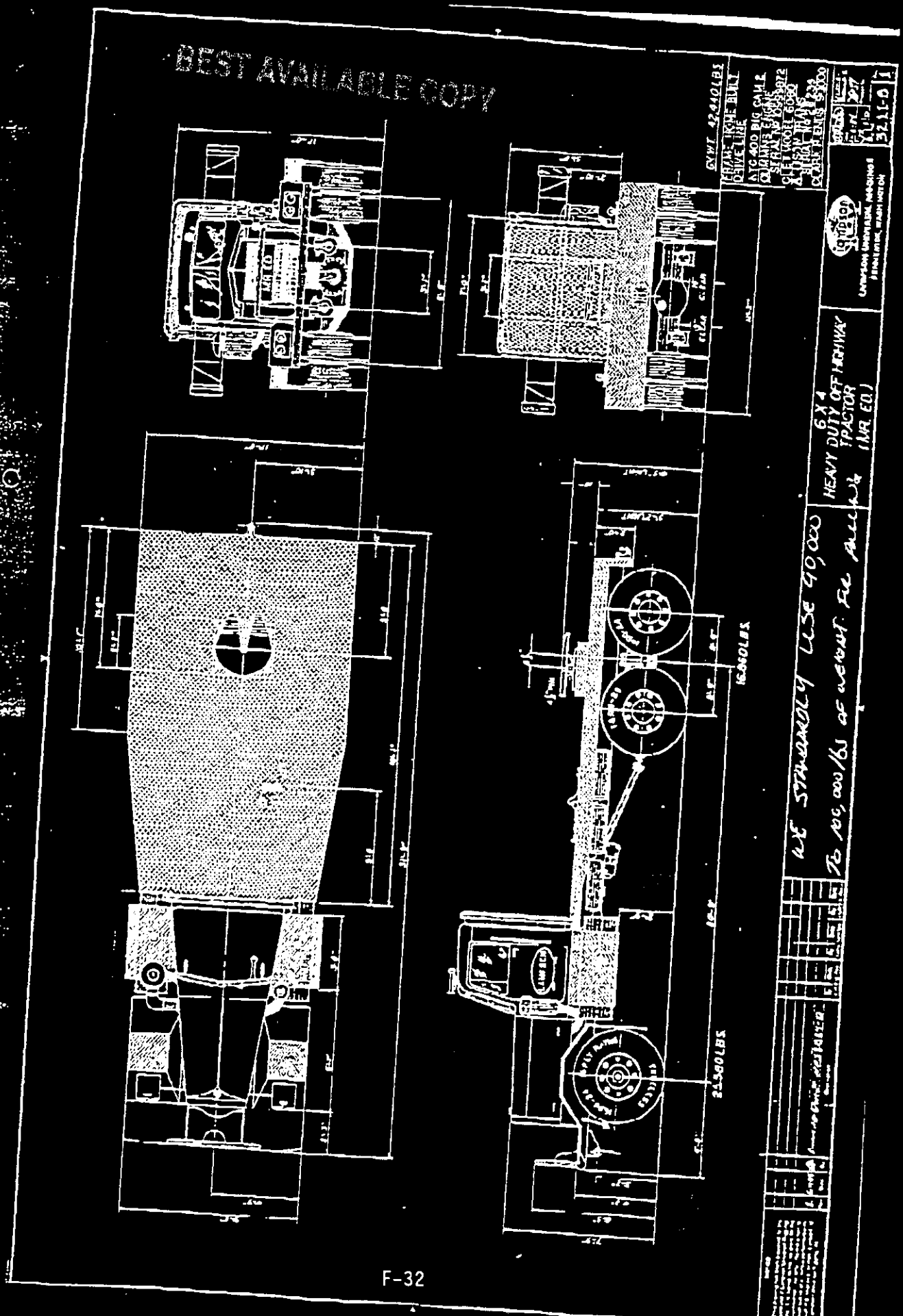
TOTAL TRAILER LOAD > 400,000 lbs.

DATA SHT. ON FOLLOWING PAGE IS LAMPSON'S TRACTOR THAT LAMPSON REFERS TO AS "MR. RD." LAMPSON HAS ANOTHER TRACTOR AVAILABLE WITH SIMILAR CAPACITY ("DINKY"). THE DATA SHT. FOR "DINKY" (IN ADDITION TO "MR. ED") ARE CONTAINED IN WHC-SD-WM-SDD-053, "SYSTEM DESIGN DESCRIPTION, 241SY101 EQUIPMENT REMOVAL SYSTEM."

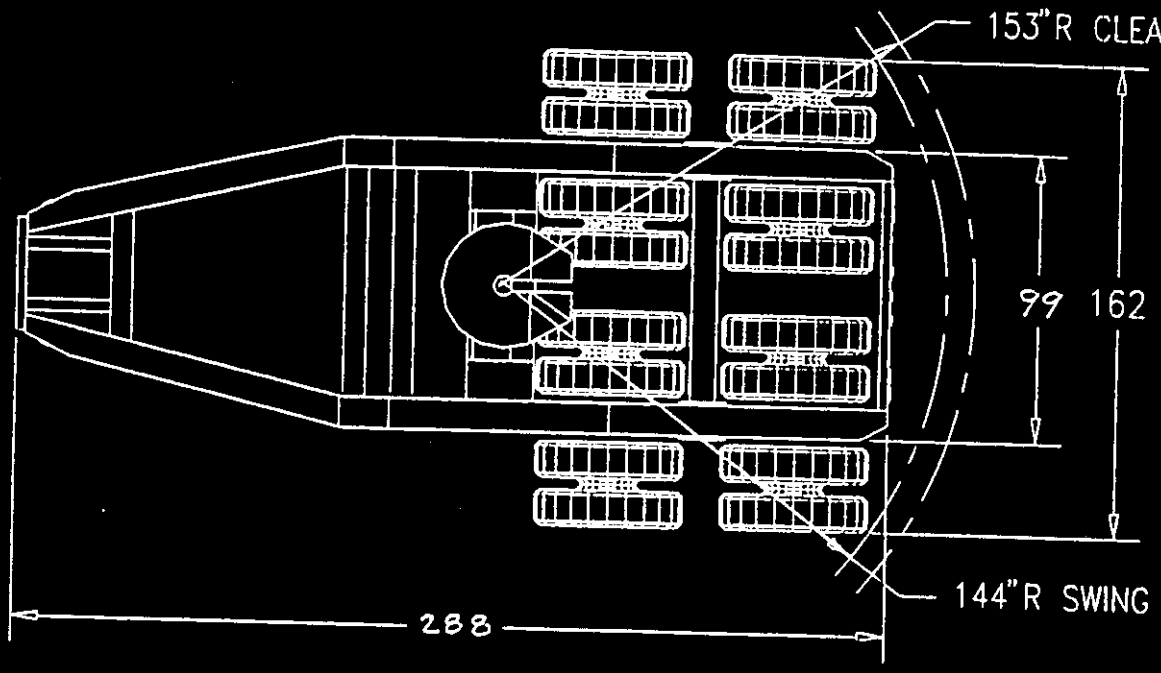
Randy Johnson 7/25/95

A-13

BEST AVAILABLE COPY

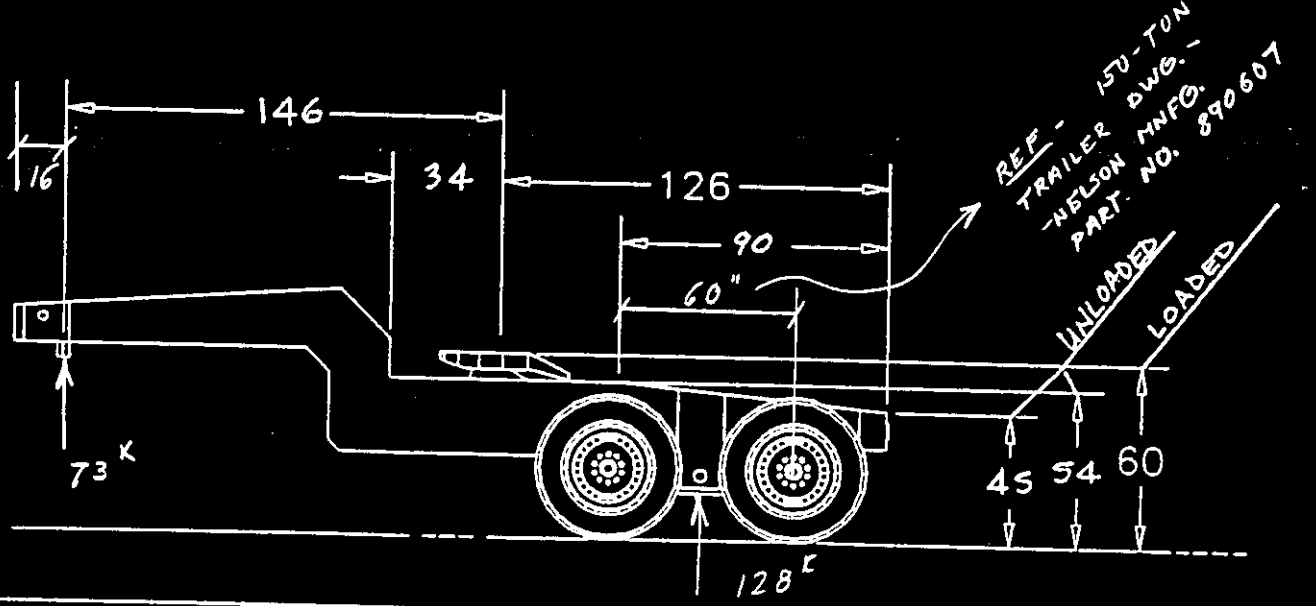


P.01
DISPATCH LAMPSON



APPROX JEEP WEIGHT – 20,000#

12.00 X 24 – 18 PLY TIRES
WALKING BEAM SUSPENSIONS
BUDD STEEL WHEELS
45,000# CAPACITY TRUNION AXLES
18 X 7 AIR BRAKES



MODEL TD-150F

SCALE – 3/16" = 1'-0"

DESIGN CALCULATION

(1) Drawing _____ (2) Doc. No. _____ (3) Page A-15 of _____

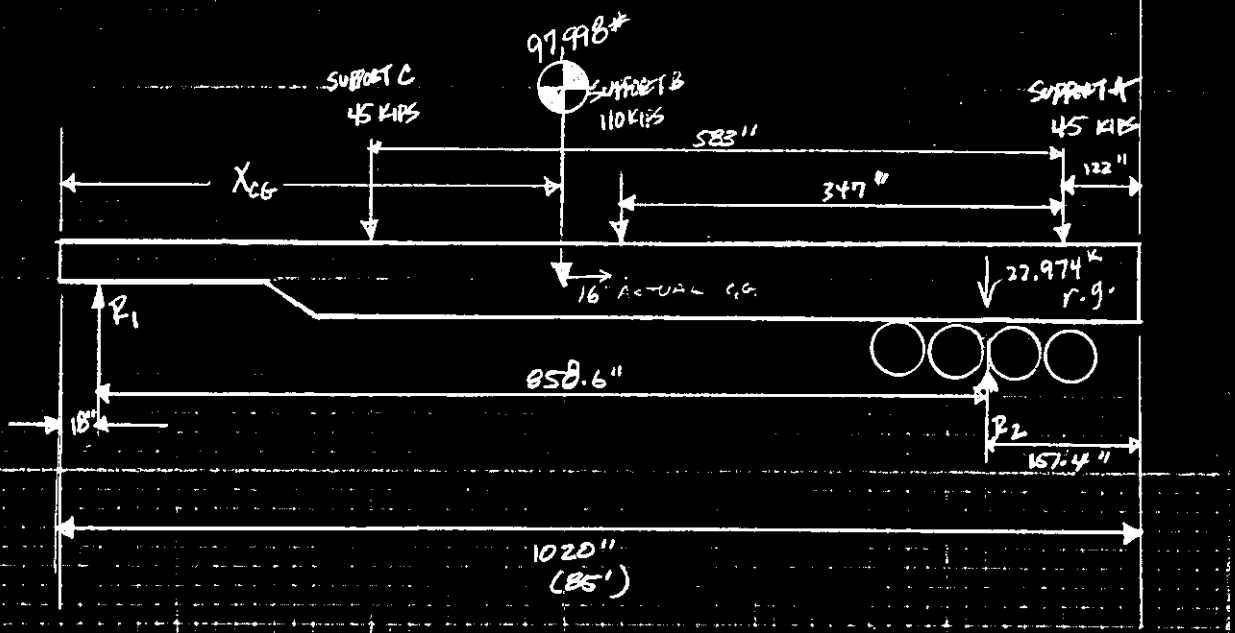
(4) Building _____ (5) Rev. _____ (6) Job No. _____

(7) Subject SY 101 TRAILER – CG CALC. WORKING BACKWARDS FROM BARR'S CALCS.

(8) Originator M.A. NEWSOM Date 12/9/94

(9) Checker [signature] Date 3/16/95

(10) CG OF TRAILER – FROM KAMP CALCS. MAX DESIGN LOAD



*NOTE: R_2 INCREASED BY 22,974# FOR THE WEIGHT OF THE RUNNING GEAR! $R_2 = 191{,}233 + 22{,}974 = 214{,}207$

$$\Sigma M_{R_1} = 0 = 45000(305") + 110000(541") + 97{,}998(X_{CG}) + 45000(858") + 22{,}974(859") - (214{,}207)(859")$$

SOLVE FOR X_{CG}:

$$X_{CG} = \frac{1.33E8 - 1.84E8}{97{,}998} = \frac{-5.11E8}{97{,}998} = -521.2 \text{ (NEG. MEANS TO THE LEFT)}$$

$$X_{CG} = 521" \text{ (FROM } R_1\text{)}, \; 337" \text{ (FROM } R_2\text{)}$$

$\Sigma F_y = 0 = 45 \text{ KIPS} + 45 + 110 + 99.998 - 214.207 + 22.974$ } $R_1 = 106{,}765$# (SAME AS G. BARR FROM KAMP SYSTEMS, INC. CALCULATED)

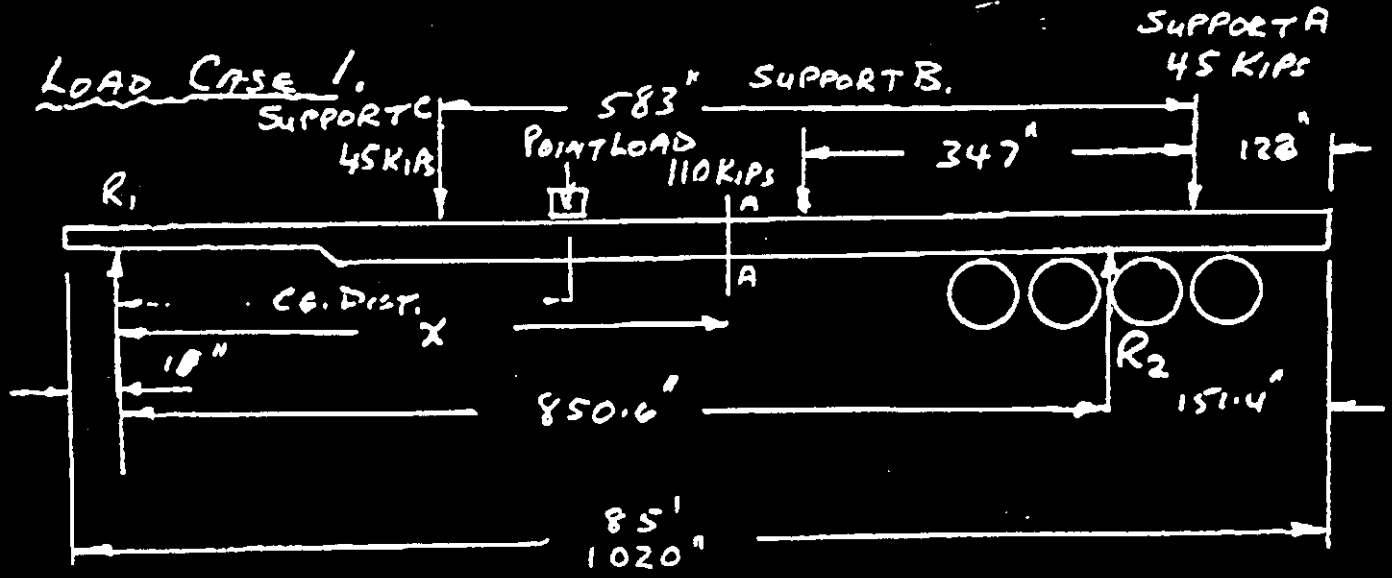
SEP A-16

GRAHAM S. S. BARR	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 5 of . . .
		ORIG BY: G.S.S.B.	DATE: 9/04/94.
		CHK'D BY:	DATE:
SUBJECT: KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM: HANFORD SY-1-1 MITIGATION/SAFETY.	

TRAILER MAIN BEAM BENDING STRESSES.

THE TRAILER COMPONENT WEIGHTS AND C.G. LOCATIONS WERE TABULATED USING A SPREAD SHEET COMPUTER PROGRAM. DATA FROM THIS WAS USED TO CALCULATE THE TONGUE AND RUNNING GEAR REACTION LOADS.

LOAD CASE 1.



TAKING MOMENTS ABOUT R_1

$$R_2 = \frac{\Sigma \text{ MOMENTS}}{850.6}$$

R_2 = 191,233 lb.

R_1 = Σ WEIGHTS − R_2

R_1 = 297,998 − 191,233

R_1 = 106,765 lb.

R_1 Should Be

DAK-324621

RECEIVING AND INSPECTION REPORT FOR EQUIPMENT

(1) Receiving Report No.

(2) Purchase Order No. GAS-BBB326627

☒ INCOMING ☐ OUTGOING

TO BE COMPLETED UPON ARRIVAL AND IMMEDIATLY PRIOR TO RELEASE FROM PROJECT OF ALL EQUIPMENT.

(3) Date Received 8-17-84

(4) Date Inspected 8-17-84

(5) Shipper Dak Mfg Co Box 188 Mitchell SDak

(6) ☐ Rail ☒ Truck Via: ☐ Express ☐

(7) Purchased F.O.B. ☐ Origin ☒ Destination

(8) Type Of Equipment Dump Body 3 axle

(9) Manufacturer Dak Mfg Co Mitchell S Dak

(10) Year 1984 (11) Equipment Unit No. 164-5737

(12) Model 4548-1220

(13) Body No.

(14) Body Make DuraEase

(15) Mfgr. Serial No. 1DA73C774EM007625

(16) Chassis No.

(17) Body Dimensions S.O.A. 28240

(18) Gross Weight

(19) License No.

(20) Key No.

ENGINE

Manufacturer

Model

Eng. Serial No.

Type ☐ Gas ☐ Diesel ☐ Air ☐ Electric ☐ Air-Cooled ☐ Water Cooled

60 TON

		Good	Fair	Bad
1	Appearance new	✓		
2	Motor (Type)			
3	Cooling System			
4	Starting Motor			
5	Wiring			
6	Ignition System			
7	Injector Pump			
8	Compressor			
9	Oil Filter			
10	Air Cleaner (Type			
11	Battery - Cable			
12	Front End Reinforced 2 steel	✓		
13	Shock Absorbers			
14	Tow Hooks			
15	Tires - Front			
16	Body Interior			
17	Glass			
18	Instruments			
19	Oil Pressure			
20	Master Clutch			
21	Transmission (No. Speeds)	✓		
22	Brakes (Type) Air	✓		
23	Emergency Brake	✓		
24	Miles - Hours	✓		
25	Cab - Body - Type Platform	✓		
26	Lights Red Marks	✓		
	SPECIAL EQUIPMENT			
27	Fire Extinguisher			
28	Heater			
29	Spot Light			
30	Seat Covers			
31				
32				
33	Tires (Rear) 10R22.5 x (12)	✓		
34	Tires (Spare) None	✓		
35	Rear Axle Eaton	✓		
36	Pintle Hook			
37	Drive Line - Joints			
38	Fifth Wheel 2" King pin	✓		
39	Tail Gate			
40	Body Hoist			
41	Horse Power			
42	Wheel Base			
43	Weight 15000 lbs approx			

		Good	Fair	Bad
44	Size 48 ft			
45	GVWR [redacted]			
46	GAWR Front 20,000 lbs			
47	GAWR Rear 2[illegible]			
48	Quick Center 2[illegible]			
49				
50				
51	Roof deck area			
52	30 x 3"			
53				
54				
55	King pin location 30"			
56	King pin height loaded			
57	49"			
58				
59				
60	Roof deck height 36"			
61				
62	Underbody 20"			
63				
64	Aprons 46"			
65				
66	Roof post 84"			
67				
68	Width at top 102"			
69				
70	3" Quality deck board			
71	oak			
72				
73	Bumper plate per print			
74	bed			
75				
76	Fuel Tank			
77	Steering Device			
78	Hyd. Pump		✓	
79	Frame		✓	
80	Open Gears			

Warranty: 12 months

Color: safety yellow

EQUIPMENT ATTACHED:

1 Instruction Card & literature in cab per spec with [illegible]

2 3" x 1" steel tie down [illegible]

3 [illegible]

4 [illegible]

5 [illegible]

6 [illegible]

☒ Acceptance ☐ Rejection

Signature Of Inspector [illegible]

Approved [illegible]

Indicate in detail and if space is insufficient, continue report on reverse side. Identify each item listed with a number. Indicate condition of each item in the appropriate column numbers. List tools on reverse side.

SD-9100-043 (5-84)

RFQ W-230247

A-10

RECEIVING AND INSPECTION REPORT FOR EQUIPMENT

[X] INCOMING [ ] OUTGOING

(1) Receiving Report No.

(2) Purchase Order No. W-SD-230247

(3) Date Received 9-6-91

(4) Date Inspected 9-8-91

TO BE COMPLETED UPON ARRIVAL AND IMMEDIATLY PRIOR TO RELEASE FROM PROJECT OF ALL EQUIPMENT.

(5) Shipper Wilson Mfg Co. 6448 U.S. RT 224 E Ottawa Ohio

(6) Via: [ ] Rail [ ] Express [X] Truck

(7) Purchased F.O.B. [ ] Origin [X] Destination

(8) Type Of Equipment Flat bed trailer with ramp

(9) Manufacturer Wilson Mfg Co. Ottawa, Ohio

(10) Year 1991

(11) Equipment Unit No. [illegible]

(12) Model TD-150F

(13) Body No. VIN # 1N9B14A6XM1012605

(14) Body Make

(15) Mfgs. Serial No. 4502

(16) Chassis No.

(17) Body Dimensions

(18) Gross Weight

(19) License No.

(20) Key No.

ENGINE

Manufacturer Jeep Iron Head 4D 15

Model Serial # 4403

VIN No. 1N9E14A6XM1012605

Type [ ] Gas [ ] Diesel [X] Air [ ] Electric [ ] Air Cooled [ ] Water Cooled

		Good	Fair	Bad
1	Appearance new			
2	Motor (Type)			
3	Cooling System			
4	Starting Motor			
5	Wiring			
6	Ignition System			
7	Injector Pump			
8	Compressor			
9	Oil Filter			
10	Air Cleaner (Type)			
11	Battery - Cable			
12	Front End			
13	Shock Absorbers			
14	Tow Hooks			
15	~~Fuel~~ Front Extendable gooseneck			
16	Body Interior (2) 8 foot			
17	Glass			
18	Instruments			
19	Oil Pressure			
20	Master Clutch			
21	Transmission (No. Speeds)			
22	Brakes (Type)			
23	Emergency Brake Air Spring release			
24	Miles - ~~Hours~~			
25	Cab - Body - Type Low boy flat bed			
26	Lights 12 VOLT			
	SPECIAL EQUIPMENT			
27	Fire Extinguisher			
28	Heater			
29	Spot Light			
30	Seat Covers			
31	1200 x 24 F (12) Jeep			
32				
33	Tires (Rear) 1300 x 24 (20) Goodyear			
34	Tires (Spare)			
35	Rear Axle 3 axle Dunn steel			
36	Pintle Hook			
37	Drive Line - Joints 2 axle Dunn Jeep			
38	Fifth Wheel			
39	Tail Gate			
40	Body Hoist			
41	Horse Power			
42	Wheel Base			
43	Weight 8 Four Un			

		Good	Fair	Bad
44	Size 150 Ton			
45	GVWR 200,000 lbs			
46	GAWR Front 45,000 lbs			
47	GAWR Rear 45,000 lbs			
48	45,000 lbs			
49	45,000 lbs			
50	45,000 lbs			
51	45,000 lbs			
52				
53				
54	Lowbed 30 ft			
55	O/A length inches			
56				
57	Trailer 105 ft			
58				
59				
60	Jeep 24 ft long			
61				
62	Equipment bed			
63	deck 13 ft 6 inch			
64				
65				
66	Jeep 12 ft wide			
67				
68	2 1/2" & 2" pins			
69				
70				
71	Ramps 60" deck height			
72				
73	+ King pin			
74				
75				
76	Fuel Tank			
77	Braking Device			
78	Hyd. Pump			
79	Frame			
80	Open Gears			

EQUIPMENT ATTACHED:

1. Equipment bed 3" thick
2. Tie down reinforcement plates
3. Hold down to wheel bed
4. Steel Ramps
5. Jeep deck width
6. Stamped with Jeep number
7. Wiring harness with connectors

Warranty: One Year

Color: White

[X] Acceptance [ ] Rejection

Signature Of Inspector

Approved

Indicate in detail and if space is insufficient, continue report on reverse side. Identify each item listed with a number. Indicate condition of each item in the appropriate column numbers. List tools on reverse side.

A-19

Reg A-214210

RECEIVING AND INSPECTION REPORT FOR EQUIPMENT

☒ INCOMING ☐ OUTGOING

(1) Receiving Report No.

(2) Purchase Order No. MSR-BBB394310

TO BE COMPLETED UPON ARRIVAL AND IMMEDIATLY PRIOR TO RELEASE FROM PROJECT OF ALL EQUIPMENT.

(3) Date Received 12-10-85

(4) Date Inspected 12-13-85

(5) Shipper Naval Const. Battalion Ctr. Port Hueneme, Calif.

(6) Via: ☐ Rail ☒ Truck ☐ Express ☐

(7) Purchased F.O.B. ☐ Origin ☒ Destination

(8) Type Of Equipment Truck Tractor

(9) Manufacturer Mack Trucks Allentown, Pa.

(10) Year 1974

(11) Equipment Unit No. [illegible]

(12) Model DM897SX

(13) Body No. [illegible]

(14) Body Make Mack

(15) Mfgs. Serial No. 1115

(16) Chassis No.

(17) Body Dimensions

(18) Gross Weight

(19) License No.

(20) Key No. [illegible]

WHC TRACTOR

ENGINE

Manufacturer Mack Trucks

Model ENDT-866 U8

Eng. Serial No. T866 8U590

95,600 31,325

Type ☐ Gas ☒ Diesel ☐ Air ☐ Electric ☐ Air Cooled ☒ Water Cooled

		Good	Fair	Bad			Good	Fair	Bad
1	Appearance Used	✓			44	Size 6x4			
2	Motor (Type) V8 Diesel	✓			45	GVWR [illegible]			
3	Cooling System Water HD	✓			46	GAWR Front 40,000 lbs			
4	Starting Motor 24 Volt	✓			47	GAWR Rear 40,000 lbs			
5	Wiring 24 Volt	✓			48	[illegible]			
6	Ignition System				49				
7	Injector Pump	✓			50	[illegible]			
8	Compressor 15 CFM	✓			51	Model [illegible]			
9	Oil Filter Replacable	✓			52				
10	Air Cleaner (Type) Dry	✓			53	100 ft [illegible] 3/4" cable			
11	Battery - Cable (4) 12 Volt	✓			54				
12	Front End	✓			55	60,000 lb capacity			
13	Shock Absorbers Front	✓			56				
14	Tow Hooks (2) (1) Tow Pin	✓			57	8" Drum			
15	Tires - Front 1200x24 14 ply (2)	✓			58				
16	Body Interior	✓			59	Unit has heat [illegible]			
17	Glass	✓			60	rack & platform			
18	Instruments Gauge	✓			61				
19	Oil Pressure	✓			62	[illegible]			
20	Master Clutch	✓			63	platform behind [illegible]			
21	Transmission (No. Speeds) 4 Manual	✓			64				
22	Brakes (Type) Air	✓			65	[illegible]			
23	Emergency Brake Spring set				66				
24	Miles - Hours 516 hrs 113.11 mi				67	3/4 Cab. [illegible]			
25	Cab - Body - Type Truck Tractor				68	[illegible]			
26	Lights 12 Volt				69				
	SPECIAL EQUIPMENT				70	[illegible]			
27	Fire Extinguisher				71	44" hide			
28	Heater & defroster				72	113" hide			
29	Spot Light				73	3/4" long			
30	Seat Covers Black Vinyl				74				
31					75				
32					76	Fuel Tank (2) [illegible] 105 gals			
33	Tires (Rear) 1400x24 20 ply (2)				77	Steering Device Power			
34	Tires (Spare) 1200x24 14 ply (1)				78	Hyd. Pump			
35	Rear Axle Tandem				79	Frame	✓		
36	Pintle Hook				80	Open Gears			
37	Drive Line - Joints					EQUIPMENT ATTACHED:			
38	Fifth Wheel 2½ or 3½"					1. [illegible]			
39	Tail Gate					2. [illegible]			
40	Body Hoist					3. [illegible]			
41	Horse Power 375 @ 2200 RPM					4. [illegible]			
42	Wheel Base [illegible] 193"					5. [illegible]			
43	Weight 31,375					6. [illegible]			
						7. [illegible]			
						8. [illegible]			
						9. [illegible]			
						10. [illegible]			
						11. [illegible]			

Warranty:

Color: Drab Green

☐ Acceptance ☐ Rejection

Signature Of Inspector [illegible]

Approval

Indicate in detail and if space is insufficient, continue report on reverse side. Identify each item listed with a number. Indicate condition of each item in the appropriate column numbers. List tools on reverse side.

BD-9100-043 (8-84)

APPENDIX G

Results of FEA Model KAMP11A

Please note that this finite-element model is nearly the same as the FEA model KAMP11. The only difference is the removal of four torsional reinforcement tubes.

```
**********************************************************************
**********************************************************************
**                                                                  **
**                                                                  **
**  CCCC   0000   SSSS   M     M   0000   SSSS     / M     M  **
**  C      0  0   S      MM   MM   0  0   S       /  MM   MM  **
**  C      0  0   SSSS   M M M M   0  0   SSSS   /   M M M M  **
**  C      0  0      S   M  M  M   0  0      S  /    M  M  M  **
**  CCCC   0000   SSSS   M     M   0000   SSSS /     M     M  **
**                                                                  **
**                                                                  **
**                       VERSION:  1.71                             **
**                     DISTRIBUTED BY:                              **
**      STRUCTURAL  RESEARCH  AND  ANALYSIS  CORPORATION            **
**               2951 28TH STREET SUITE 1000                        **
**            SANTA MONICA,   CALIFORNIA    90405                   **
**               TEL. NO.   (310)  452-2158                         **
**              COPYRIGHT  1988   S. R. A. C.                       **
**                                                                  **
**********************************************************************
**********************************************************************

Licensed to :
Problem name: KAMP11A
Date        : 07/19/1995     Time:   13:45:39
Title       :
|
Subtitle    :


 C O N T R O L  I N F O R M A T I O N
  NUMBER OF LOAD CASES  . . . . . (NLCASE)  =        1
  SOLUTION MODE . . . . . (MODEX)   =        2
     EQ. 0, STATIC ANALYSIS
     EQ. 1, BUCKLING ANALYSIS
     EQ. 2, DYNAMIC ANALYSIS
  THERMAL LOADING FLAG . . . . . .(ITHERM)  =        0
     EQ. 0, NO THERMAL EFFECTS CONSIDERED
     EQ. 1, ADD TEMPERATURE EFFECT
  GRAVITY LOADING FLAG . . . . . .(IGRAV)   =        0
     EQ. 0, NO GRAVITY LOADING CONSIDERED
     EQ. 1, ADD GRAVITY LOADING EFFECT
  CENTRIFUGAL LOADING FLAG . . . . . .(ICNTRF)  =        0
     EQ. 0, NO CENTRIFUGAL LOADING CONSIDERED
```

```
      EQ. 1, ADD CENTRIFUGAL LOADING EFFECT
   IN-PLANE STIFFENING FLAG . . . . . .(INPLN)   =        0
      EQ. 0, NO IN-PLANE EFFECTS CONSIDERED
      EQ. 1, IN-PLANE EFFECTS CONSIDERED
   SOFT SPRING ADDITION FLAG . . . . . (ISOFT)   =        0
      EQ. 0, NO SOFT SPRING OPTION
      EQ. 1, SOFT SPRING ADDED

   SAVE DECOMPOSED STIFFNESS MATRIX FLAG . . . (ISAVK)   =        0
      EQ. 0, DO NOT SAVE DECOMPOSED K
      EQ. 1, SAVE DECOMPOSED K
   FORM STIFFNESS MATRIX FLAG . . . . . .(IFORMK)  =        0
      EQ. 0, FORM STIFFNESS MATRIX
      EQ. 1, USE EXIST DECOMPOSED STIFFNESS MATRIX

  T O T A L  S Y S T E M  D A T A
   NUMBER OF EQUATIONS . . . . . .(NEQ)  =     2032
   NUMBER OF MATRIX ELEMENTS . . . . . .(NWK)  =    74451
   MAXIMUM HALF BANDWIDTH . . . . . (MK )  =       78
   MEAN HALF BANDWIDTH . . . . . .(MM )  =       36
   NUMBER OF ELEMENTS. . . . . .(NUME) =      405
   NUMBER OF NODAL POINTS. . . . . .(NUMNP)=      386
   ADJUSTED BLOCK SIZE . . . . . .(MTBLK)=    74452
   EXTRA MEMORY AVAILABLE (in 8-byte words) . . .(XMTBLK)=   675548
   NUMBER OF STIFFNESS BLOCKS. . . . . (NBLK) =        1



   MAXIMUM DIAGONAL STIFFNESS MATRIX VALUE =  0.182228E+15 (  1162)
   MINIMUM DIAGONAL STIFFNESS MATRIX VALUE =  0.295733E+07 (   998)
1
```

M A S S M O M E N T I N F O R M A T I O N					
MASS	0.596894E+03	VOLUME	0.292323E+06	WEIGHT	0.230640E+06
MASS MOMENT OF INERTIA W.R.T. C.G.					
IX	0.196419E+08	IY	0.340091E+08	IZ	0.528628E+08
MASS PRODUCT OF INERTIA W.R.T. C.G.					
PXY	0.116505E+08	PXZ	0.127500E+02	PYZ	0.150000E+01
RADII OF GYRATION W.R.T. C.G.					
RX	0.181403E+03	RY	0.238698E+03	RZ	0.297596E+03

CENTER OF GRAVITY					
CGx	-0.268174E+03	CGy	0.109935E+03	CGz	0.175000E+02
PRINCIPAL MASS MOMENT OF INERTIA					
P1	0.528628E+08	P2	0.405127E+08	P3	0.131384E+08
PRINCIPAL RADII OF GYRATION					
R1	0.297596E+03	R2	0.260523E+03	R3	0.148362E+03
PRINCIPAL AXES (DIRECTION COSINES IN ROWS W.R.T C.G)					
N_11	-0.454358E-06	N_12	0.201208E-06	N_13	0.100000E+01
N_21	0.487422E+00	N_22	-0.873167E+00	N_23	0.397152E-06
N_31	0.873167E+00	N_32	0.487422E+00	N_33	0.298658E-06

S O L U T I O N P A R A M E T E R S

NUMBER OF EIGENVALUES.	(NFR)=	10
MASS TYPE: 1-LUMPED,2-CONSISTENT. . . .	(MASS)=	1
MODE SHAPE PRINT FLAG.	(MPRNT)=	0
INTERMEDIATE SOLUTION PRINT FLAG . . .	(IFPR)=	0
STURM SEQUENCE CHECK FLAG.	(IFSS)=	0
MAXIMUM NUMBER OF ITERATIONS	(ITMAX)=	16
FREQUENCY SHIFT FLAG	(IFRSH)=	0
FREQUENCY SHIFT.	(FRSH)=	0.0000000E+00
CONVERGENCE TOLERANCE.	(RTOL)=	0.1000000E-04
COMPOSITE MODAL DAMPING CALC. FLAG . .	(IMDC)=	0
MODAL ACCELERATION FLAG.	(IMAM)=	0

S U B S P A C E I T E R A T I O N

ITERATION NUMBER 1

ITERATION NUMBER 2

ITERATION NUMBER 3

ITERATION NUMBER 4

ITERATION NUMBER 5

ITERATION NUMBER 6

ITERATION NUMBER 7

CONVERGENCE REACHED FOR RTOL 0.1000E-04

F R E Q U E N C Y A N A L Y S I S
by
S U B S P A C E A L G O R I T H M

FREQUENCY NUMBER	FREQUENCY (RAD/SEC)	FREQUENCY (CYCLES/SEC)	PERIOD (SECONDS)
1	0.6462594E+01	0.1028554E+01	0.9722389E+00
2	0.1485195E+02	0.2363761E+01	0.4230547E+00
3	0.2441739E+02	0.3886149E+01	0.2573242E+00
4	0.2877793E+02	0.4580149E+01	0.2183335E+00
5	0.3106911E+02	0.4944802E+01	0.2022326E+00
6	0.4335911E+02	0.6900816E+01	0.1449104E+00
7	0.4343020E+02	0.6912131E+01	0.1446732E+00
8	0.5025236E+02	0.7997912E+01	0.1250326E+00
9	0.5873221E+02	0.9347522E+01	0.1069802E+00
10	0.8135743E+02	0.1294844E+02	0.7722940E-01

S O L U T I O N T I M E L O G (sec)

INPUT PHASE	1
ASSEMBLAGE OF THE STIFFNESS MATRIX	0
ASSEMBLAGE OF THE MASS MATRIX	0
DECOMPOSITION OF THE STIFFNESS MATRIX	0
EIGENVALUE SOLUTION	6
OUTPUT PHASE	1
TOTAL SOLUTION TIME	8

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APPENDIX H

D.S.I. from J. L. Julyk to B. L. Coverdell

JLJ-95-001

DON'T SAY IT --- *Write It!* DATE: 7/28/95

TO: B. L. Coverdell H5-57

FROM: J. L. Julyk E6-46

Telephone: 376-3567

CC: M. S. Ruben E6-46
S. K. Farnworth E6-46
T. C. Mackey S2-03

SUBJECT: Tube-Steel removal from finite-element model (AS-BUILT)

This DSI confirms that the four 6X6 in. Tube-Steel, used in the original model (KAMP11, Dated 2/24/95), was removed from the revised model (KAMP11A, Dated 7/26/95). The revised model (KAMP11A) geometry and boundary conditions verified with the original model (KAMP11). The natural frequency of the original model (with tube-steel) slightly changed from 1.07 Hz to 1.03 Hz with the removal of the tube-steel (model KAMP11A). Therefore, the removal of the tube-steel provided a small but insignificant change to the overall response of the structure.

The original model (KAMP11) was checked by Jeff Burgess, while both models were developed by Brad Coverdell. The tube-steel was removed to reflect the as built conditions. Verification of the revised as built model was needed to confirm the validity of the revised model.