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

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WHC Information Release Administration Specialist:

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September 13, 1995

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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: For R.M. Boger 7-31-95
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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.
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☒	☐	☐	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.
☒	☐	☐	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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☒	☐	☐	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
Reviewer

Randy Jorissen

5/3/95
Date

CHECKLIST FOR INDEPENDENT REVIEW

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

Author: B. L. Coverdell

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L. S. Burgess
Reviewer

2/24/95
Date

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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

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Document Reviewed: Wind Induced Vibrational Calculations (Appendix B)

Author: R. L. Jorissen

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2-24-95
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Document Reviewed Upper Hydraulic Clevis Analysis (Appendix C)

Author B. L. Coverdell

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☒	☐	☐	Safety margins consistent with good engineering practices.
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Software QA Log Number GLC-95-013

J.A. Tuck
T.K. Peterson

Reviewer

James A. Tuck

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SOFTWARE REPORT FORM

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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 inconjunction 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.

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DATE: *5-8-95*

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Document Reviewed: Lower Hydraulic Clevis Analysis (Appendix D)

Author: B. L. Coverdell

<u>Yes</u>	<u>No</u>	<u>N/A</u>	
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☒	☐	☐	Safety margins consistent with good engineering practices.
☒	☐	☐	Conclusions consistent with analytical results and applicable limits.
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~~T. K. Peterson~~

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J. A. Tuck

James A Tuck

10 MARCH '95

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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

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H5-57

CHECKLIST FOR INDEPENDENT REVIEW

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

Author: L. A. Tuck

<u>Yes</u>	<u>No</u>	<u>N/A</u>	
☒	☐	☐	Problem completely defined.
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B. L. Coverdell BLE
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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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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 versus 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

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

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 where 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

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

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 COSMOS/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/in² 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/in².

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/in²). 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 Corporation, 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 *B.L.P.*

Date February 3, 1995

Checker James A. Truck

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, I_{xx} , I_{yy} , and the torsional resistance.

CALCULATE THE CROSS-SECTIONAL AREA OF THE SECTION

$$A_{7 \times 1.5} = 7 \cdot \text{in} \cdot 1.5 \cdot \text{in}$$

$$A_{7 \times 1.5} = 10.5 \cdot \text{in}^2$$

$$A_{13 \times 1.5} = 13 \cdot \text{in} \cdot 1.5 \cdot \text{in}$$

$$A_{13 \times 1.5} = 19.5 \cdot \text{in}^2$$

$$A_{\text{outrig}} = 2 \cdot (A_{7 \times 1.5} + A_{13 \times 1.5}) \quad A_{\text{outrig}} = 60 \cdot \text{in}^2$$

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 I_{xx} AND I_{yy} .

(I_{xx})

$$I_{7 \times 1.5} = \frac{7 \cdot \text{in} \cdot (1.5 \cdot \text{in})^3}{12} + A_{7 \times 1.5} \cdot \left(\frac{16 \cdot \text{in} - 1.5 \cdot \text{in}}{2} \right)^2 \quad I_{7 \times 1.5} = 553.875 \cdot \text{in}^4$$

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

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Originator B.L. Coverdell *BLC*

Date February 3, 1995

Checker JAT

Date 23 Feb 95

$$I_{13 \times 1.5} := \frac{1.5 \cdot \text{in} \cdot (13 \cdot \text{in})^3}{12}$$

$$I_{13 \times 1.5} = 274.625 \cdot \text{in}^4$$

Moment of inertia of
10X1.5 plate about x-axis.

$$I_{xx} := 2 \cdot (I_{7 \times 1.5} + I_{13 \times 1.5})$$

$$I_{xx} = 1657 \cdot \text{in}^4$$

Total moment of inertia of
section about x-axis.

(Iyy)

$$I_{7 \times 1.5} := \frac{1.5 \cdot \text{in} \cdot (7 \cdot \text{in})^3}{12}$$

$$I_{7 \times 1.5} = 42.875 \cdot \text{in}^4$$

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

$$I_{13 \times 1.5} := \frac{10 \cdot \text{in} \cdot (1.5 \cdot \text{in})^3}{12} + A_{13 \times 1.5} \cdot \left(\frac{7 \cdot \text{in} - 1.5 \cdot \text{in}}{2} \right)^2$$

$$I_{13 \times 1.5} = 150.281 \cdot \text{in}^4$$

Moment of inertia of
10X1.5 plate about y-axis.

$$I_{xx} := 2 \cdot (I_{7 \times 1.5} + I_{13 \times 1.5})$$

$$I_{xx} = 386.313 \cdot \text{in}^4$$

Total moment of inertia of
section about y-axis.

DETERMINE THE TORSIONAL RESISTANCE OF THE SECTION.

$$b_1 := 7 \cdot \text{in}$$

$$d_1 := 1.5 \cdot \text{in}$$

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

$$b_2 := 13 \cdot \text{in}$$

$$d_2 := 1.5 \cdot \text{in}$$

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

$$R := 2 \cdot (\alpha_1 \cdot b_1 \cdot d_1^3 + \alpha_2 \cdot b_2 \cdot d_2^3)$$

$$R = 40.905 \cdot \text{in}^4$$

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

$$A_{w30 \times 191} := 56.1 \cdot \text{in}^2$$

$$A_{w30 \times 191} = 56.1 \cdot \text{in}^2$$

Cross sectional area of W30X191 (AISC 1989)

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FIND THE LOCATION OF THE SECTION CENTROID

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

DETERMINE THE MOMENT OF INERTIA ABOUT I_{xx} AND I_{yy} .

(I_{xx})

$$I_{w30x191} = 9170 \cdot \text{in}^4$$

$$I_{w30x191} = 9170 \cdot \text{in}^4$$

Moment of inertia of single W30X191 about X-axis (AISC 1989)

(I_{yy})

$$I_{w30x191} = 673 \cdot \text{in}^4$$

$$I_{w30x191} = 673 \cdot \text{in}^4$$

Moment of inertia of single W30X191 about Y-axis (AISC 1989)

DETERMINE THE POLAR MOMENT OF INERTIA FOR THE SECTION.

$$J = 20.6 \cdot \text{in}^4$$

$$J = 20.6 \cdot \text{in}^4$$

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, I_{xx} , I_{yy} , and the torsional resistance factor. Neglect any effects due to the outer deck plates.

CALCULATE THE CROSS-SECTIONAL AREA OF THE SECTION

$$A_{w30x191} = 56.1 \cdot \text{in}^2$$

$$A_{w30x191} = 56.1 \cdot \text{in}^2$$

Area of single I-Beam (AISC 1989)

$$A_{\text{rein}} = \frac{5}{8} \cdot \text{in} \cdot 12.5 \cdot \text{in}$$

$$A_{\text{rein}} = 7.813 \cdot \text{in}^2$$

Area of 1 reinforcement plates.

$$A_{\text{total}} = A_{w30x191} + 2 \cdot A_{\text{rein}}$$

$$A_{\text{total}} = 71.725 \cdot \text{in}^2$$

Total area of section

FIND THE LOCATION OF THE SECTION CENTROID

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

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DETERMINE THE MOMENT OF INERTIA ABOUT I_{xx} AND I_{yy} .

(I_{xx})

$$I_{w30x191} = 9170 \cdot \text{in}^4$$

$$I_{w30x191} = 9170 \cdot \text{in}^4$$

Moment of inertia of W30X191 about x-axis (AISC 1989).

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

$$I_{\text{rein}} = 1914.323 \cdot \text{in}^4$$

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

$$I_{xx} = I_{w30x191} + 2 \cdot I_{\text{rein}}$$

$$I_{xx} = 12998.645 \cdot \text{in}^4$$

Total moment of inertial at section F-F about x-x axis.

(I_{yy})

$$I_{w30x191} = 673 \cdot \text{in}^4$$

$$I_{w30x191} = 673 \cdot \text{in}^4$$

Moment of inertia of W30X191 about y-axis (AISC 1989).

$$I_{\text{rein}} = \frac{\frac{5}{8} \cdot \text{in} \cdot (12.5 \cdot \text{in})^3}{12}$$

$$I_{\text{rein}} = 101.725 \cdot \text{in}^4$$

Moment of inertia due to reinforcement plates.

$$I_{yy} = I_{w30x191} + 2 \cdot I_{\text{rein}}$$

$$I_{yy} = 876.451 \cdot \text{in}^4$$

Total moment of inertia of section about y-axis.

DETERMINE THE TORSIONAL RESISTANCE OF THE SECTION.

$$b_1 = 12.5 \cdot \text{in}$$

$$d_1 = .625 \cdot \text{in}$$

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

$$R = J + 2 \cdot \alpha_1 \cdot b_1 \cdot d_1^3$$

$$R = 22.632 \cdot \text{in}^4$$

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, I_{xx} , I_{yy} , 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.

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CALCULATE THE CROSS-SECTIONAL AREA OF SECTION 1

$t_{1_flange} := 1.1875 \text{ in}$	$w_{1_flange} := 15 \text{ in}$	$t_{1_web} := 0.5 \text{ in}$
$w_{1_web} := 16.25 \text{ in} - 2 \cdot t_{1_flange}$	$w_{1_web} = 13.875 \text{ in}$	
$A_{1_flange} := t_{1_flange} \cdot w_{1_flange}$	$A_{1_flange} = 17.813 \text{ in}^2$	
$A_1 := 2 \cdot A_{1_flange} + t_{1_web} \cdot w_{1_web}$	$A_1 = 42.563 \text{ in}^2$	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 I_{xx} AND I_{yy} .

(I_{xx})

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

$$I_{xx_flange} = 1012.413 \text{ in}^4 \quad \text{Section 1 x-axis moment of inertia due to flanges.}$$

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

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

(I_{yy})

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

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

$$I_{yy} := 2 \cdot I_{yy_flange} + I_{yy_web} \quad I_{yy} = 668.113 \text{ in}^4 \quad \text{Total moment of inertia of section 1 about y-axis.}$$

DETERMINE THE TORSIONAL RESISTANCE OF SECTION 1.

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

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

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$$R_1 := 2 \cdot \alpha_1 \cdot w_{1_flange} \cdot t_{1_flange}^3 + \alpha_2 \cdot w_{1_web} \cdot t_{1_web}^3 \quad R_1 = 16.267 \cdot \text{in}^4$$

Torsional resistance of section 1.

CALCULATE THE CROSS-SECTIONAL AREA OF SECTION 2

$$t_{2_flange} := 1.1875 \cdot \text{in}$$

$$w_{2_flange} := 15 \cdot \text{in}$$

$$t_{2_web} := 0.5 \cdot \text{in}$$

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

$$w_{2_web} = 7.725 \cdot \text{in}$$

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

$$A_{2_flange} = 17.813 \cdot \text{in}^2$$

$$A_2 := 2 \cdot A_{2_flange} + t_{2_web} \cdot w_{2_web}$$

$$A_2 = 39.487 \cdot \text{in}^2$$

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 I_{xx} AND I_{yy}.

(I_{xx})

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

$$I_{xx_flange} = 355.817 \cdot \text{in}^4$$

Section 2 x-axis moment of inertia due to flanges.

$$I_{xx_web} := \frac{t_{2_web} \cdot w_{2_web}^3}{12}$$

$$I_{xx_web} = 19.208 \cdot \text{in}^4$$

Section 2 x-axis moment of inertia due to web.

$$I_{xx} := 2 \cdot I_{xx_flange} + I_{xx_web}$$

$$I_{xx} = 730.842 \cdot \text{in}^4$$

Total moment of inertia about x-axis for section 2.

(I_{yy})

$$I_{yy_flange} := \frac{t_{2_flange} \cdot w_{2_flange}^3}{12}$$

$$I_{yy_flange} = 333.984 \cdot \text{in}^4$$

Section 2 y-axis moment of inertia due to flanges.

$$I_{yy_web} := \frac{w_{2_web} \cdot t_{2_web}^3}{12}$$

$$I_{yy_web} = 0.08 \cdot \text{in}^4$$

Section 2 y-axis moment of inertia due to web.

$$I_{yy} := 2 \cdot I_{yy_flange} + I_{yy_web}$$

$$I_{yy} = 668.049 \cdot \text{in}^4$$

Total moment of inertia 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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$$\frac{w_{2_web}}{t_{2_web}} = 15.45$$

$$\alpha_2 = .313$$

Design of Welded Structures 1991, Page 2.10-2, Table 1

$$R_2 = 2 \cdot \alpha_1 \cdot w_{2_flange} \cdot t_{2_flange}^3 + \alpha_2 \cdot w_{2_web} \cdot t_{2_web}^3$$

$$R_2 = 16.026 \cdot \text{in}^4$$

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

$$A_c = 47 \cdot \text{in}^2$$

$$A_c = 47 \cdot \text{in}^2$$

Original cross-sectional area of the strongback.

$$L = 351.3 \cdot \text{in}$$

$$L = 351.3 \cdot \text{in}$$

Length of the strongback.

$$V = A_c \cdot L$$

$$V = 33022.2 \cdot \text{in}^3$$

Total volume of steel in strongback.

$$\rho_{\text{steel}} = .00073 \cdot \frac{\text{lb} \cdot \text{sec}^2}{\text{in}^4}$$

$$\rho_{\text{steel}} = 0.00073 \cdot \frac{\text{lb} \cdot \text{sec}^2}{\text{in}^4}$$

Density of steel.

$$g = 386.4 \cdot \frac{\text{in}}{\text{sec}^2}$$

$$g = 32.2 \cdot \frac{\text{ft}}{\text{sec}^2}$$

Acceleration due to gravity.

$$W_o = V \cdot \rho_{\text{steel}} \cdot g$$

$$W_o = 9314.638 \cdot \text{lb}$$

Model weight of strongback.

$$W_a = 30000 \cdot \text{lb} - 10000 \cdot \text{lb}$$

$$W_a = 20000 \cdot \text{lb}$$

Actual weight of strongback minus 10000 lb at hydraulic attachment point. A mass of 10000 lb will be used to model the hydraulic beam.

$$\rho_{\text{new}} = \frac{W_a}{V \cdot g}$$

$$\rho_{\text{new}} = 0.00157 \cdot \frac{\text{lb} \cdot \text{sec}^2}{\text{in}^4}$$

New density of strongback.

SHIPPING CONTAINER

$$A_c = 165.7 \cdot \text{in}^2$$

$$A_c = 165.7 \cdot \text{in}^2$$

Original cross-sectional area of the shipping container.

$$L = 652.5 \cdot \text{in}$$

$$L = 652.5 \cdot \text{in}$$

Length of the shipping container.

$$V = A_c \cdot L$$

$$V = 1.081 \cdot 10^5 \cdot \text{in}^3$$

Total volume of steel in shipping container.

$$W_o = V \cdot \rho_{\text{steel}} \cdot g$$

$$W_o = 30497.413 \cdot \text{lb}$$

Model weight of shipping container.

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$$W_a := 55000 \cdot \text{lb}$$

$$W_a = 55000 \cdot \text{lb}$$

Actual weight of shipping container.

$$\rho_{\text{new}} := \frac{W_a}{V \cdot g}$$

$$\rho_{\text{new}} = 0.00132 \cdot \frac{\text{lb} \cdot \text{sec}^2}{\text{in}^4}$$

New density of shipping container.

TRAILER

$$A_c := 56.1 \cdot \text{in}^2$$

$$A_c = 56.1 \cdot \text{in}^2$$

Original cross-sectional area of the trailer (used maximum cross-sectional area of trailer).

$$L := 2 \cdot 833.77 \cdot \text{in}$$

$$L = 1667.54 \cdot \text{in}$$

Length of W30x191 that makeup the trailer.
The factor of two accounts for the weight of trailer components not modeled.

$$V := A_c \cdot L$$

$$V = 93548.994 \cdot \text{in}^3$$

Total volume of steel in trailer.

$$W_o := V \cdot \rho_{\text{steel}} \cdot g$$

$$W_o = 26387.552 \cdot \text{lb}$$

Model weight of trailer.

$$W_a := 120000 \cdot \text{lb} - 23000 \cdot \text{lb}$$

$$W_a = 97000 \cdot \text{lb}$$

Actual weight of trailer minus the axles.

$$\rho_{\text{new}} := \frac{W_a}{V \cdot g}$$

$$\rho_{\text{new}} = 0.00268 \cdot \frac{\text{lb} \cdot \text{sec}^2}{\text{in}^4}$$

New density of trailer.

(1) Drawing H-2-83734 (2) Doc. No. REV 0 (3) Page 1 of 1
 (4) Building 200-G (5) Rev. (6) Job No.
 (7) Subject SECTIONAL PROPERTIES OF STORAGE CONTAINER
 (8) Originator JA TUCK Date
 (9) Checker BZ Conzadell 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:

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

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

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

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

∴ FOR COL. (8) → (15), SECTION PROPS ARE:

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

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

A 10

(1) Drawing H-2-83736 (2) Doc. No. REV. 0 (3) Page 1 Rev. 0
 (4) Building 200-G (5) Rev. _____ (6) Job No. _____
 (7) Subject STRONGBACK SECTIONAL PROPERTIES.
 (8) Originator JA TUCK Date 6 DEC. '94
 (9) Checker BJ Overdell 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 IN² DEPTH "d" = 36 IN.

FLANGE WIDTH = 12 IN.

$I_{xx} = 9750 \text{ IN}^4$ $I_{yy} = 295 \text{ IN}^4$

∴ FOR COMBINED SECTION,

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

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

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

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

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

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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

ANALYTICAL CALCULATIONS

Page 1 of 2

Subject SOIL SPRINGS - FOR USE IN SYIOI TRAILER FREQ. ANALYSIS
Originator CALCS FOR INDEPENDENT REVIEW Date 2/6/95
Checker E.L. JORISEN Date _____

SOIL SPRINGS

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

REF - TERZAGHI, "EVALUATION OF COEFF. OF SUBGRADE REACTION," GEOTECHNIQUE, V.5, 1953 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 PLATE AS MAT FOR OUTRIGGER

TEST WT. FOR HYDRAULICS TEST

$$K_s = \left[200 \text{ pci} \times \left(\frac{345.6 \text{ lb/ft}^3}{1.5 \times 1.5} \right) \right] \times \left[\frac{3 + 1}{2 \left(\frac{3}{1} \right)} \right]^2 = 136.53 \frac{\text{K}}{\text{ft}^2}$$

DAMES + MOORE RECOMMENDATION

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

ASSUME 3' x 4.5' EFFECTIVE SIZE

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

ANALYTICAL CALCULATIONS

Page 2 of 2

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

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

$$A \approx 1.5 \text{ ft}^2 \rightarrow \text{ASSUME SHAPE}$$

$$K_s = 1.5 (136.53 \frac{\text{K}}{\text{ft}^2}) = 204.80 \frac{\text{K}}{\text{ft}}$$

↳ PREVIOUS PG. - CONSERVATIVE

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

USE 2 SPRING RATES TO BOUND PROBLEM:

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

2' ϕ FOOT - $K = 17,000 \text{ lb/in}$

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.

<u>COMPONENT</u>	<u>ELEMENT GROUP</u>	<u>REAL CONSTANT</u>	<u>MATERIAL PROP.</u>
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

APPENDIX B

Hand Calculations and FEA Model Output for Wind Induced Vibration

ANALYTICAL CALCULATIONS

Page 1 of 1

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. 3267 - 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. = $0.22 = \frac{f D}{V}$ (REF. - "MECHANICAL VIBRATIONS" J.P. DEN HARTOG - 4th ED. 1956)
 f = VORTEX FREQ
 D = CYLINDRICAL STRUCTURE ϕ
 V = WIND VEL.

$$f = 0.22 \frac{V}{D}$$

$$D = 68" \text{ (CONTAINER)}$$

	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 BUMP 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

[illegible]

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

CONTROL INFORMATION

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

TOTAL SYSTEM DATA

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

MASS MOMENT INFORMATION					
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

SOLUTION PARAMETERS

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

SUBSPACE ITERATION

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 Calc for 89101 Trailer
 Originator B. J. Lovell Date 2-24-95
 Checker GO Allen Date 5-11-95

Single degree of freedom model of 89101 trailer. This model is to be used in determining the natural frequency of the trailer.

$$J\ddot{\theta} = -K\theta \quad \text{Equation of vibrations with application (pg. 17)}$$

$$J = ml^2$$

$$K = K_T\theta - mg l \cos \theta$$

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

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

$$\text{if } \theta \approx 0 \text{ then } \cos \theta = 1$$

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

ANALYTICAL CALCULATIONS

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

Subject _____
 Originator B.L. Coverdell *BLE* Date February 3, 1995
 Checker JATUCK *James A. Tuck* 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.

$$P := 1000 \cdot \text{lbf}$$

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

$$m := 55000 \cdot \text{lb} + 30000 \cdot \text{lb}$$

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.

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

$$l = 264.118 \cdot \text{in}$$

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

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

$$a := 305.13 \cdot \text{in}$$

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

$$b := a$$

$$c := .0976 \cdot \text{in}$$

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

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

$$C = 0.018 \cdot \text{deg}$$

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 JATuck *James Tuck* Date 16 MAY '95

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

$$k_t = 8.257 \cdot 10^8 \cdot \frac{\text{lbf} \cdot \text{in}}{\text{rad}}$$

Stiffness of torsional spring.

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

$$f = 1.151 \cdot \text{hz}$$

Frequency of shipping container, strongback and trailer combination.

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APPENDIX C

Upper Hydraulic Clevis Analysis

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L1n STRESS Lc=1

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.**

Date: 9/04/94

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 <small>CONSULTING ENGINEER</small>	ENGINEERING CALCULATIONS	JOB NO.: 6134	SHEET I of 1
		ORIG BY: G.S.S.B.	DATE: 11/12/94.
		CHK'D BY: JS	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

Graham S. S. Barr, P. E.

Date:

1-26-95.

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.
		CHKD BY:	DATE:
SUBJECT KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM HANFORD SY-1-1 MITIGATION/SAFETY.	

CONTENTS

Scope and Conclusions.....2.

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.

Aft Pivot Support.....21.

Main Beam Stresses Due to Lifting Loads.....24.

Tie-down Stress Calculations.....27.

References.....30.

Appendix.....31.

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 4 of 4 ²
		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.	

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 certified 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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		ORIG BY: G.S.S.B.	DATE: 9/04/94.
		CHK'D BY:	DATE:
		PROGRAM	HANFORD SY-1-1 MITIGATION/SAFETY.

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

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.

TAKING MOMENTS ABOUT R_1

$$\begin{aligned}
 R_2 &= \frac{\sum \text{MOMENTS}}{850.6} \\
 &= 191,233 \text{ lb.} \\
 R_2 &= \sum \text{WEIGHTS} - R_1 \\
 R_1 &= 297,998 - 191,233 \\
 &= 106,765 \text{ lb.}
 \end{aligned}$$

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.

Barry J. Jernigan
6/30/95

GRAHAM S. S. BARR <small>CONSULTING ENGINEER</small>	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 6 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.	

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

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

FOR $X = 515''$

$$\begin{aligned} \text{BENDING MOMENT } M_{A-A} &= 106,965 \times 515 \\ &\quad - 17,267,224 - 5,276,872 \\ &= 32,439,879 \text{ IN. LB.} \end{aligned}$$

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

[FOR EACH 30 WF 191 BEAMS]

$$\text{BENDING STRESS} = 27,123 \text{ PSI.}$$

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

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 7 of 42.
		ORIG BY: G.S.S.B.	DATE: 9/04/94.
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SUBJECT KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM HANFORD SY-1-1 MITIGATION/SAFETY.	

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

$$\begin{aligned} \text{THE RESULTING SAFETY FACTOR} &= \frac{44,300}{27,123} \\ &= 1.633. \end{aligned}$$

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 R₁

$$\begin{aligned} R_2 &= \frac{\Sigma \text{MOMENTS}}{850.6} = \frac{164,622,988}{850.6} \\ &= 195,889 \text{ lb.} \\ R_1 &= \Sigma \text{WEIGHT} - 195,889 \\ &= 297,988 - 195,889 \\ &= 102,099 \text{ lb.} \end{aligned}$$

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 8 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.	

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

$$\begin{aligned}
 \text{BENDING MOMENT } M &= 102,099 \times 258 \\
 &\quad - 1,083,906 - 1,324,346 \\
 &= 23,933,290 \text{ IN LB.}
 \end{aligned}$$

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

$$\begin{aligned}
 \text{BENDING STRESS} &= \frac{M}{S} \\
 &= 20,011 \text{ psi.}
 \end{aligned}$$

$$\begin{aligned}
 \text{FACTOR OF SAFETY} &= \frac{44,300}{20,011} \\
 &= \underline{2.21}
 \end{aligned}$$

THESE CALCULATIONS SHOW THAT THE LOAD
TRANSFER 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.

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 9 of 42.
		ORIG BY: G.S.S.B.	DATE: 9/04/94.
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THE TONGUE AND WHEEL LOADS ARE
SUMMARIZED AS FOLLOWS:

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.

$$\text{WIND LOAD, } W = 6 \times 10 \times 53 \\ = 3,180 \text{ LB}$$

MOMENTS ABOUT R_2

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

$$= 2,658 \text{ LB}$$

$$\text{LOAD / JACK} = 1,313 \text{ lb}$$

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 10 of 42.
		ORIG BY: G.S.S.B.	DATE: 9/04/94.
SUBJECT KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.	PROGRAM HANFORD SY-1-1 MITIGATION/SAFETY.	CHK'D BY:	DATE:

LATERAL WIND.

WIND LOADS,

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

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

TAKING MOMENTS ABOUT R_2 .

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

$$= 5,862 \text{ LB}$$

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

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.

$$\Sigma \text{ MOMENTS} = 18,333,804 \text{ IN LB}$$

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

$$\text{LOAD PER REAR JACK} = 19058 \text{ LB.}$$

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

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

$$= 191,482 \text{ LB.}$$

$$\text{LOAD PER FRONT JACK} = 95,741 \text{ LB.}$$

CONTAINER & STRONGBACK VERTICAL.

$$\Sigma \text{ MOMENTS} = 55,996,404 \text{ IN LB}$$

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

$$\text{LOAD PER REAR JACK} = 58,208 \text{ LB}$$

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

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

$$= 113,181 \text{ LB}$$

$$\text{LOAD PER FRONT JACK} = 56,590 \text{ LB}$$

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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 $58,208 + 2,931 \text{ lb} = \underline{\underline{61,139 \text{ LB.}}}$

LANDING GEAR LOADS & GOOSE NECK BENDING.

WORST CASE TONGUE LOAD FROM LOAD CASE 1

$$R_1 = 106,765 \text{ lb}$$

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

$$\text{LOAD PER LANDING GEAR JACK} = \underline{\underline{65,513 \text{ LB.}}}$$

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WORST CASE GOOSE NECK BENDING MOMENT [SECTION A-A]
 $= 106,765 \times 110.72'' = 11,821,021 \text{ IN. LB.}$
 $S = \frac{I}{C} = \frac{2750 \times 2}{9} = 609 \text{ IN}^3$

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

YIELD STRESS = $44,300 \text{ PSI}$

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

OUTRIGGER BEAMS FOR JACKS:

USING WORST CASE LOAD.

MOMENTS ABT R_2 .

REACTION, R_1

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

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

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

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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.

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

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

$$\text{SECTION MODULUS, } S = \frac{I}{c} = 1,517 / 8$$

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

WORST CASE BENDING MOMENT

$$= 95,740 (61.35)$$

$$= 5,873,649 \text{ IN LB.}$$

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

$$= 30,913 \text{ psi}$$

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

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

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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.

$$\begin{aligned}
 \text{DEFLECTION} &= \frac{WL^3}{3EI} = \frac{95,740 (61.35)^3}{3(29 \times 10^6)(1,517)} \\
 &= 0.1675'' \text{ [CONTAINER HORIZONTAL]}
 \end{aligned}$$

$$\begin{aligned}
 \text{WORST CASE DEFLECTION TRAILER WITH CONTAINER} \\
 \text{VERTICAL} &= \frac{61,139 (61.35)^3}{3(29 \times 10^6)(1,517)} \\
 &= 0.107''
 \end{aligned}$$

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 = $\frac{3.88}{\sqrt{\frac{WL^3}{FEI}}}$ $W = 40400 \text{ LB}$
 [CANTILEVER WITH DISTRIBUTED LOAD.] $L = 513''$
 $I = 18,340 \text{ in}^4$
 = 3.4 Hz.

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STRESSES IN BEAM CONNECTION TO TRAILER

BEARING STRESS AT R_1

$$R_1 = 203,711$$

$$\text{BEARING AREA} = (6.25)(1.5)$$

$$\text{BEARING STRESS} = 21,729 \text{ psi.}$$

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

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

$$C = 11 \text{ in [TENSION SIDE]}$$

$$= 11.5 \text{ in [COMP. SIDE]}$$

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

$$= 1,890,000 \text{ in LB}$$

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

$$= 3,530 \text{ psi}$$

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

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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 3.585 TIMES CALCULATED FOR COMPRESSION. THE SHEAR STRESS WILL ALSO BE INCREASED TO 1.92 TIMES THE CALCULATED VALUE.

FOR COMPRESSION SIDE

$$\begin{aligned}\text{WORST CASE STRESS} &= (3.585)(3,691) \\ &= 13,233 \text{ psi}\end{aligned}$$

$$\times 3:1 \text{ SAFETY FACTOR} = 39,701 \text{ psi} > 44,300 \text{ psi}$$

$$\begin{aligned}\text{SHEAR STRESS} &= \frac{VAZ}{Ib} \\ &= \frac{\left(\frac{216,000}{2}\right)(68.82)(5.6)}{(5,888)(4)}\end{aligned}$$

$$= 1,751$$

$$\times \text{CONC. FACTOR} = (1,751)(1.92) = 3,362 \text{ psi}$$

$$\times 3:1 \text{ SAFETY FACTOR} = \underline{\underline{10,088 \text{ psi}}}$$

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

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

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

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

$$TWIST, \theta = \frac{TL}{KG} = \frac{(1000)(38.5)(54.4)}{(898)(11.5 \times 10^6)}$$

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

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

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

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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 $H_1 = (155,931)(29) = 4,522,000 \text{ IN LB}$

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. ~~Horizontal~~.
 IT HAS A HORIZONTAL LOAD = $H_1 = 155,931$ LB

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

$$\text{PIN DIAMETER} = 3.00''$$

$$\begin{aligned} \text{PIN BEARING} &= \frac{159,140}{2(3 \times 3)} = \frac{17,682}{2} \text{ psi.} \\ &= 8,841 \text{ psi} \end{aligned}$$

$$\text{PIN SHEAR} = \frac{159,140}{2 \left(\frac{\pi (3)^2}{4} \right)} = 11,256 \text{ psi.}$$

TAKING MOMENTS ABOUT X

LOAD AT WELD A

$$\begin{aligned} &= \frac{H_2(15.2) + V_2(7.63)}{2(7.63)} \\ &= \frac{171,218}{15.26} \text{ LB.} \end{aligned}$$

$$\text{LENGTH OF WELD AT A} = 2 \times 33.12$$

$$\text{LOAD/INCH OF WELD} = \frac{2,584}{1} \text{ LB/IN.}$$

$$\text{ALLOWABLE STRESS FOR 3:1 S.F.} = 4,533$$

$$\text{EFFECTIVE THROAT FOR GROOVE WELD} = \frac{2,584}{4,533} = 0.57'' \text{ MINIMUM}$$

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AFT PIVOT SUPPORT BEAM

$$\begin{aligned}
 V_2 \text{ WITH CONTAINER VERTICAL} \\
 &= \frac{108.6}{2} + 6_{(WIND)} \text{ KIPS} \\
 &= 60,300 \text{ LB.}
 \end{aligned}$$

SECTION MODULUS AT A-A

$$\begin{aligned}
 S_{xx} &= \frac{15.25 (17)^3 - 12.54 (12)^3}{(12)(8.5)} \\
 &= 522 \text{ IN}^3
 \end{aligned}$$

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

$$\text{BENDING STRESS} = \frac{M}{I/c} = \underline{\underline{2,367 \text{ psi.}}}$$

HORIZONTAL BENDING & TORSION DUE TO H₂.

$$\begin{aligned}
 \text{SECTION MODULUS, } S_{yy} &= \frac{17 (15.25)^3 - 13 (13.25)^3}{12 (7.625)} \\
 &= 328 \text{ IN}^3
 \end{aligned}$$

$$\text{BENDING MOMENT} = \frac{155,391}{2} \times 20.5 = 1,592,757 \text{ IN LB.}$$

$$\text{BENDING STRESS} = \frac{M}{I/c} = \underline{\underline{4,849 \text{ psi.}}}$$

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

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

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SHEAR STRESS DUE TO TORSION = 6,017 psi

COMBINED STRESS INTERACTION

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

$$\left(\frac{6,017}{7,200} \right)^2 + \left(\frac{4,849}{12,000} \right)^2 = \underline{\underline{0.861}} - \text{OK.}$$

FORWARD CLEVIS:

WORST CASE LOAD DUE TO
SHEAR FROM H₁, 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

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

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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 PAGE 19 & 21

$$H_1 = 155,931 \text{ LB} \quad V_1 = 140,401 \text{ LB}$$

$$H_2 = 155,931 \text{ LB} \quad V_2 = 31,801 \text{ LB ACTING UP}$$

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

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

$$\begin{aligned} \text{REACTIONS AT } R_1 \text{ \& } R_2 \text{ DUE TO } M_1 \pm M_2 &= \frac{M_1 + M_2}{487} \\ &= 28,000 \text{ LB UP AT } R_1 \text{ \& } \text{DOWN AT } R_2. \end{aligned}$$

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FOR REACTION AT R_1 DUE TO $V_1 \pm V_2$ 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 $R_1 \pm R_2$ DUE TO TRAILER WEIGHT
AND BENDING MOMENT DUE TO TRAILER WEIGHT
AT THE CYLINDER PIVOT WERE CALCULATED WITH
THE SPREADSHEET.

$$\text{TRAILER WT. } R_1 \text{ COMPONENT} = 97,813 \text{ LB.}$$

$$\text{TRAILER WT. } R_2 \text{ COMPONENT} = 23,184 \text{ LB.}$$

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

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

$$\text{MOMENT AT CYL. PIVOT DUE TO TRAILER WTS. } M_{TW}$$

$$= 19,200,973 \text{ IN LB.}$$

$$\text{BENDING MOMENT AT CYL PIVOT} = (\Sigma R_1)(207) - M_{TW}$$

$$= (198,569)(207) - 19,200,973$$

$$= 21,902,810 \text{ IN LB.}$$

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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" X 0.5" X 108" STRIPS OF A36 STEEL WERE WELDED TO THE TOP AND BOTTOM FLANGES OF EACH BEAM.

THE COMPOSITE SECTION HAS A MOMENT OF INERTIA

$$\begin{aligned}
 &= I_{\text{BEAM}} + 2q\bar{r}^2 & q &= \text{AREA OF PLATE} \\
 & & \bar{r} &= \text{DISTANCE FROM} \\
 & & & \text{CENTROID OF BEAM TO} \\
 & & & \text{CENTROID OF PLATE.} \\
 &= 9170 + 2(12.5)(15)(15.59)^2 \\
 &= 12,208 \text{ IN}^4
 \end{aligned}$$

$$c = 15.34 + 0.5 = 15.84 \text{ IN.}$$

$$\text{SECTION MODULUS, } S = \frac{I}{c} = 770 \text{ IN}^3$$

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

BENDING MOMENT AT FRONT EDGE OF CYLINDER

$$\begin{aligned}
 \text{PIVOT ASSEMBLY} &= \sum R_i (207 - 18) - M_{\text{TW}} \\
 &= (198,569)(191) - 18,500,000 \\
 &= 19,426,679 \text{ IN LB.}
 \end{aligned}$$

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

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

GRAHAM S. S. BARR

CONSULTING ENGINEER

ENGINEERING
CALCULATIONS

JOB NO.: 6194

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DATE: 9/04/94.

CHK'D BY:

DATE:

SUBJECT

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

PROGRAM

HANFORD SY-1-1
MITIGATION/SAFETY.

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

TIE-DOWN STRESSES:

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

$$\begin{aligned} \text{LENGTH OF WELD} &= 12 - 1 \frac{3}{4} \\ &= 10.25 \text{ INCHES} \end{aligned}$$

$$\begin{aligned} \text{LOAD} &= 33,000 \# \\ \text{X } 3:1 \text{ SF} & \\ \text{LOAD/INCH} &= 3,220. \\ &= 9,660 \text{ LB/IN.} \end{aligned}$$

$$\text{ALLOWABLE STRESS} = 13,600 \text{ psi.}$$

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

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

$$\text{SECTION A-A } I = 1841.6 \text{ IN.}^4$$

$$C = 18.4 \quad S = 100 \text{ IN.}^3$$

$$\text{BENDING MOMENT} = 1,185,000 \text{ IN. LB}$$

$$\text{BENDING STRESS} = \underline{\underline{11,850 \text{ psi.}}}$$

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 28 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.	

FRONT SUPPORT :

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

SECTION A-A

$$I = 829 \text{ IN}^4$$

$$C = 7.5 \text{ IN}$$

$$S = 110 \text{ IN}^3$$

$$\text{BENDING MOMENT} = 1,500,000 \text{ IN-LB.}$$

TRAILER.

$$\text{BENDING STRESS} = 13,636 \text{ PSI.}$$

$$\text{ALLOWABLE WITH 3:1 S.F.} = 14,766$$

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

CERTIFIED MILL REPORT
(P. E-44) - $F_{Y \text{ MINIMUM}} = 44,300 \text{ PSI} \div 3 = 14,766$

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 45,000 LB ^{LONGITUDINAL} ~~LATERAL~~ LOAD AND 180,000 IN-LB OF BENDING.

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$$S_w = \frac{d^2}{3} = \frac{10^2}{3} = 33.3 \text{ in}^2$$

$$A_w = 2(10) = 20 \text{ in.}$$

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

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

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

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

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

$$= \frac{6,600}{14,850} = \underline{0.44 \text{ in.}}$$

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 30 of 42
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SUBJECT KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM HANFORD SY-1-1 MITIGATION/SAFETY.	

REFERENCES

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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.

GRAHAM S. S. BARR

CONSULTING ENGINEER

**ENGINEERING
CALCULATIONS**

JOB NO.: 6194

SHEET 31 of 42.

ORIG BY: G.S.S.B.

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KAMP SYSTEMS, INC.
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APPENDIX.

OUTRIGGER DESIGN

SUPPORT ACTUATOR ATTACHMENT TO OUTRIGGER BEAM

→ PEAK OUTRIGGER LOAD

$$R_1 = 93^k \quad (G. BARR \text{ CALCS} - DL + LL + LATERAL \text{ WIND})$$

ADD LONGITUDINAL LOAD = 10% OF VERT. LOAD

$$0.10 \times 200^k \text{ CAPACITY} = 20^k \text{ @ PIN}$$

$$\Sigma M_{R_2} = -20^k (102.35") + R_1 (457") \quad \Rightarrow \quad R_1 = \frac{4.20^k}{2}$$

$$R_1 \text{ TOTAL} = 93 + 2.10 = 95.1^k \quad - 2.10^k$$

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

R₁ MAX

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

PROBLEM - PROVIDE BOLTED CONNECTION - CYLINDER TO OUTRIGGER
(CANNOT WELD - DISSIMILAR METALS)

"A" WELDS - FILLETS ON BOTH SIDES - EACH 1"

VERT. LOAD = 95.1K

CONSIDER OUTER WELDS ONLY

$$J_u = \frac{d(3b^2 + d^2)}{6}$$

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

BUDGET

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

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

"A" WELDS -

$$V = 95.1^k$$

$$VERT = 95.1^k$$

$$M = 6'' (95.1^k) = 571 \text{ in-k}$$

$$f_{bV} = \frac{M}{S_w} = \frac{571}{170.7} = 3.35 \text{ k/in}$$

$$f_{sV} = \frac{V}{A_w} = \frac{95.1}{64} = 1.49 \text{ k/in}$$

$$LATERAL = 0.90^k$$

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

$$f_{bLAT} = \frac{M_w}{S_w} = \frac{39.9}{170.7} = 0.23 \text{ k/in}$$

$$f_{sLAT} = \frac{V_{LAT}}{A_w} = \frac{0.90}{64} = \text{IGNORE}$$

$$LONGITUDINAL = 5^k$$

$$f_{T_{LON}} : \text{TORSION} = 5^k \left(36.31 + \frac{16}{2} \right) = 224.6 \text{ in-k}$$

$$f_{T_{LON}} = \frac{T_{OR}}{J_w} = \frac{224.6}{970.7} = 0.23 \text{ k/in}$$

$$f_{V_{LON}} = \frac{5^k}{64} = 0.08 \text{ k/in}$$

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

$h = 16''$
 $S_w = \frac{I_{C-D}}{h} = \frac{c(16)}{16} = 96$

$$F = \sqrt{(3.35 + 0.23 + 0.31)^2 + (0.23 + 0.08)^2 + 1.49^2} = 4.18 \text{ k/in}$$

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

LEG

"B" WELD

$$V = 95.1$$

$$VERT. = 95.1$$

$$M = 4.5" (95.1) = 428 \text{ in.-k}$$

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

ESTIMATED

$$b = 36$$

$$f_{s_v} = \frac{95.1}{32} = 2.97$$

$$d = \frac{16}{18}$$

$$J_w = \frac{d(36^2 + d^2)}{6} = \frac{16(36^2 + 16^2)}{6} = \frac{1074.7}{1152.0}$$

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

$$A_w = 2(16) = 32$$

LATERAL

$$f_{b_{LAT}} = M_w = 0.90^k (44.31") = 39.9 \text{ in.-k}$$

$$f_{b_{LAT}} = \frac{39.9}{\frac{85.33}{108}} = \frac{0.37}{1.02}$$

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

LONGITUDINAL = 5^k

$$F_{T_{CON.}} : \text{TORSION} = 5^k (44.31") = 221.6 \text{ in.-k}$$

$$f_{T_{CON.}} = \frac{TOR}{J_w} = \frac{221.6}{\frac{1074.7}{1152}} = \frac{0.19}{0.93}$$

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

$$f_{b_{CON.}} = \frac{M_w}{J_w} = \frac{5^k (4.5")}{\frac{1152}{108}} = \frac{0.21}{0.10}$$

$$S_w = bd = \frac{18(16)}{108} = \frac{1.6}{1.0}$$

$$f = \sqrt{\left(\frac{3.96}{5.02} + \frac{0.37}{1.02} + 0.03 + \frac{0.21}{0.10}\right)^2 + \left(\frac{0.19}{0.93} + \frac{0.14}{0.16}\right)^2} = \frac{5.29}{6.46} \text{ in.}$$

$$w = \frac{6.46}{7.20} = 0.90 = \frac{3}{4} \text{ EFFEC. THROAT}$$

b = 8

"C" WELD

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

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

$$A_w = 48$$

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

$$VERT. = 95.1^k$$

$$V = 95.1$$

$$M = 9"(95.1) = 856 \text{ in.-k}$$

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

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

$$LATERAL = 0.90^k \text{ - previous pg.}$$

$$f_{lat} = \frac{37.9 \text{ in.-k}}{213.3} = 0.19$$

$$f_{lat} = \frac{0.90}{48} = .02 \text{ - IGNORE}$$

$$LONGITUDINAL = 5^k$$

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

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

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

$$f = \sqrt{(4.01 + 0.19 + 0.30)^2 + 1.98^2 + (.10 + .10)^2} = 4.92 \text{ ksi}$$

$$\omega = \frac{4.92}{7.2} = 0.68 \cdot \frac{3}{4} \text{ FILLET}$$

BOLTS

REF: SALMON + JOHNSON - 2ND ED - "STEEL STRUCTURES"
 P. 154

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

$$V = 95.1^K$$

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

BEARING CONNECTION

TRY 1" BOLTS

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

SHEAR ONLY - $R_{ss} = F_s \times \text{AREA} = \frac{30^K}{2} (.7854) = 11.76^K/\text{BOLT}$

WHC SF

TENS. ONLY - $R_T = F_T \times \text{AREA} = \frac{44^K}{2} (.7854) = 17.28^K/\text{BOLT}$

EST. NO. BOLTS = $n = \sqrt{\frac{GM}{R_p}}$

n = MOM. PER LINE OF BOLTS

R = LOAD IN TENS./BOLT

p = PITCH

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

$$n = \frac{95.1}{11.76} = 4.04 \text{ BOLTS FOR SHEAR}$$

$$n = \sqrt{n_{\text{tens.}}^2 + n_{\text{shear}}^2} = \sqrt{4.54^2 + 4.04^2} = 6.1 \text{ PER LINE}$$

TOO MANY

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

$$\text{SHEAR ONLY - } R_s = \frac{30}{2} (1.227 \text{ in}^2) = 18.41$$

$$\text{TENS. ONLY - } R_t = \frac{44}{2} (1.227) = 27.0$$

BOLT NO. REQ.

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

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

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

$$\Sigma A_y^2 = 4 (1.227 \text{ in}^2) (10.5^2 + 3.5^2) = 601.23 \text{ in}^4$$

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

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

INTERACTION - TENS./SHEAR

$$F_t = \sqrt{\left(\frac{22^2}{4} \right) - 2.15 f_v^2} = \sqrt{\left(\frac{22^2}{4} \right) - 2.15 (9.69)^2} = 16.8 \text{ ksi} > F_t = 12.46$$

WHC ALLOWABLES = $\frac{F_t}{2} = 11$ O.K.

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

7" PITCH

THOS. EXCLUDED

9 1/4" O.D. - 7 1/2" BORE

1 1/4" BOLT - STD. HOLE

EDGE DISTANCE = $1\frac{7}{8}$ INCS TABLE J35

WRENCH CLEARANCE: SOCKET - $1\frac{11}{16}'' = \frac{1}{2}$ DIA. - O.F.

HAND-RAILS

LOAD - 200^{lb} PT. LOAD @ TOP OF RAIL

$$\sum M_A = -200(48) + R_B(200)$$

$$R_B = 1600 \text{ lb.}$$

$$R_A = 1800 \text{ lb.}$$

$$M_{max} = 200(48) = 9600 \text{ in.-lb.}$$

$$S = .326$$

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

PIPE MAT'L - A52 Grade B

$$F_y = 35 \text{ ksi}$$

REQ'D SF. = 1.1 YIELD (TOM MACKET) $\therefore$ O.K.

WELD -

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

$$A_w = 12$$

$$d = 6 \text{ ||}$$

$$M = 200(52) = 10,400 \text{ in.-lb.}$$

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

$$f_v = \frac{200}{12} = .02 \text{ ksi}$$

$$w = \frac{.87}{7.2} = .12$$

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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AUG - 5-94 FRI 14:55 KAMP Systems Inc
AUG 5 '94 12:42 FROM BROWN-STRAUSS STEEL

WMC-S0001-00194
Rev. 0

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

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

MECHANICAL PROPERTIES		CHEMICAL PROPERTIES							
YIELD STRENGTH	TENSILE STRENGTH	ELONGATION	REDUCTION OF AREA	PHOSPHORUS	SULFUR	SELENIUM	COPPER	ANTHRACENE	CO
MIN	MIN	%	%	%	%	%	%	%	%
43756	45500	27	07	049	020	04	16	30	
40770	48600	28	05	073	014	02	21	24	
44145	47500	30	05	073	014	02	21	24	
44072	47500	31	06	054	022	02	19	30	
41603	45300	26	06	054	022	02	19	30	
44046	53900	26	07	056	017	02	10	30	
43982	53200	30	07	056	017	02	10	30	
	50000	30	08	063	018	02	21	32	
	50700	31	08	063	018	02	21	32	
	46600	31	07	060	014	02	12	32	
	47600	32	07	060	014	02	12	32	
	44300	32	05	065	019	01	11	30	
	44800	33	05	065	019	01	11	30	
	51100	30							
	51900	29							

ELONGATION BASED ON 8.00 INCH GAGE LENGTH.

BEST AVAILABLE COPY

WE 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

E-44

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 crimping on outrigger beams and web crimping 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: <i>KS</i>	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

$$\begin{aligned}
 &= \frac{2J(3.5)}{52.6} \\
 &= 0.13 \text{ JACK LOAD.}
 \end{aligned}$$

SUBJECT

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

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MITIGATION/SAFETY.WHC-SD-WM-DA-194
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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 CLEVISSES 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.]

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

$$\text{BENDING STRESS} = 196 \text{ PSI.}$$

CALCULATIONS

ORIG BY: G.S.S.B. DATE: 11/12/94.

CHK'D BY: BS DATE:

SUBJECT

KAMP SYSTEMS, INC.
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3. UPPER CLEVIS LOADS.

$$\text{CYLINDER LOAD} = 209,826 \text{ lb (AT LIFT-OFF)}$$

$$\text{HORIZONTAL COMPONENT} = 155,931 \text{ lb.}$$

$$\text{VERTICAL COMPONENT} = 140,401 \text{ lb.}$$

$$\text{PIN BEARING AREA} = (2.875)(3.25) \quad (\text{IN CYLINDER})$$

$$= 9.34 \text{ in}^2$$

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

$$= 16.6 \text{ in}^2$$

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

$$= 22,456 \text{ psi}$$

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

$$= 12,646 \text{ psi}$$

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 = $\frac{67,154}{2 \times 12,646} = 2.655$

GRAHAM S. S. BARR

CONSULTING ENGINEER

ENGINEERING
CALCULATIONS

JOB NO.: 6194

SHEET 4 of 4

ORIG BY: G.S.S.B.

DATE: 11/12/94.

CHK'D BY: KES

DATE:

SUBJECT

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

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MITIGATION/SAFETY.

3.0 UPPER CLEVIS LOADS (CONTD.)

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THE BEARING AREA IN THE CLEVIS

$$= 2 \times 2 \times 3.25$$

$$= 13 \text{ in.}^2$$

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

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

THIS SHOULD BE ACCEPTABLE WITH A-36 STEEL PLATE.

WELD SIZING:

TWO WELDS 13" LONG ARE
CONSIDERED LOAD BEARING.

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

$$= 6,000 \text{ lb/in.}$$

$$\text{BENDING MOMENT} = 156,000 \times 5.5$$

$$= 858,000 \text{ IN. LB.}$$

$$S = \frac{13^2}{6} = 56.33$$

$$\text{BENDING STRESS} = \frac{\text{LOAD}}{S} = \frac{858,000}{56.33} = 15,230 \text{ lb/in.}^2$$

CALCULATIONS

ORIG BY: G.S.S.B.

DATE: 11/12/94.

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SUBJECT

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3. UPPER CLEVIS LOADS (CONT'D)

$$\text{COMBINED LOAD} = \sqrt{6,000^2 + 15,230^2}$$
$$= 16,369 \text{ lb/in.}$$

$$\text{REQUIRED } W = \frac{16,369}{7,200} = \underline{2.25"}.$$

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-
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H. 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.

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

THE EXTREME FIBER STRESS IN THE SPLICE

$$\text{WELD} = 12,614 \times \frac{30.68}{30.68 + 1.25}$$

$$= 12,120 \text{ psi} \quad [\text{ALLOWABLE} = 12,000 \text{ psi}]$$

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		ORIG BY: G.S.S.B.	DATE: 11/12/94
		CHK'D BY: HB	DATE:
SUBJECT KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		PROGRAM HANFORD SY-1-1 MITIGATION/SAFETY.	

5. WEB CRIPPLING

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OUTRIGGER BEAMS.

BEAM WEB PER SKETCH,
EDGES CLAMPED.

CRITICAL SHEAR STRESS, S_s FROM ROARK 4th EDITION = $K \frac{E}{1-\nu^2} \left(\frac{t}{b}\right)^2$

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

$$= 2,553,169.9 \text{ psi.} - \text{ADEQUATE.}$$

MAIN BEAMS.

CRITICAL SHEAR

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

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

CALCULATIONS

ORIG BY: G.S.S.B. DATE: 11/12/94

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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 39,701 psi. THIS IS LESS THAN THE YIELD STRESS VALUES IN THE CERTIFICATIONS EVEN WITH THIS ~~S~~ WORST CASE ASSUMPTION.

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KAMP SYSTEMS, INC.
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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.

$$\text{CALCULATED SHEAR STRESS} \quad [PCE. 21]$$

$$= 11,256 \text{ psi}$$

$\times 3 \text{ S.F.} = 33,768 \text{ psi}$ 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 67,154 psi.

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

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KAMP SYSTEMS, INC.
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8Q) 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" ~~BEVEL~~ ^{FILLET} WELD, 7,200 LB/IN ALLOW.

WORST CASE LOAD = 150,000 LB SIDE LOAD.

$$\begin{aligned} \text{REQUIRED WELD} &= \frac{150,000}{7,200} \\ &= 21 \text{ INCHES.} \end{aligned}$$

ACTUAL WELD > 100 INCHES.

8b) FRONT SUPPORT:— WEDGE FASTENING.

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

CALCULATIONS

ORIG BY: G.S.S.B. DATE: 11/12/94.

CHK'D BY: *KS*

DATE:

SUBJECT

KAMP SYSTEMS, INC.
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86) FRONT SUPPORT! - WEDGE FASTENING. (CONTD)

AT PRESENT, THE DRAWING SHOWS ⁴ 2EA 1.00-8
A-325 b. / ts
~~4EA JACK SCREWS~~ BEHIND THE WEDGE AND
2EA 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.*Clayton Jansen* 2/10/95

CALCULATIONS

ORIG BY: G.S.S.B. DATE: 11/12/94

CHK'D BY: KS DATE:

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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.

CALCULATIONS

ORIG BY: G.S.S.B. DATE: 11/12/94

CHK'D BY: HE

DATE:

SUBJECT

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101-SY HYDRAULIC TRAILER ANALYSIS.

PROGRAM

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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

$$\therefore \text{FREQUENCY, } n = (0.207) \frac{22}{5.5}$$

$$= 0.828 \text{ cps FOR } 15 \text{ mph WIND}$$

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/FT² ON THE PROJECTED
AREA. FOR THE 53' CYLINDER THIS GIVES
A STEADY STATE LOAD OF 164 LB.

CALCULATIONS

ORIG BY: G.S.S.B. DATE: 11/12/94

CHK'D BY: KB

DATE:

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

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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 ± 16416 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:

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

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

SINCE THE CONTAINER PLUS THE STRONG BACK WEIGHS
A TOTAL OF 84,000 LB OUR WORST CASE
WIND LOAD OF 16416 WILL MOVE THE
CENTER OF GRAVITY $14.28 \times \frac{16416}{84,000} = 0.027$ INCHES

THIS ASSUMES THE NATURAL FREQUENCY COINCIDES
WITH THE EXCITATION FREQUENCY.

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 8184	SHEET 16 of 17
SUBJECT KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.	ORIG BY: G.S.S.B.	DATE: 11/12/94.	
	CHK'D BY: KB	DATE: 2-9-95	
	PROGRAM HANFORD SY-1-1 MITIGATION/SAFETY.		

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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, 175.

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.

CALCULATIONS

ORIG BY: G.S.S.B.

DATE: 11/12/94.

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SUBJECT

KAMP SYSTEMS, INC.
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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 $2 \times 2 \times \frac{1}{4}$.
A 200 LB LOAD ON THE CENTER WILL HAVE A
BENDING MOMENT = 1200 IN LB.

SECTION MODULUS, $S = 0.247 \text{ IN}^3$.

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:

$$M_x = 58.5 \text{ IN LB}$$

ELEMENT.

$$M_y = 64.4 \text{ IN LB}$$

WORST CASE BENDING STRESS

$$= \frac{M}{S} = \frac{58.5}{\left[\frac{3.75(4.75)^2}{6} \right]}$$

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

GRAHAM S. S. BARR

CONSULTING ENGINEER

ENGINEERING
CALCULATIONS

JOB NO.: 6194

SHEET 7 of 1

ORIG BY: G.S.S.B.

DATE: 11/12/94.

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SUBJECT

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$$\text{MAXIMUM BOUNDARY REACTION} = 26.58 \text{ lb}$$

$$\begin{aligned}\text{SHEAR AREA} &= 4.75 \times 0.102 \\ &= 0.485 \text{ in}^2\end{aligned}$$

$$\begin{aligned}\text{SHEAR STRESS} &= \frac{26.58}{0.485} \\ &= 54.8 \text{ psi.} - \text{ LOW.}\end{aligned}$$

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
16	0.000E+00	1.125E+01	3.503E-01	3.761E-02	0.000E+00
17	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
41	0.000E+00	3.000E+01	0.000E+00	0.000E+00	0.000E+00
42	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

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

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
1.900E+01	7.500E+00	-2.393E+00
1.900E+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

SUBJECT

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

PROGRAM

HANFORD SY-1-1
MITIGATION/SAFETY.MHC-SD-WM-DA-194
Rev. 0

II) 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 GUSSETED 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 15x1.5 PLATE IS

$$\frac{bd^3}{6} = \frac{15 \times 1.5^3}{6} = 5.625$$

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

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

BENDING STRESS = 2,786 PSI. SMALL.

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

GRAHAM S. S. BARR CONSULTING ENGINEER	ENGINEERING CALCULATIONS	JOB NO.: 6194	SHEET 2 of 2
SUBJECT KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.	ORIG BY: G.S.S.B.	DATE: 11/12/94.	CHK'D BY:
	PROGRAM HANFORD SY-1-1 MITIGATION/SAFETY.		

WHC-SD-WM-DA-194
Rev. 0

II. KING PIN BRACKETRY.

THE KING PIN WELDS INTO A 0.5" PLATE, WHICH IS SUPPORTED ON THE WIDE FLANGE LONGITUDINAL BEAMS $\pm$ 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

Page 1 of 16Subject SY-101 TRAILER STUDY SUMMARYOriginator W.A. NENSONDate 3/3/95Checker Garry J. JansenDate 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	$R_1 = 6,000^*$ $R_2 = 114,400^*$	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 DOWE	150 TON	WHC NO JEEP	$R_1 = 36,100^*$ $R_2 = 172,900^*$	NO

ANALYTICAL CALCULATIONS

Page 2 of 16

Subject SY-101 TRAILER STUDY SUMMARY

Originator W.A. NEWSON

Date 3/3/95

Checker Randy J. Jumper

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. BD-6400-080.1 (07/93)

ANALYTICAL CALCULATIONS

Page 3 of 16

Subject S4-101 TRAILER STUDY SUMMARY

Originator WA NELSON

Date 3/16/95

Checker Randy Jonsson

Date 3/16/95

NOTES :

① R_1 = KINGPIN RXN FORCE

R_2 = CENTER OF REAR AXLES RXN FORCE

VEHICLE CAPACITIES = GVWR LESS VEHICLE WT.

② • 60 TON TRAILER = 60,000# FOR R_2 • WMC TRACTOR = 64,385# KINGPIN
• 150 TON TRAILER = 135,000# FOR R_2 • LAMPSON TRACTOR > 80,000# KIP.
★ KAMP TRAILER = 240,000# FOR R_2 • JEEP = 70,000# > 400,000# TOTAL LOAD

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

FOR CALCULATIONS, CONTAINER WAS POSITIONED ON TRAILER AS FAR FORWARD (i.e., CLOSEST TO KINGPIN) AS POSSIBLE.

④ WHEN CONTAINER IS TO BE POSITIONED ON TRAILER, REFER TO THIS CALCULATION PACKAGE FOR LOCATING CONTAINER ON TRAILER.

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

DESIGN CALCULATION

WHC-SD-WM-DA-194
Rev. 0

(1) Drawing _____ (2) Doc. No. _____ (3) Page 4 of 16
(4) Building _____ (5) Rev. _____ (6) Job No. _____
(7) Subject Q4-101 TRAILER STUDY
(8) Originator WJ NEWSON Date 2/3/95
(9) Checker Randy Janner Date 3/16/95

(10)

Q4101 TRAILER WEIGHTS:

1) TRAILER WT. = 120,962 # (TRAILER 97,988# + Running GEAR 22,974#)
(REF. GRAHAM BARR CALLS, Pg. J)

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 #
- CAPS = 1703 # + 1709 #
- PLATES = 2281 # + 1764 #
(OUTSIDE) (INSIDE)

CG = 29.54' (355") (ALL THREE ARE REF. FROM WHC-SD-TP-SEP-026 Pg. B6-B69)

3) WT. OF STRONGBACK:

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

4) WT. OF PUMP:

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

5) WT. OF SHIELDING: TO COL #14

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

$$\text{DEN. LEAD} = .409 \text{ lbs/in}^3$$

$$\text{DEN STEEL} = .283 \text{ lbs/in}^3$$

(REF. MANUAL OF STEEL CONSTRUCTION, 9th Ed., pg 6-8) (AISC)

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

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

ANALYTICAL CALCULATIONS

Page 5 of 16

Subject SY-101 TRAILER STUDY

Originator W.A. NEWCOM

Date 3/15/95

Checker Benny Jones

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 = $(73,000\#) \left(\frac{-203}{-409} \right) = 50,500\#$
- (REF: WHC-SD-TP-SEP-026)

ANALYTICAL CALCULATIONS

Page 6 of 16

Subject S4101 CONTAINER, PUMP, & SHIELDING LOADED ON 60 TON TRAILER
Originator WA Newson Date 2/8/95
Checker Randy Jonin Date 3/16/95

60 TON LOWBOY

TRAILER WIDTH = 10'

CONTAINER LENGTH = 53' (638")

" " WITH CAPS = 54' 4" = 651"

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

CONTAINER CAPS FACING REAR OF TRAILER

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

$$R_1 = -9300 \#$$

$$(651 - 355 - 189 - 166 = -59")$$

CG. OF PUMP, CONT, & SHIELDING IS TO THE LEFT OF R_2 , THIS SKETCH ABOVE DOES NOT CORRECTLY SHOW THIS)

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

Page 7 of 16

Subject Sy 101 CONT. PUMP & SHIELDING ON 60 TON LOWBOY
 Originator WA NEWSON Date 2/8/95
 Checker Randy Jansen Date 3/16/95

CASE #2

(REF. DWG. ON PREV. PAGE)

LEAD SHIELDING
TO COL. #14
31,000 #

CONTAINER CAPS FACE FRONT

$$\sum M_{R2} = 0; R_1(380") = (110,000)(0") + (20,000)(148")$$

(355 - 189 - 166 = 0)

$$R_1 = \frac{2.96 \text{ EG}}{380} = \underline{7,800 \#}$$

< 64,000 #

OKAY TO USE

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

$$\underline{R_2 = 122,200 \#} > 60,000 \#$$

NOT OK TO USE

CASE #3

(REF. DWG. ON PREV. PAGE)
(CAPS FACE REAR)

LEAD SHIELDING TO
COL. #25 WT. OF
173,000 #

$$\sum M_{R2} = 0; R_1(380") = (145,000)(-86") + (20,000)(148")$$

(651 - 382 - 189 - 166 = -86")

$$R_1 = \frac{-9.57 \text{ EG}}{380} = \underline{-25,000 \#}$$

< 64,000 #

CAN NOT USE

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

(UPLIFT ON KING PIN)

$$\underline{R_2 = 190,000 \#} > 60,000 \#$$

CAN NOT USE

ANALYTICAL CALCULATIONS

Page 8 of 16

Subject 60 TON TRAILER LOADED W/ 54701 CONTAINER - STEEL SHOT
 Originator W.A. NEWSON Date 3/9/95
 Checker Gandy Jansen Date 3/16/95

CASE #4

(SEE SKETCH FOR 60 TON TRAILER)
(CAPS FACE REAR)

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

$$\begin{aligned} F.R. &= 651 - 303 - 189 - 166 = -7 \\ F.F. &= 303 - 189 - 166 = -52 \\ R_1 &= -6000 \# \end{aligned}$$

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

CONTAINER WT. @ C-6 REF.
CALCS. IN APPENDIX
NT = 100,450 #
CG = 303 in

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

$$R_1 = 6,000 \# < 64,400 \#$$

OK
TO USE WMC
TRACTOR

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

$$R_2 = 114,450 \# > 60,000 \#$$

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

Page 9 of 16

Subject SY-101 CONTAINER, PUMP & SHIELDING ON 150 TON TRAILER
 Originator WA Newsom Date 2/8/95
 Checker Randy Jensen Date 3/16/95

CASE #6

NELSON LOWBOY TRAILER, WIDTH = 13'6"

SOLVE FOR R_1 & R_2 :

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

$$R_1 = \frac{2.98 \times 10^7}{636} = \underline{46,900 \#} < 64,000 \#$$

∴ CAN USE WHC TRACTOR

$$\sum F_y = 0; 110,000 + 64,000 - 46,900 = R_2$$

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

∴ OKAY TO USE

ANALYTICAL CALCULATIONS

Page 10 of 16

Subject SH-01 CONT. PUMP & SHIELDING ON 150 TON TRAILER
Originator WA NEWCOM Date 2/3/95
Checker Randy Janner 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 :

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

$$R_1 = \frac{2.3357}{636} = \underline{\underline{36,700\#}} < 64,000$$

∴ CAN USE
WAC TRACTOR

$$\sum F_y = 0 ; 110,000 + 64,000 - 36,700 = R_2$$

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

$$\text{TOTAL LOAD} = 110,000 + 64,000 = 174,000 < 200,000$$

∴ NO JEEP REQ

∴ CAN NOT USE
TRAILER

ANALYTICAL CALCULATIONS

Page 11 of 16

Subject Sy-101 CONT., PUMP, & SHIELDING ON 150 TON TRAILER
Originator W.A. NEWSON Date 2/8/95
Checker Gandy Jounin Date 3/16/95

CASE #8

(SEE PREVIOUS TRAILER SKETCH)

(CONTAINER CONFIGURED W/ CAPS FACING

REAR OF TRAILER) [Facing other dir. won't work]

SHIELDED TO COL # 25
W/ LEAD SHOT
WT. OF 173,000 #

Container CG = 382" - WHC-SD-TP-SER-026

$$\text{Solve for } R_1 \text{ \& } R_2: \text{ CG of CONT. Moment About } = 651" - 382" = 269" - 63" = 206" - 132" = 74"$$

$$\sum M_{R_2} = 0; R_1(636) = (64,000)(191) + (145,000)(74)$$

$$R_1 = \frac{2,3037}{636} = \underline{\underline{36,100 \#}} < 64,000 \#$$

∴ CAN USE
WHC TRACTOR

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

$$R_2 = \underline{\underline{172,900 \#}} > 135,000 \# \therefore \text{NOT USABLE}$$

EXCEEDS TRAILER
LIMIT

(SEE PREV. 150 TON SKETCH)

(CONTAINER CONFIGURED W/ CAPS FACING
FRONT)

SHIELDING TO COL # 25
W/ LEAD SHOT
WT. OF 173,000 #

$$\sum M_{R_2} = 0; R_1(636) = (64,000)(191) + (145,000)(151)$$

$$R_1 = \frac{3,9357}{636} = \underline{\underline{61,900 \#}} < 64,000 \#$$

∴ OK TO USE WHC
TRACTOR

$$\sum F_y = 0; 145,000 + 64,000 - R_1 = \underline{\underline{147,000 \#}} > 135,000 \#$$

∴ EXCEEDS TRAILER
CAPACITY & CAN'T USE

ANALYTICAL CALCULATIONS

Page 12 of 16

Subject S4-101 TRAILOR & STRONG BACK C.B. & TONGUE LOAD KAMP TRAILER
 Originator W.H. Hanson Date 12/28/94
 Checker Randy Johnson Date 3/16/95

CASE # 11

STRONG BACK
ONLY

SOLVE FOR TONGUE LOAD (RUN FREE 21) :

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

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

$$\underline{R_1 = 42,800 \neq}$$

WITHIN WMC TRACTOR CAPACITY
NO JEEP REQ'D

$$\sum F_y = 0; \quad R_2 = 97,366 + 28,340 - R_1$$

$R_2 = 82,906^{\#}$ <

∴ OK TO USE

ANALYTICAL CALCULATIONS

Page 13 of 16

Subject Sy 101 TONGUE LOAD W/ EMPTY CONTAINER KAMP TRAILER

Originator NA Newson

Date 12/28/94

Checker Randy Johnson

Date 3/16/95

CASE # 12

EMPTY CONTAINER

REF.
STEAM BACK W/ T
APPROX.
H-2-83936

* CONTAINER WT.
& C.G. REF.

WHC-SD-TP-SEP-026
Pg. B6-B

* STEAM BACK WT.
& C.G. REF.

WHC-SD-WM-DA-165
Pg. 10

SOLVE FOR REACTION FORCE R_1 (TONGUE LOAD) :

$$\sum M_{R_2} = 0 : R_1 (850.6) = (97,366)(330) + (28,340)(157) + (57,000)(307)$$

$$R_1 = \frac{5.39 E 7 \# \cdot \text{in}}{850.6 \text{ in}}$$

$$R_1 = 63,400 \#$$

< 64,400# $\therefore$ OKAY
TO USE WHC
TRACTOR

$$\sum F_y = 0 ; R_2 = 97,366 + 28,340 + 57,000 - R_1$$

$$R_2 = 119,300 \# < 240,000 \#$$

$\therefore$ NOT EXCEED TRAILER
AXLE CAPACITY, OK TO USE

ANALYTICAL CALCULATIONS

Page 14 of 16

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

Originator W.A. Newson

Date 2/27/95

Checker Randy J. Jansen

Date 3/16/95

Solve for R_1 :

$$\sum M_{R_2} = 0; R_1(850.6) = 97,366(330) + 28,340(150.6) + 110,000(334)$$

$$R_1 = \frac{7.31 \times 10^7}{850.6}$$

$$R_1 = 86,000 \#$$

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

$$R_2 = 149,700 \# < 240,000 \# \text{ OK}$$

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

ANALYTICAL CALCULATIONS

Page 15 of 16

Subject SY-101 CONTAINER ON KAMP TRAILER

Originator W.A. NEWCOM

Date 3/9/95

Checker Randy J. Jansen

Date 3/16/95

CASE #14

(SEE SKETCH ON PREV. PAGE)

SHIELDED TO COL #25
W/ LEAD SHOT
WT. OF 13,000

$$\sum M_{BZ} = 0;$$

CONTAINER CG = 382"
REF.

WHC-SD-TP-SFP-026

$$R_1(850.6) = 97,366(330) + 28,340(150) + (145,000)(361)$$

WT = 145,000#

TP-36-9

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

$$R_1 = 104,340 \# > 64,400 \#$$

∴ CANNOT USE
WHC TRACTOR

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

$$R_2 = 166,400 \# < 240,000$$

∴ NOT EXCEED
TRAILER CAPACITY

ANALYTICAL CALCULATIONS

Page 16 of 16

Subject SY-101 ON KAMP TRAILER CONTINUED

Originator W.A. NEWSON

Date 2/28/95

Checker Randy Jensen

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 :

REF. Appendix C.M.C.
Moment Arm For CG = $303 \text{ in} + 8 \text{ in} - 29.4 \text{ in}$
= 281.6 in

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

$$R_1 = \frac{6.4757}{850.6}$$

$$R_1 = \underline{\underline{76,000 \#}}$$

> 64,400 # THUS CANT USE
WHC TRACTOR W/O
A JEEP. OR USE LAMPSON
TRACTOR

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

$$R_2 = \underline{\underline{150,100 \#}}$$

< 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 KING PIN LOAD FOR
THE WHC TRACTOR (CASE # 15) THEN CASE # 16
WILL OBVIOUSLY EXCEED WHC TRACTOR CAPACITY.

ANALYTICAL CALCULATIONS

Page 16 A of 16

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

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

$$R_1 = \frac{60,680}{0.50.6} = \underline{\underline{71,338}}^{\#}$$

64,385 # WMC TRACTOR
CANNOT USE.
(11% OVER-LOAD)

USE WHC JEEP

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

$R_2 = 130,400^\#$ $\angle 240,000$ - TRAILER OK

ANALYTICAL CALCULATIONS

Page A-1 of

Subject SY-101
Originator W.A. Newson Date 3/6/95
Checker Barry Johnson Date 3/16/95

APPENDIX :

- SKETCH SHOWING LAYOUT DIMENSIONS OF COLUMNS : A-2
(REF. DWG H-2-B3734)
- SKETCH SHOWING EMPTY CONTAINER CG & CAP DIMENSIONS : A-3
(REF. DWG H-2-B3734)
- 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 B96607)
(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 CAL. #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
- GERMAN BARR CALC & WA NEWSON COMPARISON : A-15 & A-16
- 60 TON, 150 TON, & TRACTOR SPEC SHEETS : A-17 - A-19

ANALYTICAL CALCULATIONS

Page A-2 of

Subject SY-101 CONTAINER, PUMP & SHIELDING CG

Originator W.A. Newson

Date 2/5/95

Checker Randy Louren

Date 3/16/95

CONTAINER
DWG# H-2-83734

ANALYTICAL CALCULATIONS

Page A-3 of

Subject SY-101 EMPTY CONTAINER C.G. & WEIGHT
Originator W.A. NEWCOM Date 3/1/95
Checker Randy Jansen Date 3/16/95

- CONTAINER DIM'S REF. DWG H-Z-83734
- CAP DIM'S REF. DWG H-Z-83734
- C.G. & WT. OF CONTAINER REF. WHC-SD-TP-SEP-026, PG. 86-8 & 86-9

ANALYTICAL CALCULATIONS

Page A-4 of

Subject C.G. OF KAMP TRAILER FROM SCALE WEIGHTS
 Originator WLA Newkirk Date 2/3/95
 Checker Gandy Johnson Date 3/16/95

SCALE WEIGHTS ON KAMP TRAILER: [EMPTY]

KING PIN = 37,740 # RUNNING GEAR WT. = 22,974 # (FROM KAMP INFO)
 REAR DRIVES = 82,600 #
 TOTAL WT. = 120,340 # TRAILER WT. W/O RUNNING GEAR = 97,366 #

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

$$\underline{\underline{X_{CG, ACTUAL} = 330. \#}} \quad (\text{DIST. FROM RYN FORCE } R_2, \text{ NOT THE REAR OF TRAILER!})$$

DIST. FROM TRAILER REAR-STRONGBACK BASKET TO
 C.G. = 332.8" + 29.4" = 359.1"

GRAHAM BARR & CALC. $\Rightarrow CG = 337"$

DIFF. = 337" - 330.1" = 7.1"

ANALYTICAL CALCULATIONS

Page A-5 of

Subject CG OF 150 TON TOWER
Originator W.H. Newcom Date
Checker Randy J. Jansen Date 3/16/95

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

FIND CG:

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

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

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

$$186 - 18 - 445 = \underline{\underline{323}} \text{ (C.G. FROM REAR OF TOWER)}$$

ANALYTICAL CALCULATIONS

Page A-6 of

Subject TRACTOR-WHC ALLOWABLE KINGPIN LOAD

Originator W.A. Newson

Date 3/1/95

Checker Randy Jensen

Date 3/16/95

TRACTOR

GVWZ = 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

Page A-7 of

Subject DETERMINE C.G. OF LEAD & STEEL SHOT ALONE FOR S&101

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

Checker Gary Jones Date 3/16/95

By PRINCIPLES OF SUPERPOSITION:

$$M_1 X_1 + M_2 X_2 = M_3 X_3 \quad ; \quad X_2 = \frac{M_3 X_3 - M_1 X_1}{M_2} = \frac{M_1 (X_3 - X_1) + M_2 X_3}{M_2}$$

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

$$\underline{\underline{X_2 = 13.28 \text{ ft}}}$$

ANALYTICAL CALCULATIONS

Page A-8 of

Subject FIND C.G. OF CONTAINER W/ STEEL SHOT TO COL #14
 Originator WHA NEWCOM Date 3/2/95
 Checker Randy Johnson Date 3/16/95

BY PRINCIPLES OF SUPERPOSITION

$$M_1 X_1 + M_2 X_2 = M_3 X_3$$

$$X_3 = \frac{M_1 X_1 + M_2 X_2}{M_3} = \frac{M_1 X_1 + M_2 X_2}{M_1 + M_2}$$

$$X_3 = \frac{(57,000)(27.3) + (21,450)(13.28)}{78,450}$$

$$\underline{\underline{X_3 = 23.47 \text{ ft (282")}}}$$

$M_1 = 57,000 \#$: EMPTY CONT.

$X_1 = 27.3 \text{ FT.}$

$M_2 = 21,450 \#$: STEEL SHOT TO COL 14
REF PREV. CALC.

$X_2 = 13.28 \text{ FT}$: 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.

$$M_1 X_1 + M_2 X_2 = M_3 X_3$$

$$X_3 = \frac{M_1 X_1 + M_2 X_2}{M_3}$$

$$X_3 = \frac{(79,000)(28.45) + (21,450)(13.28)}{100,450}$$

$M_1 = 79,000 \#$: CONTAINER & PUMP (# IS PLUS 3,000#)

$X_1 = 28.45 \text{ FT}$: REF WHC-SD-TP-SEP-026, pg B6-9

$M_2 = 21,450 \#$: STEEL SHOT TO COL. 14, REF
PREV. CALC.

$X_2 = 13.28 \text{ FT}$: REF PREV. CALC.

$M_3 = 100,450 \#$:

$X_3 = ?$: FIND

$$\underline{\underline{X_3 = 25.21 \text{ ft (303 in)}}} = \underline{\underline{\text{LOADED POINT W/ STEEL SHOT TO COL #14 C.G.}}}$$

ANALYTICAL CALCULATIONS

Page A-9 of

Subject WT. OF STEEL SHOT TO COL. # 14
 Originator W.A. NEWSON Date 3/2/95
 Checker Garry J. Jansen 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.

$$\begin{aligned} \text{WT. OF STEEL SHOT} &= \left(\frac{\text{WT. OF LEAD SHOT}}{\text{TO COL. \# 14}} \right) \left(\frac{\text{Dens. Steel}}{\text{Dens. Lead}} \right) \\ &= (31,000\#) \left(\frac{.283 \text{ lbs/in}^3}{.409 \text{ lbs/in}^3} \right) = 21,450\# \end{aligned}$$

$$\text{WT. OF STEEL SHOT} = \underline{\underline{21,450\#}}$$

TO COL. #14

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 are conservative estimates of the actual weight and are the primary input parameter 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: $W_{\text{empty}} = 57,000 \text{ lbs}$
CG of empty package no shielding: $cg_{\text{empty}} = 27.3 \text{ ft}$
2. Weight of empty package with shielding to Column 14:
 $W_{\text{sh1pack}} = 88,000 \text{ lbs}$
CG of empty package with shielding to Column 14:
 $cg_{\text{sh1pack}} = 22.36 \text{ ft}$
3. Weight of empty package with full shielding (Column 25):
 $W_{\text{sh2pack}} = 130,000 \text{ lbs}$
CG of empty package with full shielding (Column 25):
 $cg_{\text{sh2pack}} = 26.62 \text{ ft}$
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

$$W_{\text{pack}} = 76,000 \text{ lbs}$$

CG of loaded package with no shielding:

$$cg_{\text{pack}} = 28.45 \text{ ft}$$

5. Weight of loaded package shielded to Column 14:

$$W_{\text{packsh1}} = 110,000 \text{ lbs}$$

CG of loaded package shielded to Column 14:

$$cg_{\text{packsh1}} = 29.59 \text{ ft}$$

6. Weight of loaded package fully shielded to Column 25:

$$W_{\text{packsh2}} = 145,000 \text{ lbs}$$

CG of loaded package fully shielded to Column 25:

$$cg_{\text{packsh2}} = 31.83 \text{ ft}$$

ANALYTICAL CALCULATIONS

Subject LAMPSON TRACTOR CAPACITY Page A-12 of
Originator W.A. NEWSON
Checker Randy Jounen Date 3/6/95
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. ED." 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,
2413Y101 EQUIPMENT REMOVAL SYSTEM."

Randy Jounen
7/25/95

A-13

BEST AVAILABLE COPY

6X4
HEAVY DUTY OFF-HIGHWAY
TRACTOR
(M.R. ED.)

UNIFORM MEASUREMENTS
FINDING, WASH. D.C.

WE STAND BY USE 40,000
To 10,000/65 of weight. Re. all...

WE STAND BY USE 40,000
To 10,000/65 of weight. Re. all...

Item	Description	Quantity	Unit	Price	Total
1	Tractor	1	EA	10,000.00	10,000.00
2	Blade	1	EA	5,000.00	5,000.00
3	Implement	1	EA	5,000.00	5,000.00
4	Engine	1	EA	5,000.00	5,000.00
5	Transmission	1	EA	5,000.00	5,000.00
6	Drive Shaft	1	EA	5,000.00	5,000.00
7	Front Axle	1	EA	5,000.00	5,000.00
8	Rear Axle	1	EA	5,000.00	5,000.00
9	Wheels	4	EA	5,000.00	20,000.00
10	Tires	4	EA	5,000.00	20,000.00
11	Brakes	4	EA	5,000.00	20,000.00
12	Lighting	1	EA	5,000.00	5,000.00
13	Paint	1	EA	5,000.00	5,000.00
14	Tools	1	EA	5,000.00	5,000.00
15	Accessories	1	EA	5,000.00	5,000.00
16	Subtotal				100,000.00
17	Tax				10,000.00
18	Freight				10,000.00
19	Insurance				10,000.00
20	Warranty				10,000.00
21	Grand Total				140,000.00

12.00 X 24 - 18 PLY TIRES
WALKING BEAM SUSPENSIONS
BUDD STEEL WHEELS
45,000# CAPACITY TRUNION AXLES
18 X 7 AIR BRAKES

SCALE - 3/16" = 1'-0"

DESIGN CALCULATION

WHC-SD-WM-DA-194
Rev. 0

- (1) Drawing _____ (2) Doc. No. _____ (3) Page A-15 of _____
 (4) Building _____ (5) Rev. _____ (6) Job No. _____
 (7) Subject SH 101 TRAILER - CG CALC. MOVING BACKWARDS FROM BARR'S CALLS.
 (8) Originator NA WILSON Date 12/9/94
 (9) Checker Randy J. Jansen Date 3/16/95

(10) CG OF TRAILER - FROM KAMP CALLS.

MAX DESIGN LOAD

* NOTE: R_2 INCREASED BY 22,974 # FOR THE WEIGHT OF THE RUNNING GEAR! $R_2 = 191,233 + 22,974 = 214,207$

$$\sum M_{R_1} = 0 = 45000(305) + 110000(541) + 97,998(X_{CG}) + 45000(888) + 22,974(859) - (214,207)(859)$$

SOLVE FOR X_{CG} :

$$X_{CG} = \frac{1.33E8 - 1.84E8}{97,998} = \frac{-5.11E7}{97,998} = -521.2 \text{ (NEG. MEANS TO THE LEFT)}$$

$$X_{CG} = 521" \text{ (FROM } R_1), 337" \text{ (FROM } R_2)$$

$$\sum F_y = 0 = 45 \text{ KIPS} + 45 + 110 + 99.998 - 214.207 + 22.974 \left. \begin{array}{l} R_1 = 106,765 \# \\ \text{(SAME AS G. BARR} \\ \text{FROM KAMP SYSTEMS,} \\ \text{INC. CALCULATED)} \end{array} \right\}$$

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
SUBJECT KAMP SYSTEMS, INC. 101-SY HYDRAULIC TRAILER ANALYSIS.		CHKD BY:	DATE:
		PROGRAM HANFORD SY-1-1 MITIGATION/SAFETY.	

TRAILER MAIN BEAM BENDING STRESSES.

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

TAKING MOMENTS ABOUT R_1

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

$$\begin{aligned}
 R_2 &= 191,233 \text{ lb.} \\
 R_2 &= \sum \text{WEIGHTS} - R_1 \\
 &= 297,998 - 191,233 \\
 R_1 &= 106,765 \text{ lb.}
 \end{aligned}$$

R₁ should be

RECEIVING AND INSPECTION REPORT FOR EQUIPMENT

(1) Receiving Report No.

WHC-SD-WM-DA-194
Rev. 0☒ INCOMING☐ OUTGOING

(2) Purchase Order No.

415-BBB-326627

TO BE COMPLETED UPON ARRIVAL AND IMMEDIATELY PRIOR
TO RELEASE FROM PROJECT OF ALL EQUIPMENT.

(3) Date Received

8-17-84

(4) Date Inspected

8-17-84

(5) Shipper

Via: ☐ Rail ☒ Truck

(7) Purchased F.O.B.

☐ Origin☒ Destination

(8) Type of Equipment

Cable, hoisting 3 cable

(9) Manufacturer

Sintering Co. Mitchell & Nichols

(10) Year

1984

(11) Equipment Unit No.

64-5737

(12) Model

4548-1220

(13) Body No.

(14) Base - Make

Quilcase

(15) Mfg. Serial No.

1DA73CT774E31007625

(16) Chassis No.

(17) Body Dimensions

S.O. # 28240

(18) Gross Weight

(19) License No.

(20) Reg. No.

Manufacturer

Model

Eng. Serial No.

Type

☐ Gas☐ Diesel☐ Air☐ Electric☐ Air Cooled☐ Water Cooled

		Good	Fair	Bad		Good	Fair	Bad
1	Appearance				44	Size		
2	Motor (Type)				45	GVWR		
3	Cooling System				46	GAWR Front		
4	Starting Motor				47	GAWR Rear		
5	Wiring				48	CAWR Center		
6	Ignition System				49			
7	Injector Pump				50			
8	Compressor				51			
9	Oil Filter				52			
10	Air Cleaner (Type)				53			
11	Battery - Cable				54			
12	Front End				55			
13	Shock Absorbers				56			
14	Tow Hooks				57			
15	Tires - Front				58			
16	Body Interior				59			
17	Glass				60			
18	Instruments				61			
19	Oil Pressure				62			
20	Master Clutch				63			
21	Transmission (No. Speeds)				64			
22	Brakes (Type)				65			
23	Emergency Brake				66			
24	Miles - Meter				67			
25	Cab - Body - Type				68			
26	Lights				69			
SPECIAL EQUIPMENT					70			
27	Fire Extinguisher				71			
28	Heater				72			
29	Spot Light				73			
30	Seat Covers				74			
31					75			
32					76			
33	Tires (Rear)				77	Fuel Tank		
34	Tires (Spare)				78	Steering Device		
35	Rear Axle				79	Hyd. Pump		
36	Pintle Hook				80	Frame		
37	Drive Line - Joints					Open Gears		
38	Fifth Wheel					EQUIPMENT ATTACHED:		
39	Tail Gate					1. Hydraulic Lift & Winch		
40	Body Hoist					2. 3" x 1" milled tie down		
41	Horse Power					3. 1st & 2nd hand		
42	Wheel Base					4. 12" x 7" x 3" Cam Lock		
43	Weight					5. 10" x 7" x 3" Cam Lock		
Warranty:						6. Hydraulic Winch		
Color:						7. 12" x 7" x 3" Cam Lock		
						8. 10" x 7" x 3" Cam Lock		
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						99. 12" x 7" x 3" Cam Lock		
						100. 10" x 7" x 3" Cam Lock		

☐ Acceptance
☐ Rejection

Signature of Inspector

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 (8-84)

REG 4250241

A-10

RECEIVING AND INSPECTION REPORT FOR EQUIPMENT				(1) Receiving Report No.																																																																																																																																																																																																																																																																																																																																																																																																									
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(5) Shipper Robert Mfg Co. 6448 U.S. RT 224E Via: ☐ Rail ☒ Truck ☐ Express ☐ Origin ☐ Destination ☒ (8) Type of Equipment Self-propelled trailer with pup				(4) Date Invoiced 9-8-91																																																																																																																																																																																																																																																																																																																																																																																																									
(9) Manufacturer Robert Mfg Co. Atkinson, Ohio				(11) Equipment Unit No. 604-24597																																																																																																																																																																																																																																																																																																																																																																																																									
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<table border="1"><thead><tr><th></th><th>Good</th><th>Fair</th><th>Bad</th><th></th><th>Good</th><th>Fair</th><th>Bad</th></tr></thead><tbody><tr><td>1 Appearance</td><td></td><td></td><td></td><td>44 Size</td><td></td><td></td><td></td></tr><tr><td>2 Motor (Type)</td><td></td><td></td><td></td><td>45 GVWR</td><td></td><td></td><td></td></tr><tr><td>3 Cooling System</td><td></td><td></td><td></td><td>46 GAWR Front</td><td></td><td></td><td></td></tr><tr><td>4 Starting Motor</td><td></td><td></td><td></td><td>47 GAWR Rear</td><td></td><td></td><td></td></tr><tr><td>5 Wiring</td><td></td><td></td><td></td><td>48</td><td></td><td></td><td></td></tr><tr><td>6 Ignition System</td><td></td><td></td><td></td><td>49</td><td></td><td></td><td></td></tr><tr><td>7 Injector Pump</td><td></td><td></td><td></td><td>50</td><td></td><td></td><td></td></tr><tr><td>8 Compressor</td><td></td><td></td><td></td><td>51</td><td></td><td></td><td></td></tr><tr><td>9 Oil Filter</td><td></td><td></td><td></td><td>52</td><td></td><td></td><td></td></tr><tr><td>10 Air Cleaner (Type)</td><td></td><td></td><td></td><td>53</td><td></td><td></td><td></td></tr><tr><td>11 Battery - Cable</td><td></td><td></td><td></td><td>54</td><td></td><td></td><td></td></tr><tr><td>12 Front End</td><td></td><td></td><td></td><td>55</td><td></td><td></td><td></td></tr><tr><td>13 Shock Absorbers</td><td></td><td></td><td></td><td>56</td><td></td><td></td><td></td></tr><tr><td>14 Tow Hooks</td><td></td><td></td><td></td><td>57</td><td></td><td></td><td></td></tr><tr><td>15 Bumper - Front</td><td></td><td></td><td></td><td>58</td><td></td><td></td><td></td></tr><tr><td>16 Body Interior</td><td></td><td></td><td></td><td>59</td><td></td><td></td><td></td></tr><tr><td>17 Glass</td><td></td><td></td><td></td><td>60</td><td></td><td></td><td></td></tr><tr><td>18 Instruments</td><td></td><td></td><td></td><td>61</td><td></td><td></td><td></td></tr><tr><td>19 Oil Pressure</td><td></td><td></td><td></td><td>62</td><td></td><td></td><td></td></tr><tr><td>20 Master Clutch</td><td></td><td></td><td></td><td>63</td><td></td><td></td><td></td></tr><tr><td>21 Transmission (No. Speed)</td><td></td><td></td><td></td><td>64</td><td></td><td></td><td></td></tr><tr><td>22 Brakes (Type)</td><td></td><td></td><td></td><td>65</td><td></td><td></td><td></td></tr><tr><td>23 Emergency Brake</td><td></td><td></td><td></td><td>66</td><td></td><td></td><td></td></tr><tr><td>24 Miles - Hrs.</td><td></td><td></td><td></td><td>67</td><td></td><td></td><td></td></tr><tr><td>25 Cab - Body - Type</td><td></td><td></td><td></td><td>68</td><td></td><td></td><td></td></tr><tr><td>26 Lights</td><td></td><td></td><td></td><td>69</td><td></td><td></td><td></td></tr><tr><td colspan="4">SPECIAL EQUIPMENT</td><td>70</td><td></td><td></td><td></td></tr><tr><td>27 Fire Extinguisher</td><td></td><td></td><td></td><td>71</td><td></td><td></td><td></td></tr><tr><td>28 Heater</td><td></td><td></td><td></td><td>72</td><td></td><td></td><td></td></tr><tr><td>29 Spot Light</td><td></td><td></td><td></td><td>73</td><td></td><td></td><td></td></tr><tr><td>30 Seat Covers</td><td></td><td></td><td></td><td>74</td><td></td><td></td><td></td></tr><tr><td>31</td><td></td><td></td><td></td><td>75</td><td></td><td></td><td></td></tr><tr><td>32</td><td></td><td></td><td></td><td>76</td><td></td><td></td><td></td></tr><tr><td>33 Tires (Rear)</td><td></td><td></td><td></td><td>77 Fuel Tank</td><td></td><td></td><td></td></tr><tr><td>34 Tires (Spare)</td><td></td><td></td><td></td><td>78 Lifting Device</td><td></td><td></td><td></td></tr><tr><td>35 Rear Axle</td><td></td><td></td><td></td><td>79 Hyd. Pump</td><td></td><td></td><td></td></tr><tr><td>36 Pintle Hook</td><td></td><td></td><td></td><td>80 Open Gears</td><td></td><td></td><td></td></tr><tr><td>37 Drive Line - Joint</td><td></td><td></td><td></td><td colspan="4">EQUIPMENT ATTACHED:</td></tr><tr><td>38 Fifth Wheel</td><td></td><td></td><td></td><td colspan="4">1. 3" steel deck</td></tr><tr><td>39 Tail Gate</td><td></td><td></td><td></td><td colspan="4">2. tie down straps</td></tr><tr><td>40 Body Hoist</td><td></td><td></td><td></td><td colspan="4">3. Holland fifth wheel</td></tr><tr><td>41 Horse Power</td><td></td><td></td><td></td><td colspan="4">4. steel plate</td></tr><tr><td>42 Wheel Base</td><td></td><td></td><td></td><td colspan="4">5. 4x4 axle assembly</td></tr><tr><td>43 Weight</td><td></td><td></td><td></td><td colspan="4">6. 4x4 axle assembly</td></tr><tr><td colspan="4">Warranty: one year</td><td colspan="4">7. 4x4 axle assembly</td></tr><tr><td colspan="4">Color: white</td><td colspan="4">8. 4x4 axle assembly</td></tr><tr><td colspan="4">☒ Acceptance ☐ Rejection</td><td colspan="4">Signature of Inspector</td></tr><tr><td colspan="4">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.</td><td colspan="4">Signature of Inspector</td></tr></tbody></table>							Good	Fair	Bad		Good	Fair	Bad	1 Appearance				44 Size				2 Motor (Type)				45 GVWR				3 Cooling System				46 GAWR Front				4 Starting Motor				47 GAWR Rear				5 Wiring				48				6 Ignition System				49				7 Injector Pump				50				8 Compressor				51				9 Oil Filter				52				10 Air Cleaner (Type)				53				11 Battery - Cable				54				12 Front End				55				13 Shock Absorbers				56				14 Tow Hooks				57				15 Bumper - Front				58				16 Body Interior				59				17 Glass				60				18 Instruments				61				19 Oil Pressure				62				20 Master Clutch				63				21 Transmission (No. Speed)				64				22 Brakes (Type)				65				23 Emergency Brake				66				24 Miles - Hrs.				67				25 Cab - Body - Type				68				26 Lights				69				SPECIAL EQUIPMENT				70				27 Fire Extinguisher				71				28 Heater				72				29 Spot Light				73				30 Seat Covers				74				31				75				32				76				33 Tires (Rear)				77 Fuel Tank				34 Tires (Spare)				78 Lifting Device				35 Rear Axle				79 Hyd. 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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.				Signature of Inspector																																																																																																																																																																																																																																																																																																																																																																																																									

[illegible]

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 M  0  0    S /   M 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 :

CONTROL INFORMATION

```
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

SOLUTION PARAMETERS

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)=	0.000000E+00
CONVERGENCE TOLERANCE.	(RTOL)=	0.100000E-04
COMPOSITE MODAL DAMPING CALC. FLAG	(IMDC)=	0
MODAL ACCELERATION FLAG.	(IMAM)=	0

SUBSPACE ITERATION

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.